

*A Federal Framework and Action Plan
for Climate Services*

PRODUCT OF THE
FAST TRACK ACTION COMMITTEE ON CLIMATE SERVICES
OF THE NATIONAL SCIENCE AND TECHNOLOGY COUNCIL



March 2023

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About the Fast Track Action Committee on Climate Services

The objective of the Fast Track Action Committee is to advance the development of an operational framework for federal climate services that is consistent with legal mandates including the National Climate Program Act of 1978, the Global Change Research Act of 1990, and the Weather Research and Forecasting Innovation Act of 2017. In developing this report, the committee built on the vision and principles outlined in the response to EO 14008 (Section 211d), *Opportunities for Expanding and Improving Climate Information and Services for the Public*. The FTAC is comprised of members from 17 departments and agencies and the Executive Office of the President.

About this Document

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White House Office of Science and Technology Policy

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Fernanda Zermoglio

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U.S. Global Change Research Program

Reuben Aniekwu

Michael Kuperberg

Toral Patel-Weynand

Interagency Council for Advancing Meteorological Services

Scott Weaver

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Executive Summary

The ability for people from all walks of life to access and use knowledge and information about the climate and how it is changing is critical to enabling effective climate action. That capability is provided through what are called climate services, or “scientifically-based, usable information and products that enhance knowledge and understanding about the impacts of climate change on potential decisions and actions.”¹ Climate services vary widely and can include information about future climate change, drivers of those changes, impacts on humans and nature, as well as options for responding.

The Federal Government has been a credible source of climate information for decades, but the speed, scale, and types of impacts of climate change have accelerated faster than the current delivery of useful services. Federal agencies provide a range of climate services for the entire Nation and tailored products for stakeholders in specific regions or sectors. The need for a more coherent strategy for climate services has long been recognized but is becoming more urgent as demand for more useful climate services increases substantially.

The Biden-Harris Administration’s Executive Order 14008 (Section 211d), *Tackling the Climate Crisis at Home and Abroad*,² called for expansion and improvement of the Nation’s climate forecast capabilities and information products for the public. In response to this directive, the Federal Government developed a report entitled *Opportunities for Expanding and Improving Climate Information and Services for the Public* that articulated a vision and recommended actions for the future direction of federal climate services.³ Central to that vision is the ambition to provide every American, every community, and every business with access to useful and usable climate services. To translate recommendations of the Section 211d report into federal actions, the National Science and Technology Council established an interagency Fast Track Action Committee (FTAC) on Climate Services.

The work of the FTAC consisted of deliberations among agencies regarding the scope, challenges, and opportunities associated with building a more cohesive and strategic federal climate services enterprise. A series of listening sessions with external experts and stakeholders offered independent perspectives on useful pathways forward. And, throughout its deliberations, the FTAC paid close attention to previous Congressional direction, for example as provided in the National Climate Program Act of 1978⁴ or the Global Change Research Act of 1990.⁵

¹ Office of Science and Technology Policy, National Oceanic and Atmospheric Administration, and Federal Emergency Management Agency, 2021. *Opportunities for Expanding and Improving Climate Information and Services for the Public—A Report to the National Climate Task Force*. <https://downloads.globalchange.gov/reports/eo-14008-211-dreport.pdf>.

² Executive Office of the President, 2021. Executive Order on Tackling the Climate Crisis at Home and Abroad. <https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/>

³ Office of Science and Technology Policy, National Oceanic and Atmospheric Administration, and Federal Emergency Management Agency, 2021. *Opportunities for Expanding and Improving Climate Information and Services for the Public—A Report to the National Climate Task Force*. <https://downloads.globalchange.gov/reports/eo-14008-211-dreport.pdf>.

⁴ Public Law 95-367, September 17, 1978. National Climate Program Act. <https://www.govinfo.gov/content/pkg/STATUTE-92/pdf/STATUTE-92-Pg601.pdf>

⁵ Public Law 101-606, November, 16, 1990. Global Change Research Act. <https://www.govinfo.gov/content/pkg/STATUTE-104/pdf/STATUTE-104-Pg3096.pdf>

This report is the result of the deliberations of the FTAC. First and foremost, it emphasizes the key role of individual agencies in continuing to develop and deliver climate services to meet their own needs and the needs of their stakeholders. At the same time, it recognizes the urgent need to enhance the collective effectiveness of federal climate services, and it presents a whole-of-government framework and action plan to advance that goal. The report recommends initial steps to enhance interagency coordination and strategic planning to boost the effectiveness of the climate services enterprise, strengthen governance and leadership, build consistency across the Federal Government, and increase investment. This will result in a more seamless and useful experience for users of climate services, which, in turn, generates positive outcomes for the Nation, such as the protection of nature, more sustainable economic prosperity, infrastructure that is climate-resilient, enhanced homeland security, and more just and equitable communities.

To set in motion a process to achieve these outcomes, **the FTAC's overarching recommendation is for the U.S. Global Change Research Program (USGCRP) to expand its research coordination role to provide national leadership in coordination and strategic planning of climate services.** This recommendation is grounded in knowledge of 1) the USGCRP's considerable experience in effectively coordinating global change research and assessment; 2) its mandate under the Global Change Research Act of 1990 to inform decisions; 3) its track record of producing useful climate services; and 4) USGCRP's *2022-2031 Strategic Plan* which includes an ambitious agenda to advance usable science and engage the public.⁶ Extending the USGCRP's activities from the current focus on coordination of research to also include coordination of services will necessitate structural changes to USGCRP. The FTAC identified options for alternate structures and evaluated each, but does not recommend any particular configuration at this time. Rather, the FTAC recommends that USGCRP use this report as a foundation for further engagement with agencies and the White House to determine the best organizational structure to maximize effective coordination of climate services across the Federal Government, building on the strong capabilities of individual agencies.

The FTAC discussed the following additional recommendations for addressing existing challenges associated with service delivery, supporting development of the broader framework, and building capacity for climate service development and delivery. These recommendations, which are described in more detail within the report, are grouped into four categories. These recommendations should be considered potential options available to the Federal Government, and should be revisited once a more detailed operational plan has been developed.

Recommendation 1: Enhance Engagement and Partnerships with Federal and Non-federal Producers and Users of Climate Services

Recommendation 1.1: Launch a Climate Services Summit that brings together federal and non-federal producers and users of climate data and tools.

Recommendation 1.2: Use public/private partnerships to enhance access to, and use of, non-federal climate service capabilities.

⁶ USGCRP, 2022. The U.S. Global Change Research Program 2022–2031 Strategic Plan. U.S. Global Change Research Program, Washington, DC, USA. <https://www.doi.org/10.7930/usgcrp-2022-2031-strategic-plan>

Recommendation 1.3: Develop guidance for federal agencies on the effective use of co-production methods for the design and dissemination of climate services.

Recommendation 2: Strengthen Governance, Leadership, and Oversight of Federal Climate Services

Recommendation 2.1: Direct USGCRP to facilitate coordination among agencies specifically regarding climate service development, delivery, and use.

Recommendation 2.2: Establish or identify a climate service coordinator position(s) or capability within each federal agency, leveraging, where possible, existing capabilities and organizational structures for the development, delivery and/or use of climate services.

Recommendation 2.3: Develop a decadal strategic plan and interim implementation progress reports on federal climate service efforts.

Recommendation 2.4: Develop an operational definition of climate services for the Federal Government.

Recommendation 3: Develop Common Infrastructure and Processes for the Development and Delivery of Climate Services Across the Federal Government

Recommendation 3.1: Identify and/or develop common platforms and system architectures for supporting the development and delivery of existing and new climate services.

Recommendation 3.2: Develop and maintain an inventory of climate service data, products, and tools.

Recommendation 4: Enhance the Capacity of the Federal Government and Non-federal Partners to Develop and Deliver Climate Services

Recommendation 4.1: Conduct an evaluation of the Federal Government's training and professional development needs with respect to climate including the capacity to effectively develop, deliver, and use climate services.

Recommendation 4.2: Launch a specific training program or capability that builds capacity among federal personnel to discover and use available climate services.

Recommendation 4.3: Expand guidance and outreach for navigating federal funding opportunities that support climate service development and implementation.

1 Introduction

Climate change has emerged as a major disruptive force for the Nation and the world. Recent estimates indicate that the U.S. Federal Government alone could spend an estimated \$25 billion to \$128 billion each year in addressing climate damages,⁷ but considerable costs will also be borne by individual communities and businesses across the country. The timely creation and delivery of information on climate variability and change, as well as effective response options, are fundamental to successfully managing these risks. This endeavor necessitates combining understanding of the information needs and capacities of practitioners and decision-makers with a robust understanding of Earth system science and research that includes observations, modeling, and projections. That combination enables science insights to be delivered in ways that are credible, accessible, relevant, and actionable. The capabilities that deliver such insights are commonly referred to as climate services.⁸

Under the direction of the U.S. Congress, the Federal Government has been providing climate services for decades. The National Climate Program Act of 1978 directed the Secretary of Commerce to establish a program office to provide climate services that includes “*mechanisms for intergovernmental climate-related studies and services, including participation by universities, the private sector and others concerned with applied research and advisory services.*”⁹ The Global Change Research Act (GCRA) of 1990 established an integrated global change research program [now the U.S. Global Change Research Program or USGCRP],¹⁰ with one objective being providing “*usable information on which to base policy decisions relating to global change.*” More recently, the National Aeronautics and Space Administration (NASA) Authorization Act of 2008 directed NASA to prioritize “*securing practical benefits for society*” in its Earth Science Program.¹¹

A range of other agencies have climate risk management as part of their mission, either directly in terms of hazard mitigation, or indirectly, through their science programs and the public sharing of climate information. As a result, the Federal Government is one of the most recognized sources of information on climate change and its consequences, and it offers a rich array of data, information, and services to the public. Information users, from farmers, to local officials, to water utility managers, to businesses, increasingly depend on these climate services to plan for climate change and act.

Nevertheless, the size and breadth of the Federal Government, and the diversity of user needs, have caused federal climate services to develop in an ad hoc manner that is more reactive than anticipatory or strategic. The development of a nationally coherent approach to climate services has been proposed

⁷ Office of Management and Budget, 2022. Climate Risk Exposure: An Assessment of the Federal Government’s Financial Risks to Climate Change. White Paper. Executive Office of the President, Washington, DC. https://www.whitehouse.gov/wp-content/uploads/2022/04/OMB_Climate_Risk_Exposure_2022.pdf

⁸ Office of Science and Technology Policy, National Oceanic and Atmospheric Administration, and Federal Emergency Management Agency, 2021. Opportunities for Expanding and Improving Climate Information and Services for the Public—A Report to the National Climate Task Force. <https://downloads.globalchange.gov/reports/eo-14008-211-dreport.pdf>

⁹ Public Law 95-367, September 17, 1978. National Climate Program Act. <https://www.govinfo.gov/content/pkg/STATUTE-92/pdf/STATUTE-92-Pg601.pdf>

¹⁰ Public Law 101-606, November 16, 1990. Global Change Research Act. <https://www.congress.gov/101/statute/STATUTE-104/STATUTE-104-Pg3096.pdf>

¹¹ Public Law 110-422, October 11, 2010. National Aeronautics and Space Administration Authorization Act of 2010. <https://www.govinfo.gov/content/pkg/PLAW-111publ267/html/PLAW-111publ267.htm>

multiple times over the past two decades by the National Academies of Sciences, Engineering, and Medicine (NASEM),^{12,13} the Government Accountability Office (GAO),¹⁴ and Congress.^{15,16} In building on these prior recommendations, the Biden-Harris Administration's Executive Order 14008 (Section 211d), *Tackling the Climate Crisis at Home and Abroad*,¹⁷ called for the expansion and improvement of the Nation's climate forecast capabilities and information products for the public. In response to this EO, the Federal Government produced a report that described a vision and set of principles for the future direction of federal climate services as well as recommended actions to deliver on that vision.¹⁸

While that report laid the conceptual foundation for advances in climate services, additional work remains in identifying and implementing specific courses of action that can be pursued by the Federal Government. Hence, the Fast Track Action Committee (FTAC) on Climate Services was launched under the auspices of the National Science and Technology Council (NSTC) to oversee the rapid development of an action plan to improve climate services and their value to users. The FTAC's action plan communicates how the Federal Government can develop a more coordinated framework for the development and delivery of climate services. The primary audience for the action plan is the leadership of federal agencies and interagency bodies that contribute to the supply of, or have demand for, climate services, as well as those outside the Federal Government that are developing, delivering, and using climate services themselves. The FTAC was co-chaired by the White House Office of Science and Technology Policy (OSTP), the National Oceanic and Atmospheric Administration (NOAA) and the Federal Emergency Management Agency (FEMA) and consisted of representatives from 17 other federal agencies and White House offices.

In pursuing its work, the FTAC focused on what users of climate services need in order to respond effectively to the climate crisis, with a particular emphasis on disadvantaged and underserved populations that have limited capacity or capability to develop and apply climate services. Understanding of user needs was informed by FTAC participants' knowledge of their programs and their engagement with their own stakeholders. In addition, the FTAC conducted a series of listening sessions with state, local, Tribal, and territorial (SLTT) governments; private sector providers of climate services; non-profit and philanthropic organizations; and experts from the Nation's colleges and universities.

¹² NASEM, 2001. A climate services vision: First steps toward the future. National Academies of Sciences, Engineering, and Medicine, Washington, DC. <https://www.nap.edu/catalog/10198/a-climate-services-vision-first-steps-toward-the-future>

¹³ NASEM, 2010. Informing an Effective Response to Climate Change. National Academies of Sciences, Engineering, and Medicine, Washington, DC. <https://www.nap.edu/catalog/12784/informing-an-effective-response-to-climate-change>

¹⁴ GAO, 2015. A National System Could Help Federal, State, Local, and Private Sector Decision Makers Use Climate Information. Government Accountability Office, Washington, DC. <https://www.gao.gov/assets/gao-16-37.pdf>

¹⁵ U.S. Senate, 2001. S.1716 - Global Climate Change Act of 2001. <https://www.congress.gov/bill/107th-congress/senate-bill/1716/text>

¹⁶ U.S. Senate, 2007. S.2307 - Global Change Research Improvement Act of 2007. <https://www.congress.gov/bill/110th-congress/senate-bill/2307/text>

¹⁷ Executive Office of the President, 2021. Executive Order on Tackling the Climate Crisis at Home and Abroad. <https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/>

¹⁸ Office of Science and Technology Policy, National Oceanic and Atmospheric Administration, and Federal Emergency Management Agency, 2021. Opportunities for Expanding and Improving Climate Information and Services for the Public—A Report to the National Climate Task Force. <https://downloads.globalchange.gov/reports/eo-14008-211-dreport.pdf>.

The result is an action plan that clarifies understanding of the scope of climate services across the Federal Government, provides an initial framework for organizing federal agencies, and identifies specific actions that can be taken to build a more effective system of climate services for the Nation. Through the vigorous and sustained implementation of these actions, the Federal Government, along with non-federal partners, will be well-positioned to support climate actions in the years ahead that reduce climate risk and enhance the Nation’s resilience.

2 Toward a Common Understanding of Federal Climate Services

The Federal Government has been engaged in the provision of climate services for decades. Those efforts have been distributed across agencies, and, appropriately, relevant to specific agency missions. To date, the Federal Government has lacked a common understanding of what constitutes climate services and what the scope of those services should be. To address that limitation, the FTAC identified the various ways in which climate services have been defined to date and the processes involved in the development and application of climate services. In addition, the FTAC identified key dimensions of climate services that should be integrated moving forward in order to have a whole-of-government understanding that can be applied consistently.

2.1 Defining Climate Services

As stated in the report responding to EO 14008 (Section 211d), *Opportunities for Expanding and Improving Climate Information and Services for the Public* (hereafter, the *Opportunities* report), climate services can be defined as “scientifically-based, usable information and products that enhance knowledge and understanding about the impacts of climate change on potential decisions and actions.”¹⁹ This report continues to rely upon this definition, which is consistent with others that have appeared in the scientific literature over the past two decades.^{20,21,22,23,24} In practice, federal agencies’ interpretations of climate services may vary based on individual agencies’ unique missions and mandates. A common defining feature of climate services is their focus on supporting a particular mission or action, which distinguishes climate services from climate science and research. Climate services are explicitly designed to facilitate the implementation of policies, programs, practices, and choices by individuals, organizations, and communities. This may involve services that are available for consistent use as well as more ongoing, deliberative services shaped by engagement, knowledge co-production, and capacity-building. In addition, Indigenous, traditional and local knowledge are

¹⁹ Office of Science and Technology Policy, National Oceanic and Atmospheric Administration, and Federal Emergency Management Agency, 2021. *Opportunities for Expanding and Improving Climate Information and Services for the Public—A Report to the National Climate Task Force*. <https://downloads.globalchange.gov/reports/eo-14008-211-dreport.pdf>.

²⁰ American Meteorological Service, 2015. *Climate Services*. A Policy Statement of the American Meteorological Society. <https://www.ametsoc.org/index.cfm/ams/about-ams/ams-statements/statements-of-the-ams-in-force/climate-services1/>

²¹ World Meteorological Organization, 2013. *What Do We Mean by Climate Services?* Bulletin n° : Vol 62 <https://public.wmo.int/en/bulletin/what-do-we-mean-climate-services>

²² National Research Council, 2001. *A Climate Services Vision: First Steps Toward the Future*. The National Academies Press. Washington, DC. <https://doi.org/10.17226/10198>

²³ World Meteorological Organization, *Global Framework for Climate Services*. <https://gfcs.wmo.int/national-frameworks-for-climate-services>.

²⁴ World Meteorological Organization, *National Frameworks for Climate Services*. <https://gfcs.wmo.int/national-frameworks-for-climate-services>.

important components for developing climate services in some contexts or for specific cultures and communities.

2.2 The Climate Services Knowledge Value Chain

Climate services are not simply the provision of climate data. Instead, they are often the products of a knowledge value chain – the sequences of steps involved in producing information products for a customer (Figure 2.1) – as well as the recognition of end users, decision makers, and communities who help drive the dynamic feedback loops in the chain. The primary inputs in the value chain are climate science and resulting data and information generated by that science. For example, the Earth science and social science research undertaken by federal agencies and coordinated by the U.S. Global Change Research Program have been the primary source of information from which the Federal Government’s climate services have been derived. However, other forms of knowledge exist and are relevant to climate services, including Indigenous, traditional and local knowledge that is grounded in cultural learning and lived experience.

The development phase of climate service provision involves the synthesis and translation of information to distill key findings or enhance the accessibility of the information for different audiences. It also includes the design process of climate services, which necessitates appreciation of the needs of intended users and the extent to which knowledge co-production can add value in meeting those needs. Moreover, development of climate services involves processes for building user interfaces, data dashboards, and various types of products and tools.

The delivery link is associated with processes for the dissemination and sharing of knowledge. A broad range of communication challenges are inherent in such delivery. For example, products and tools for mapping and visualizing climate information are increasingly common. But delivery often involves more than making data available. For example, agricultural extension services work hand-in-hand with users within the sector to co-produce information and analyses that those users apply directly on their own farms. Hence, the process of building trust and ongoing working relationships between producers and users of climate services is as important as the information itself. Failure to appreciate these dynamics result in efforts to provide climate services failing to meet expectations.²⁵

Once delivered, a diverse community of users will use climate services to address different questions, such as how to identify potential risks and opportunities associated with climate variability and change, how to plan and implement responses, and how to pursue opportunities to build long-term community resilience to climate change. Users may be motivated to act on climate change based on a range of factors. Those could range from market signals that suggest competitive opportunity, a response to policy signals and mandates such as EO 14008 or notice of funding opportunities associated with the Bipartisan Infrastructure Law (BIL) and the Inflation Reduction Act (IRA), or an urgent need to address climate damages that are already being experienced in a community. In some instances, users may be responding to best practices for environmental management within a given industry or sector. Those

²⁵ Findlater, K., Webber, S., Kandlikar, M., and Donner, S., 2021. Climate services promise better decisions but mainly focus on better data. *Nature Climate Change*, 11(9), 731-737.

users span not only different professional contexts, but also different geographic and cultural contexts with different levels of capacity and ways of knowing (Figure 2.2).

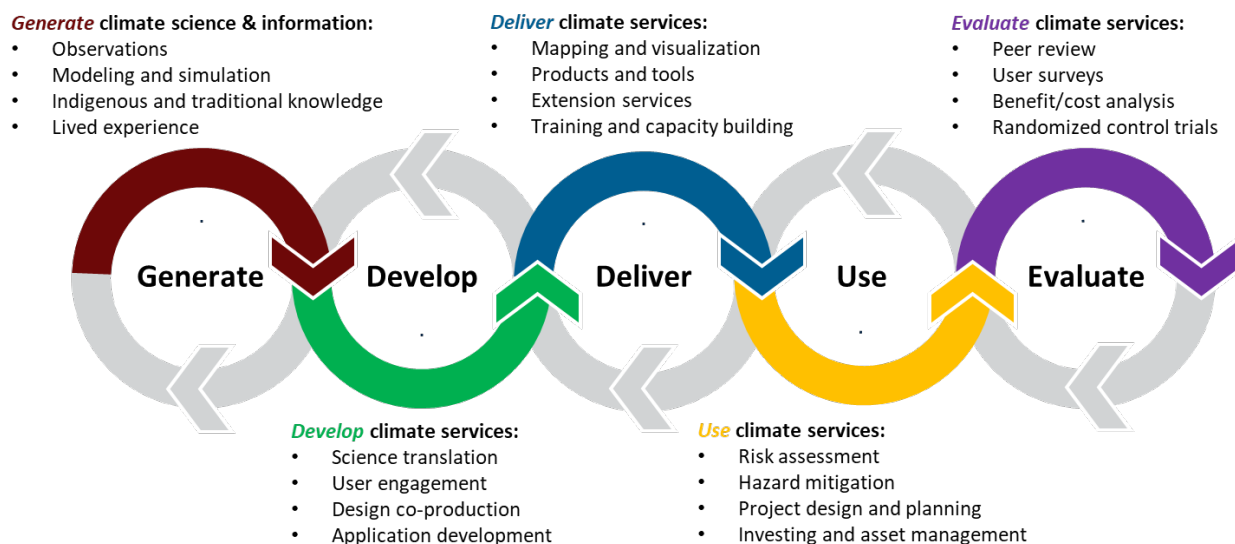


Figure 2.1. Core links in the knowledge value chain for climate services²⁶

The use of climate services should be evaluated on an ongoing basis to gauge their effectiveness in supporting needs. This evaluation should consider the credibility of the information being delivered, the user experience in engaging with that information, and the extent to which the information is able to address the needs of users and enable them to take the next step in responding to climate change. A range of evaluation methods could be applied to climate services, ranging from eliciting feedback from users about their experiences²⁷ to randomized control trials that can provide a more unbiased assessment of service performance.²⁸

²⁶ Adapted from Vogel, C., Steynor, A., and Manyuchi, A. 2019. Climate services in Africa: Re-imagining an inclusive, robust and sustainable service. *Climate Services*, 15, 100107.

²⁷ NASA, NOAA, and OSTP, 2016. Climate data user study, results. 18F. <https://github.com/18F/climate-labs/blob/master/download/final-report-and-results.pdf>

²⁸ See Tall, A., Coulibaly, J. Y., and Diop, M., 2018. Do climate services make a difference? A review of evaluation methodologies and practices to assess the value of climate information services for farmers: Implications for Africa. *Climate Services*, 11, 1-12.

Urban and rural planning professionals	<ul style="list-style-type: none"> • Urban and regional planners • Hazard mitigation and disaster planners
Emergency managers	<ul style="list-style-type: none"> • First responders and incident managers • Hazard mitigation planners
Senior policy makers	<ul style="list-style-type: none"> • Public sector executives and legislators • Corporate officers and boards
Sector-specific practitioners	<ul style="list-style-type: none"> • Farmers, fishers, and aquaculturists • Energy system managers
Asset owners and operators	<ul style="list-style-type: none"> • Infrastructure owner • Pension fund operators
Researchers and analysts	<ul style="list-style-type: none"> • University research staff • Technical analysts in the public and private sectors
Legal practitioners	<ul style="list-style-type: none"> • Climate and environmental regulators • Civil litigators
Educators and science communicators	<ul style="list-style-type: none"> • Primary, secondary, tertiary educators • Science translators and communicators
Civil society and Indigenous people's organizations	<ul style="list-style-type: none"> • Tribal leaders and Indigenous organizations • Individual households

Figure 2.2. A typology of potential users of climate services and illustrative roles.

All these links in the knowledge value chain are supported by feedback loops that reflect on prior links and send observations and learning back throughout the chain. This feedback is achieved by engagement among producers who generate information, developers who translate it into products and services, and those involved in the downstream delivery, use, and evaluation of the services. In the absence of such engagement and feedback, climate services fall into the trap of the so-called 'linear model of expertise': science provides answers to policymakers who then make policy.²⁹ Effective climate services recognize that decision-making about climate is instead an ongoing, iterative, and dynamic process (Figure 2.1).

2.3 The Road Ahead: Using Climate Services to Address Climate Challenges

The preceding text provides a general overview of what climate services are, how they are developed and used, and by whom. The Federal Government encompasses diverse agencies with diverse missions.

²⁹ Beck, S. 2011. Moving beyond the linear model of expertise? IPCC and the test of adaptation. *Regional Environmental Change*, 11, 297-306.

Therefore, a common understanding of climate services that works across the Federal Government is needed. This includes a vision for climate services, core operating principles for their development and use, and articulation of what is and is not within the scope of climate services.

2.3.1 Vision and Principles for Climate Services

Building a coherent approach to climate services across the Federal Government requires a common vision. The *Opportunities* report described that vision as follows:

“We envision a future in which every American, every community, and every business has access to usable climate services that empower them to prepare, respond, and be resilient to climate change.”³⁰

Rather than framing climate services as a purely scientific endeavor, the above language emphasizes the use of climate services as a means of empowering people to proactively manage, mitigate, and adapt to various climate related-hazards and risks. In addition, the emphasis on resilience includes the use of climate services in emergency management to help communities prepare for, respond to, and recover from disasters in a way that increases their climate resilience. While the vision is one articulated by the Federal Government, it is comprehensive in recognizing that all elements of American society have a potential need for climate information and a role to play in addressing the climate crisis.

In pursuing this vision, the *Opportunities* report identified four key principles that are consistent with best practices for climate services implementation. In its deliberations, the FTAC confirmed the relevance of each, and proposed clarifications to ensure the principles are robust to the mission of different agencies and the diversity of potential users:

- Foster sustained engagement with information users;
- Empower all individuals, communities, and organizations to anticipate, manage, and adapt to climate-related risks and opportunities;
- Strengthen federal and non-federal partnerships, including those with the private sector; and
- Continuously ground climate services in sound science.

These principles emphasize climate service delivery as an ongoing and iterative process that adapts in response to new scientific discoveries and the changing needs of users. Hence, a robust system of climate services seeks to balance the demand for climate information with the supply of information. Too much emphasis on efforts to meet immediate user needs can lead to services becoming disconnected from the underlying science and analytic capabilities that enable the delivery of credible information. However, too much emphasis on scientific advances can lead to services failing to be responsive to the needs of potential users.

A second report responding to EO 14008 Section 211d, *Advancing the Nation’s Geospatial Capabilities to Promote Federal, State, Local, and Tribal Climate Planning and Resilience* (hereafter the *Geospatial*

³⁰ Office of Science and Technology Policy, National Oceanic and Atmospheric Administration, and Federal Emergency Management Agency, 2021. *Opportunities for Expanding and Improving Climate Information and Services for the Public—A Report to the National Climate Task Force*. <https://downloads.globalchange.gov/reports/eo-14008-211-dreport.pdf>.

report), focused on the specific opportunities associated with improving the use of geospatial information for climate change assessment and action.³¹ Bolstering the digital infrastructure for hosting, analyzing, integrating, and sharing geospatial data is an important element of the Nation's climate services capabilities. Accordingly, in enhancing the Nation's climate services, consideration needs to be given to the existing data management infrastructure and capabilities and the opportunities that exist to boost these capabilities and develop common solutions that work across multiple agencies.

2.3.2 Desired Outcomes for Climate Services

An ambitious, coordinated, whole-of-government approach to climate services can help achieve a range of positive outcomes for the Nation. For example, analyses of the National Weather Service have estimated that between three and six percent of the annual variability in U.S. GDP is attributable to weather, or \$700 billion to \$1.4 trillion using 2021 GDP values.^{32,33} Comparable estimates of the value of U.S. climate services, specifically, are lacking. However, the *Fourth National Climate Assessment* provided a comprehensive illustration of the diverse ways in which climate and climate change affect the Nation.³⁴ Improving the ability of users to anticipate these impacts, manage the risks, mitigate climate change and plan for the future will have far-reaching benefits.

Accordingly, the FTAC endeavored to specify how climate services can contribute to positive outcomes for the Nation. In so doing, the FTAC prioritized those outcomes that are a) consistent with large-scale challenges and opportunities for the Nation; b) reflect the diversity of missions, programs, and operations associated with the Federal Government; and c) are shared and thus relevant to multiple agencies. The seven outcomes identified by the FTAC span both the natural and built environments, incorporate different economic sectors, and acknowledge the importance of equity and inclusivity (Table 2.1). These seven outcomes could become the organizing elements for future efforts on climate services. Planned investments in climate services should be clearly linked back to one of these outcomes. For example, agriculture and food security can be mapped back to the outcomes "Nature is valued and protected" and "People's well-being and livelihoods are secure." As a result, these outcomes help to structure decision-making around climate services and the prioritization of investments.

³¹ Federal Geographic Data Committee, 2021. Advancing the Nation's geospatial capabilities to promote Federal, State, local, and Tribal climate planning and resilience—A report to the National Climate Task Force: Federal Geographic Data Committee, 10 p., <https://www.fgdc.gov/resources/key-publications/2021-climate-mapping-report>.

³² Lazo, J. K., Lawson, M., Larsen, P. H., & Waldman, D. M. (2011). U.S. Economic Sensitivity to Weather Variability, *Bulletin of the American Meteorological Society*, 92(6), 709-720. Retrieved Jan 20, 2023, from https://journals.ametsoc.org/view/journals/bams/92/6/2011bams2928_1.xml

³³ NWS (2017) National Weather Service Enterprise Analysis Report https://www.weather.gov/media/about/Final_NWS%20Enterprise%20Analysis%20Report_June%202017.pdf

³⁴ USGCRP, 2018. Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018.

Table 2.1. The contributions of climate services to realizing positive outcomes for the Nation.

Desired Outcome	Contributions of Climate Services
Climate is stable	<ul style="list-style-type: none"> ● Developing indicators of global change and monitoring critical thresholds ● Analyzing opportunities and monitoring progress in climate mitigation
Nature is valued and protected	<ul style="list-style-type: none"> ● Guiding the planning and implementation of ecosystem conservation, preservation, and restoration projects ● Assessing and managing risks of climate change to ecosystems and their services
People’s well-being and livelihoods are secure	<ul style="list-style-type: none"> ● Assessing health-related risks of climate change ● Analyzing opportunities for enhancing food, water, and energy security and reliability ● Integrating Indigenous, traditional, and local knowledge into planning and decision-making for climate risk management
Infrastructure is resilient and sustainable	<ul style="list-style-type: none"> ● Developing climate adaptation guidance for infrastructure siting, design, and operations ● Assessing climate-related infrastructure vulnerabilities, including to future change
The economy creates prosperity and growth	<ul style="list-style-type: none"> ● Assessing climate-related financial opportunities and risks ● Informing climate entrepreneurship and innovation opportunities ● Anticipating future workforce needs
Homeland and national security are strengthened	<ul style="list-style-type: none"> ● Assessing risks of climate change to critical infrastructure ● Anticipating human migration in response to climate change ● Developing early warning systems for environmental threats to human and national security
Communities are just and equitable	<ul style="list-style-type: none"> ● Identifying geographic and demographic disparities in exposure to climate pollutants and hazards ● Planning interventions to mitigate flood and extreme heat risk

2.3.3 Expanding the Scope of Climate Services

Based on the vision and principles outlined above and the feedback from external stakeholders from the listening sessions, the FTAC identified several aspects regarding the scope of federal climate services that merit clarification in the development of a common federal understanding. These include the following:

- First, the *Opportunities* report appropriately emphasized the importance of addressing high-priority, acute climate hazards that are responsible for significant economic losses as well as impacts on human health and safety. Efforts should continue to prioritize such acute hazards and their changes over time. Nevertheless, it is also important to **advance climate services for chronic threats**. For example, communities and ecosystems are affected by acute disruptions, such as wildfire and extreme heat, but also by chronic sea-level rise, ocean acidification, and shifts in average temperature and precipitation.
- Second, while climate services are often defined narrowly as the provision of information about the climate itself, **consideration should also be given to the drivers of climate change**. This includes greenhouse gas emissions and the sources, status, and trends associated with those emissions as an element of climate services. For example, greenhouse gas information from the U.S. Environmental Protection Agency (EPA), the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), the National Institute of

Standards and Technology (NIST), or the Department of Energy's (DOE) Energy Information Agency all represent forms of climate services oriented toward greenhouse gas information.³⁵

- Third, **climate services complement weather services**. The NOAA National Weather Service, for example, has a long history of successfully providing both weather and climate information to users. Those efforts ultimately are foundational to understanding, modeling, and predicting climate and climate change. However, weather services tend to focus on shorter time scales, ranging from hours to seasons, whereas climate services focus on longer time scales, from years to decades. The two vary in terms of scientific methods, sources and magnitude of uncertainties, and the types of decision contexts for which they are used. Depending on the decision, however, users, may need seamless access to both, and thus the two should be integrated as much as possible.
- Fourth, **decision-makers need information on how to manage risks and capitalize on opportunities** through investments in climate resilience and climate mitigation services. Climate resilience services include those that support preparedness, response, recovery and adaptation to acute and chronic climate hazards. Meanwhile, climate mitigation services include those that support reductions in the rate and magnitude of climate change, largely through greenhouse gas emissions. Hence, information and services that can support users in assessing the costs, benefits, effectiveness, and feasibility of different risk management options, as well as strategies for building back better in the wake of disasters, can be helpful for decision-makers attempting to decide how best to address the climate crisis in their own context.
- Fifth, **user engagement, technical assistance, and capacity building are critical elements of climate services**. Improving the availability of, and access to, information on climate change, its consequences, and potential response options may generate limited benefits for communities if they are not adequately empowered to use that information or do not understand or trust it. Users need trusted allies they can work with to increase their understanding of climate information and its relevance to their own challenges and aspirations. For example, agencies can follow the recent White House guidance on the use of Indigenous Knowledge as they work with Tribal communities in developing climate services.³⁶ In addition, responding to information about climate variability and change necessitates practitioners having the resources to implement projects and programs, and those resources are often lacking, particularly in disadvantaged communities. Climate services should include consideration for how to support users in identifying and accessing programs that can fund the implementation of climate action.
- Sixth, maximizing the value of climate services may necessitate **users having access to a broad range of non-climatic information, data, and tools**. Understanding the risks of sea-level rise, for

³⁵ The Biden-Harris Administration recently released for public comment a draft *Federal Strategy to Advance an Integrated U.S. Greenhouse Gas Monitoring & Information System* that focuses on strategies for enhancing greenhouse gas data and information.

³⁶ Executive Office of the President, 2022. Guidance for Federal Departments and Agencies on Indigenous Knowledge. Office of Science and Technology Policy and Council on Environmental Quality, Washington, DC. See <https://www.whitehouse.gov/wp-content/uploads/2022/12/OSTP-CEQ-IK-Guidance.pdf>

example, may require information on coastal elevation and the location of infrastructure assets and their vulnerability and economic value. Particularly at the local level, the Federal Government may be limited in the comprehensiveness and quality of its non-climatic information. Therefore, the co-production of services with local partners who can bring such data to the table may be necessary. Additionally, designing services so that users can integrate their own information with that of the Federal Government may be an effective strategy.

2.4 Recent Progress on the Development and Use of Federal Climate Services

The Biden-Harris Administration has made significant progress on climate action. Some of these accomplishments include the following:

- developing federal agency adaptation plans;³⁷
- creating the National Climate Task Force’s Interagency Working Groups, which have focused on advancing understanding of high-priority climate hazards (extreme heat, drought, flood, coastal flooding, and wildfire);³⁸
- forming a Climate Smart Infrastructure Working Group to support implementation of federal investments under the Bipartisan Infrastructure Law and the Inflation Reduction Act;³⁹
- enhancing data and information regarding greenhouse gas emissions;⁴⁰
- advancing climate mitigation technologies, for example through the Inflation Reduction Act and the Administration’s Net-Zero Game Changers Initiative;^{41,42}
- implementing the Federal Flood Risk Management Standard to enable more forward-looking consideration of flood risk;⁴³

³⁷ Executive Office of the President, 2021. Annual Adaptation Plans. Council on Environmental Quality, Washington, DC. See <https://www.sustainability.gov/progress.html>

³⁸ Executive Office of the President, 2021. National Climate Task Force. See <https://www.whitehouse.gov/climate/>

³⁹ Executive Office of the President, 2022. Readout of the March National Climate Task Force Meeting. See <https://www.whitehouse.gov/briefing-room/statements-releases/2022/03/15/readout-of-the-march-national-climate-task-force-meeting/>

⁴⁰ Executive Office of the President, 2022. Fact Sheet: Biden Administration Tackles Super-Polluting Methane Emissions. See <https://www.whitehouse.gov/briefing-room/statements-releases/2022/01/31/fact-sheet-biden-administration-tackles-super-polluting-methane-emissions/>

⁴¹ Executive Office of the President, 2022. Fact Sheet: Biden-Harris Administration Makes Historic Investment in America’s National Labs, Announces Net-Zero Game Changers Initiative. <https://www.whitehouse.gov/briefing-room/statements-releases/2022/11/04/fact-sheet-biden-harris-administration-makes-historic-investment-in-americas-national-labs-announces-net-zero-game-changers-initiative/>

⁴² Executive Office of the President, 2022. U.S. Innovation to Meet 2050 Climate Goals. Assessing Initial R&D Opportunities. <https://www.whitehouse.gov/wp-content/uploads/2022/11/U.S.-Innovation-to-Meet-2050-Climate-Goals.pdf>

⁴³ Executive Office of the President, 2021. Readout of the First White House Flood Resilience Interagency Working Group Meeting on Implementation of the Federal Flood Risk Management Standard. <https://www.whitehouse.gov/ceq/news-updates/2021/08/27/readout-of-the-first-white-house-flood-resilience-interagency-working-group-meeting-on-implementation-of-the-federal-flood-risk-management-standard/>

- launching a national initiative to advance building codes to help SLTT governments improve climate resilience and reduce energy costs;⁴⁴
- incentivizing climate change financial risk disclosure and assessing the impacts of climate change on the federal budget;⁴⁵
- establishing an interagency working group on climate change and migration to coordinate U.S. Government efforts to respond to migration associated with climate change and its consequences;⁴⁶
- investing in resilience in disadvantaged communities;⁴⁷
- enhancing the integration of Indigenous and traditional knowledge⁴⁸ and citizen science⁴⁹ into planning and decision making.

Through these efforts, the Federal Government has documented the diversity of needs that exist with respect to climate services.

3 Opportunities and Challenges for Climate Services

The timely provision of climate services is fundamental to enabling society to successfully manage climate risk, take advantage of opportunities, and plan for the future. This endeavor necessitates a robust understanding of the Earth system through science spanning observations, modeling, and projections, and advances in global change research, but also requires that knowledge and information about climate be delivered in ways that are credible, accessible, relevant, and legitimate such that they can be applied with confidence in planning, investment, and decision-making. The process of producing actionable information has long been recognized as a grand challenge that spans science (including the social sciences), policy, and practice. It necessitates placing users at the center of efforts to design climate services so that climate information can be viewed within the context that users find themselves. While a number of long-standing barriers exist to the seamless and comprehensive delivery of useful and useable information to users at different scales and in different sectors, a range of ongoing

⁴⁴ Executive Office of the President, 2022. Fact Sheet: Biden-Harris Administration Launches Initiative to Modernize Building Codes, Improve Climate Resilience, and Reduce Energy Costs. <https://www.whitehouse.gov/briefing-room/statements-releases/2022/06/01/fact-sheet-biden-harris-administration-launches-initiative-to-modernize-building-codes-improve-climate-resilience-and-reduce-energy-costs/>

⁴⁵ Executive Office of the President, 2021. Executive Order on Climate-Related Financial Risk. <https://www.whitehouse.gov/briefing-room/presidential-actions/2021/05/20/executive-order-on-climate-related-financial-risk/>

⁴⁶ Executive Office of the President, 2021. Fact Sheet: Prioritizing Climate in Foreign Policy and National Security. <https://www.whitehouse.gov/briefing-room/statements-releases/2021/10/21/fact-sheet-prioritizing-climate-in-foreign-policy-and-national-security/>

⁴⁷ Executive Office of the President, 2021. Justice 40: A Whole of Government Initiative. <https://www.whitehouse.gov/environmentaljustice/justice40/>

⁴⁸ Executive Office of the President, 2022. Guidance for Federal Departments and Agencies on Indigenous Knowledge. Office of Science and Technology Policy and Council on Environmental Quality, Washington, DC. See <https://www.whitehouse.gov/ceq/news-updates/2022/12/01/white-house-releases-first-of-a-kind-indigenous-knowledge-guidance-for-federal-agencies/>

⁴⁹ Public Law 15 USC 3724, January 6, 2017, .Crowdsourcing and Citizen Science Act of 2016. <https://www.govinfo.gov/content/pkg/USCODE-2016-title15/pdf/USCODE-2016-title15-chap63-sec3724.pdf>

and more recent developments have created new opportunities for advancing climate services. Each of these are discussed further below, organized around core themes.

3.1 Opportunities

3.1.1 Science Policy

The United States government has long been a source of information on climate change, its consequences, and responses, with much of the mandate for global change science activities grounded in the GCRA (see Section 2). Implementation of the GCRA and subsequent climate-related policies have led to a growing body of federal data and products on climate and climate change. In the Biden-Harris Administration, EO 14008 significantly expanded the Federal Government's responsibilities to account for climate change in federal decision-making while also increasing demand for climate services by directing federal agencies to consider climate change in infrastructure investments. EO 14008 is complemented by a range of other federal policy initiatives including an emphasis on greater uptake of nature-based solutions in environmental management (EO 14072),⁵⁰ the pursuit of less carbon-intensive procurement and supply chains (EO 14057),⁵¹ and investments in climate-resilient infrastructure (3.1.2).

As federal agencies implement agency adaptation plans that are required through EO 14008, they have been developing different climate service capabilities in order to advance climate action within and external to the Federal Government. Moreover, the increased attention placed on the needs of the Nation's most vulnerable communities and environmental justice by the Administration has mobilized climate resilience planning at the local level, including consideration for the causes and consequences of climate vulnerability. Making federal climate change efforts more inclusive and empowering action at the local level are important elements of addressing environmental inequities and supporting historically disadvantaged communities.

3.1.2 Infrastructure and Resilience Investments

Congressional appropriations for the Bipartisan Infrastructure Law (BIL) and the Inflation Reduction Act (IRA) provided historical amounts of funding for addressing climate change. This legislation, in combination with Executive Orders 14008 and 14052,⁵² which direct federal agencies to prioritize climate resilience in federal-funded infrastructure projects, calls for Federal investments in infrastructure to be resilient to future climate conditions. The application of climate services has a role to play in ensuring those investments are made appropriately.

In addition to data and products, BIL represents investments in human capital by providing funding for training and professional development of the federal workforce. This is creating opportunities for a large

⁵⁰ Executive Office of the President, 2022. Executive Order on Strengthening the Nation's Forests, Communities, and Local Economies, <https://www.whitehouse.gov/briefing-room/presidential-actions/2022/04/22/executive-order-on-strengthening-the-nations-forests-communities-and-local-economies/>

⁵¹ Executive Office of the President, 2021. Executive Order on Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability, <https://www.whitehouse.gov/briefing-room/presidential-actions/2021/12/08/executive-order-on-catalyzing-clean-energy-industries-and-jobs-through-federal-sustainability/>

⁵² Executive Office of the President, 2022. Executive Order on the Implementation of the Energy and Infrastructure Provisions of the Inflation Reduction Act of 2022. <https://www.whitehouse.gov/briefing-room/presidential-actions/2022/09/12/executive-order-on-the-implementation-of-the-energy-and-infrastructure-provisions-of-the-inflation-reduction-act-of-2022/>

cohort of federal employees to better integrate climate change into their programs and projects. In so doing, however, they may draw upon existing federal data and tools, but may also identify gaps in those capabilities that necessitate future investments in science, science translation, and product development.

BIL and IRA are complemented by the Justice40 initiative,⁵³ which sets a goal that 40 percent of the overall benefits of certain federal investments flow to disadvantaged communities. Justice40 thereby creates opportunities for greater flow of benefits from climate services to those communities most in need of support for managing the risks posed by climate change.

3.1.3 Technology

The past decade of technological advances has increased the opportunities for efficiently developing useful climate services. In particular, advances in data analytics, including techniques such as machine learning, automated decision-making algorithms, and network science are increasingly enhancing the ability to collect, clean, analyze, and visualize data. Such tools have seen use in addressing other scientific and societal challenges ranging from COVID-19 response (e.g., supply chain resilience), to cybersecurity (e.g., tracking the vulnerabilities of systems exposed to emerging threats), to tracking societal opinions, norms, and values (e.g., analysis of social media data). For these and other challenges, the ability to translate complex scientific questions into results that the public can understand with little training is a necessity. For climate services, data analytics can reduce the barriers to rapidly exploring output from a range of climate models or evaluating relationships between climate variables and potential social or economic impacts (e.g., the relationship between extreme temperatures and health outcomes at the local level). Enhancing the power and usability of such analytic tools will allow practitioners of climate services to continuously improve those services and more effectively communicate results.

In addition to general advances in data analytics, the growing power of geospatial capabilities creates opportunities for more streamlined sharing of data and for providing data analytics at a user's fingertips. This enables users to spend less time searching for, downloading, and manipulating data and more time conducting analyses that suit their needs. The maturation of cloud computing resources are also improving data discoverability, accessibility, and usability and enabling climate service providers. For example, NASA is investing in moving Earth observation datasets to the cloud to enhance access to a wide range of users. Moreover, increasing interoperability among data and software platforms creates opportunities for leveraging common architectures that can be applied in the creation of diverse tools that cater to different users. This includes capabilities that allow users to access, visualize, and analyze federal information alongside of their own data via application programming interfaces (APIs) and geospatial data hubs. The federal GeoPlatform, for example, which was featured in the Section 211d *Geospatial* report provides applications and tools for accessing, integrating, synthesizing, analyzing, and visualizing geospatial data. Such shared resources can enhance interoperability and internal consistency among federal datasets and analytic tools, while reducing the costs of developing and delivering new services.

⁵³ Executive Office of the President, 2021. Justice 40: A Whole of Government Initiative.
<https://www.whitehouse.gov/environmentaljustice/justice40/>

3.1.4 Regional Engagement

A major feature of the Federal Government's efforts to deliver climate services is through the use of regional applied science and service organizations that work with stakeholders to build understanding around information needs and then work to co-produce information that meets those needs. These include NOAA's Climate Adaptation Partnerships (CAPs; formerly Regional Integrated Sciences and Assessments), the Climate Adaptation Science Centers (CASCs; DOI entities operated by USGS), and USDA's Climate Hubs. Efforts are underway to extend such programs, such as the Climate Adaptation Partnerships, into regions that have not been previously covered and enhance integration within and across these various programs.

Continued investment in regional organizations, and exploration of their implementation to support other agency missions, could enhance science translation that helps to bridge from federal data and capabilities to the implementation of solutions in specific locations. Similar efforts are being pursued under NOAA's Climate Smart Communities Initiative, which focuses on adaptation planning at the community level. Other proposed concepts such as the Civilian Climate Corps⁵⁴ and the Climate Grant Universities,⁵⁵ could similarly bring additional human capital and capabilities together to help facilitate on-the-ground climate action.

In addition, several agencies, including the Department of Health and Human Services (HHS), FEMA, Government Services Administration (GSA), U.S. Army Corps of Engineers (USACE), and EPA have regional offices to facilitate engagement at the state, Tribal, and local levels including actions supported by BIL and IRA resources (Section 3.1.2). Increasingly, that engagement involves providing services ranging from information on climate change impacts to guidance on approaches to mitigating and adapting to those impacts in the context of each agency's mission.

3.1.5 Growth of the Non-Federal Climate Services Community

Some of the most significant opportunities for advancing the Nation's climate services are associated with developments outside of the Federal Government. Recent years have witnessed significant growth in the provision of various types of climate services by a broad range of actors, including universities, non-governmental organizations (NGOs), as well as the private sector, such as consulting firms and specialist climate analytics companies. These actors are catering to different users and markets and in so doing are meeting the needs of different classes of users. In addition, SLTT governments are increasingly investing in their own climate service capabilities to support climate action at the regional, state, and local level. For example, California has long supported the CalAdapt system,⁵⁶ the City of New York has its own climate assessment body, the New York City Panel on Climate Change,⁵⁷ and various states maintain climate centers that are affiliated with NOAA's Regional Climate Centers.⁵⁸ While such efforts

⁵⁴ U.S. Senate, 2021. S.1244 - Civilian Climate Corps for Jobs and Justice Act. <https://www.congress.gov/bill/117th-congress/senate-bill/1244>

⁵⁵ Kopp, R.E., 2021. Climate Grant Universities Could Mobilize Community Climate Action. Eos, American geophysical Union, 6 May, 2021. <https://eos.org/opinions/climate-grant-universities-could-mobilize-community-climate-action>

⁵⁶ University of California, Berkeley, Cal-Adapt <https://cal-adapt.org/>

⁵⁷ New York City Panel on Climate Change, 2019. New York City Panel on Climate Change 2019 Report Executive Summary. Annals of the New York Academy of Science, 1439, 11-21. <https://doi.org/10.1111/nyas.14008>

⁵⁸ National Centers for Environmental Information, Regional Climate Centers <https://www.ncei.noaa.gov/regional/regional-climate-centers>

are led by non-federal actors, they often have critical links to federal agencies. The vast majority of non-federal actors working with projections of future climate, for example, are pulling foundational data from the same database of Earth System Model simulations. That database is supported by federal investment and hosts data from U.S. modeling centers. Some organizations are funded directly by federal agencies in the form of contracts for services, cooperative agreements, or grants.

3.2 Challenges

3.2.1 Limits of Scientific Knowledge

One constraint in the ability to provide useful data and products to decision-makers is limits in scientific understanding regarding aspects of future climate change of interest to users. One relevant challenge is in the modeling and prediction of extreme weather events.⁵⁹ Earth system modeling and downscaling techniques, for example, continue to advance rapidly in concert with computational and data analytic capabilities. Yet, scientific challenges remain in modeling future extreme weather events (such as flooding, tropical cyclones, or wildfire) that are responsible for the largest economic losses, as well as translating those results into usable information. As a result, advancing the science regarding the detection, attribution, and prediction of such extreme events is a priority for global change research.⁶⁰ Moreover, participants in the stakeholder listening sessions emphasized the importance of not only advancing the science, but also enhancing the ability to effectively use that science in decision-making. For example, challenges exist regarding data interoperability among available climate data services. Nevertheless, uncertainties associated with the modeling of extreme weather events do not have to stand in the way of practitioners acting.

The scientific challenges associated with providing useful climate information are not limited to the physical sciences regarding climate change or climate-related hazards. The type of knowledge and information people seek and how they access and use that information have important behavioral, societal, economic, and cultural dimensions. For example, scientific methods to link global climate models to local climate projections are critically needed for future building codes and standards. The ability to effectively engage different communities of users of climate services and the development of services that speak to their challenges and priorities requires expertise in social sciences, experience in user engagement, as well as trusted relationships with communities. In addition to informing climate service delivery, research on the interaction between climate impacts and human behavior, economics, and social or cultural dimensions are needed to improve the climate services themselves. The practice of knowledge co-production is increasingly viewed as an effective approach for developing and delivering climate information that is useful and useable.⁶¹ Nevertheless, like other approaches and tools, the

⁵⁹ NSTC, 2020. Earth System Predictability Research and Development Strategic Framework and Roadmap. Fast Track Action Committee on Earth System Predictability Research and Development, National Science and Technology Council. https://www.icams-portal.gov/organization/researchandinnovation/esp_randd_strategic_framework_roadmap.pdf

⁶⁰ USGCRP, 2022. The U.S. Global Change Research Program 2022–2031 Strategic Plan. U.S. Global Change Research Program, Washington, DC, USA. <https://www.doi.org/10.7930/usgcrp-2022-2031-strategic-plan>

⁶¹ Mach, K.J., Lemos, M.C., Meadow, A.M., Wyborn, C., Klenk, N., Arnott, J.C., Ardoin, N.M., Fieseler, C., Moss, R.H., Nichols, L. and Stults, M., 2020. Actionable knowledge and the art of engagement. *Current Opinion in Environmental Sustainability*, 42, pp. 30-37.

appropriate use of co-production requires understanding those contexts in which co-production works and those where other methods may be more effective.⁶²

3.2.2 Alignment to User Needs

The Federal Government has generated a number of climate change datasets, products, and tools that have become indispensable to the management of climate change risk. Examples include the U.S. Climate Resilience Toolkit,⁶³ the National Climate Assessment⁶⁴, the Sea Level Rise Portal,⁶⁵ as well as a range of products that have been developed by SLTT governments, non-profit organizations, and the private sector. Nevertheless, a number of factors often limit the ability of such data and tools to complete the “last mile” of decision-support. These include spatial or temporal scales that are limited by scientific factors and less useful to users, the need for derived variables not directly generated by climate models, or lack of capacity of users to understand and use information effectively. In particular, significant user knowledge is needed regarding the contemporary modeling paradigm that generates climate projections – from modeling centers, to scenarios, to downscaling – in order to effectively access and appropriately use many of the climate data and products available.

Insufficient attention has been given to the experiences of users in engaging with the wealth of data and tools that currently exist and their struggles in finding the right information for their needs.⁶⁶ This is exacerbated by the differential needs of practitioners operating in different sectors that need climate information integrated with local, sector-specific data and management practices. Building trusted relationships between information providers and information users on the ground is time- and labor-intensive, but this is often the most effective way to support decision-making. This approach is illustrated by various regional organizations and programs (see 3.1.4).^{67,68} Opportunities exist to build on these and other regional programs. One is to explore the value of expanding the use of such regional approaches to better link federal investment to local challenges. Another is to enhance coordination among existing regional entities, as well as between regional organizations and other federal agencies, to ensure the services developed adequately support stakeholder needs and obligations with respect to other agencies.

3.2.3 Governance

With climate change being fundamental to diverse social, economic, and environmental outcomes, climate services need to be distributed and flexible, building on the capabilities that exist across federal agencies and partners to enable diverse users to find value in the services that are generated. At present, multiple federal agencies operate different climate services at both national and regional scales

⁶² Lemos, M.C., Arnott, J.C., Ardoin, N.M., Baja, K., Bednarek, A.T., Dewulf, A., Fieseler, C., Goodrich, K.A., Jagannathan, K., Klenk, N. and Mach, K.J., 2018. To co-produce or not to co-produce. *Nature Sustainability*, 1(12), pp.722-724

⁶³ NOAA, Climate Resilience Toolkit, <https://toolkit.climate.gov/>

⁶⁴ USGCRP, 2018 Fourth National Climate Assessment. <https://nca2018.globalchange.gov/>

⁶⁵ NASA, Sea Level Change Portal, <https://sealevel.nasa.gov/>

⁶⁶ NASA, NOAA, and OSTP, 2016. Climate data user study, results. 18F. <https://github.com/18F/climate-labs/blob/master/download/final-report-and-results.pdf>

⁶⁷ U.S. Army Corps of Engineers, 2021. U.S. Army Corps of Engineers Climate Action Plan, <https://www.sustainability.gov/pdfs/usace-2021-cap.pdf>

⁶⁸ U.S. Environmental Protection Agency, 2021. Climate Adaptation Plans, <https://www.epa.gov/climate-adaptation/climate-adaptation-plans>

for accessing climate information. This diversity is an adaptive solution to addressing the many needs of diverse users, which may influence the choice of dataset or the design of a product or tool. For example, users may be directed to use a particular federal dataset or tool in applying for federal funding or as part of maintaining regulatory compliance. However, in such instances where funding, compliance, and decision-making are directly tied to climate services, inconsistencies in the information available to users across the Federal Government can be problematic, because it creates confusion regarding the credibility of the information and what source of information should be used. More problematic are the gaps in elements of the climate service value chain (e.g. gaps in data) that users need.

Federal agencies can, and frequently do, collaborate in the development and dissemination of climate data and products, but the Federal Government lacks an organizational structure for tracking federal investments in service development and delivery, or harnessing the respective capabilities of different agencies to deliver high-priority services. Moreover, many of the decision-making challenges exist at the local level, making coordination with federal, state, local, Tribal, and territorial governments, non-governmental organizations, academic institutions, and the private sector critical. Federal agencies have extensive stakeholder networks outside of the Federal Government that they routinely work with, but clear guidance is lacking regarding how the Federal Government should engage with this critical external community.

3.2.4 Funding for Climate Services

Climate services investments are critical for the delivery of usable scientific information, the identification of knowledge gaps in user communities, and to inform future investments in fundamental science that are inspired by user feedback. To date, USGCRP has prioritized developing a robust understanding of the Earth system and global change processes as a means of elucidating the problem facing the Nation and the world.⁶⁹ Advancements in foundational and applied global change research continue to be needed, now and into the future. In addition, because many users of federal science outputs are seeking to implement solutions, focusing on climate services is essential. For example, the USGCRP *2022-2031 Strategic Plan* emphasizes the importance of pursuing science that engages decision-makers and informs decision-making,⁷⁰ suggesting broad interagency awareness of the changing expectations of users and the need for agencies to invest in engagement and service delivery. However, the *2022-2031 Strategic Plan* did not identify requisite capabilities or specific agency actions needed to meet those expectations.

Users of Federal Climate Services have had multiple opportunities in recent years to identify gaps in climate services that undermine their ability to respond to climate change. For example, a 2016 report from NASA, NOAA, and OSTP on users of climate data reported that users perceived federal data to be

⁶⁹ USGCRP's annual *Our Changing Planet* report responds to the Global Change Research Act mandate to provide an overview of the Program's progress in delivering on its strategic goals as well as a summary of agency expenditures under USGCRP's budget crosscut. The report provides budget allocations by agency, but has not routinely provided a break-down of funding by research priorities or research topic. The FY2010 report included \$151 million (6% of USGCRP's total budget) allocated to activities to "Explore the uses and identify the limits of evolving knowledge to manage risks and opportunities related to climate variability and change." In comparison, \$421 million was allocated to other research and \$887 million to observations.

⁷⁰ USGCRP, 2022. The U.S. Global Change Research Program 2022–2031 Strategic Plan. U.S. Global Change Research Program, Washington, DC, USA. <https://www.doi.org/10.7930/usgcrp-2022-2031-strategic-plan>

inconsistently maintained, hard to use, and scattered and difficult to find. Furthermore, federal data and tools often lack the necessary science translation and connection to local context that users often need.⁷¹ Listening sessions conducted by the FTAC with non-federal participants echoed these challenges and also raised the importance of helping users with accessing federal funding to respond to climate change. Moreover, services that build capacity among users to understand the local implications of climate change and plan responses may be more beneficial than those that simply provide data and information about climate.

The BIL and IRA provide historic levels of funding to expand and diversify existing personnel and infrastructure in support of climate services. This includes support for fundamental science as well as the science translation needed to take knowledge about climate change and potential response options and turn it into insights that inform decision-making. Additional work is necessary to identify gaps in knowledge and capabilities for different regions, sectors, and ecosystems, as well as for different communities ranging from large urban areas, to rural and remote communities, as well as environmental justice communities on the front lines of climate change. The Administration will continue to leverage BIL, IRA, and other funding to support agency research programs addressing critical scientific uncertainties and to develop and deliver effective climate services that empower users to apply that science.

4 Improving Our Approach to Climate Services

Implementing the vision and scope outlined in Section 2 and addressing the challenges and opportunities discussed in Section 3 necessitate developing a whole-of-government approach to climate services.⁷² This section outlines an approach for scaling climate services to meet demand as well as a high-level operational framework for organizing the Federal Government's climate services enterprise.

4.1 Scaling Federal Climate Services

Three decades of analysis and recommendations by the NASEM,^{73,74} GAO,⁷⁵ and Congress^{76,77} have consistently highlighted the need for, and potential value of, developing a more coherent national strategy and framework for effective production and delivery of climate services. In addition, the listening sessions conducted with external stakeholders and experts under the auspices of the FTAC

⁷¹ NASA, NOAA, OSTP, 2016. Climate data user study, results. 18F. <https://github.com/18F/climate-labs/blob/master/download/final-report-and-results.pdf>

⁷² Office of Science and Technology Policy, National Oceanic and Atmospheric Administration, and Federal Emergency Management Agency, 2021. Opportunities for Expanding and Improving Climate Information and Services for the Public—A Report to the National Climate Task Force. <https://downloads.globalchange.gov/reports/eo-14008-211-dreport.pdf>.

⁷³ NASEM, 2001. A climate services vision: First steps toward the future. <https://www.nap.edu/catalog/10198/a-climate-services-vision-first-steps-toward-the-future>

⁷⁴ NASEM, 2010. Informing an Effective Response to Climate Change. <https://www.nap.edu/catalog/12784/informing-an-effective-response-to-climate-change>

⁷⁵ GAO, 2015. Climate Information: A National System Could Help Federal, State, Local, and Private Sector Decision Makers Use Climate Information, GAO-16-37, Washington, DC. <https://www.gao.gov/products/gao-16-37>

⁷⁶ U.S. Senate (2001) S.1716 - Global Climate Change Act of 2001, <https://www.congress.gov/bill/107th-congress/senate-bill/1716/text>

⁷⁷ U.S. Senate, 2007. S.2307 - Global Change Research Improvement Act of 2007. <https://www.congress.gov/bill/110th-congress/senate-bill/2307/text>

delivered a clear message of the importance of consistent, sustainable, federal leadership for advancing climate services.

The push for climate action within the Biden-Harris Administration, combined with the Federal Government's investments in science, infrastructure, resilience, and workforce through BIL and IRA, have created a window-of-opportunity for improving and expanding the Federal Government's climate services (Section 3.1.2). In capitalizing on that window, however, the Federal Government must do more than simply recognize the value of climate services. Rather, it must catalyze greater commitment to, investment in, and coordination of climate services. Furthermore, it must drive changes in how the Federal Government values, develops, and uses climate services, including how different elements of the government work together to achieve success. There are ample cases of climate service practices across the Federal Government that offer models for the kinds of processes and practices needed to advance the enterprise. What is urgently needed, however, is the capacity to scale the Nation's climate services to keep up with growing demand and make them more efficient and effective (Figure 4.1).^{78,79}

To do this, the Federal Government needs to achieve two goals. First, it needs to scale up by building a stronger institutional foundation for the governance of climate services. This includes a more formalized approach to managing federal climate services with clearer agency roles and mechanisms to coordinate, identify whole-of-government priorities, track resources, assess efficacy of service delivery, and evaluate the return on investment. This will enhance the visibility of climate services and the recognition of the role of climate services as an enabling condition for achieving sustained resilience to a changing climate, as well as greenhouse gas mitigation objectives. It will also provide clarity regarding the resources needed to operate a comprehensive and effective system of credible services. The institutionalization and strategic coordination of federal climate services will ultimately benefit all agencies by helping them more effectively deliver on their respective missions.

Second, the Federal Government can scale out climate services by expanding the communities of users it serves and improving the services it provides. By developing new partners, the Federal Government can contribute to a richer system of national and global climate services that enables action on climate change. This could include replicating successful climate service programs in new areas or expanding the capacity of existing programs to reach a larger number of people. Opportunities also exist for diversifying the forms of knowledge integrated into climate services, such as expanding the use of Indigenous knowledge as well as traditional and local knowledge, in climate services. Ultimately, the Federal Government should strive to build a stronger network and community of practice that drives knowledge sharing and sustained refinement of climate services over time.

⁷⁸ Etzion, D., 2018. Management for sustainability. *Nature Sustainability* 1, 744–749. <https://doi.org/10.1038/s41893-018-0184-z>

⁷⁹ Lam, D.P.M., Martín-López, B., Wiek, A. et al., 2020. Scaling the impact of sustainability initiatives: a typology of amplification processes. *Urban Transformation* 2, 3. <https://doi.org/10.1186/s42854-020-00007-9>

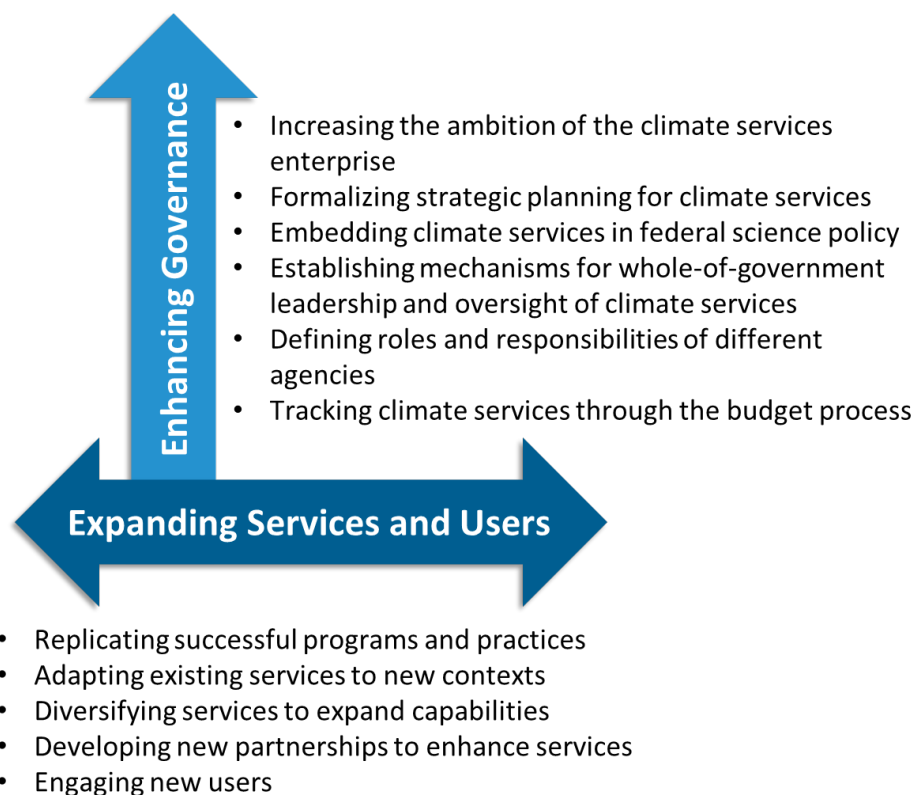


Figure 4.1. Processes associated with the scaling of federal climate services.

Through these efforts, the Federal Government can develop a more ambitious and effective climate services enterprise that helps move the Nation toward the outcomes discussed in Section 2 (Table 2.1). However, scaling the Federal Government’s climate services to achieve these outcomes necessitates not only increasing the collective ambition of agencies, but also developing an institutional framework that a) enables that ambition to be effectively exercised within the day-to-day operations of the Federal Government and b) serves as an effective platform for directing resources to climate service development, delivery, and use. The remainder of this section therefore focuses on describing an operational framework for how agencies, individually and collectively, would advance climate services for the Nation.

4.2 A Coherent and Effective Operational Framework for Climate Services

Increasing the ambition and effectiveness of the Nation’s climate services necessitates integrating existing capabilities in climate and meteorological sciences into a coherent, whole-of-government framework that enables strategic planning, prioritization, and evaluation as well as engagement with the diverse community of federal and non-federal stakeholders. The development of such a framework is recognized around the world as a foundation for climate services. For example, the third World Climate Conference established the Global Framework for Climate Services (GFCS) in 2009 as a mechanism to “strengthen the production, availability, delivery and application of science-based climate prediction and

services.”⁸⁰ Moreover, the WMO has promoted the development of national frameworks for climate services as a means of translating the GFCS into practice. National frameworks support the implementation of climate services, including assessing climate vulnerabilities; identifying adaptation options; and helping to prepare, maintain, and communicate Nationally Determined Contributions (NDCs) under the United Nations Framework Convention on Climate Change.⁸¹

Building on the WMO’s endorsement of national frameworks, the following sections identify and discuss five core components of a U.S. framework for climate services that provide the structural foundation to advance a whole-of-government enterprise. These components include enhanced mechanisms for intra- and inter-agency coordination, enhanced partnerships with external organizations (domestic and international), and processes for eliciting ongoing external advice. Each of these components leverages existing institutions, programs, and relationships, but, in so doing, they shift climate services toward a more effective and impactful system of services.

4.2.1 Intra-agency Leadership and Coordination

Within a whole-of-government framework for climate services, individual agencies are the primary actors responsible for the development and delivery of climate services. This section therefore describes the importance of agencies to climate services and offers recommendations for how to bolster this component of a national framework.

For many types of federal climate services, individual agencies are often best-positioned to understand the information and service needs of their stakeholders, the pathways by which those needs can be met, and the existing capabilities within the agency to deliver and/or use those services (Box 4.1). Moreover, the budgeting process makes agencies the primary entity for identifying opportunities and challenges with respect to climate service development, delivery, and use. Agencies need the flexibility to determine how best to contribute to the Nation’s climate services in a manner consistent with their missions and capabilities.

Nevertheless, given growing demand on agencies to provide and/or use climate services to fulfill their missions and operate programs, there is a need for enhanced strategic planning and coordination within agencies to more effectively manage service development, delivery, and use. Therefore, agencies with a significant role in either the supply or application of climate services should establish, or identify an existing, **Climate Services Coordination (CSC)** capability. Specific responsibilities of agency CSCs could include the following:

- Facilitating continuous engagement with each agency’s stakeholders (federal and non-federal) regarding the supply and demand of the agency’s climate services
- Leading the development of an ambitious program of climate services that is responsive to stakeholder needs

⁸⁰ World Meteorological Organization, Global Framework for Climate Services, <https://www.gfcs-climate.org/>

⁸¹ World Meteorological Organization, National Frameworks for Climate Services, <https://gfcs.wmo.int/national-frameworks-for-climate-services>.

- Maintaining situational awareness regarding agency climate service capabilities, data, and products, as well as the programs and personnel associated with those capabilities
- Engaging other agencies and interagency coordinating bodies on climate service needs and priorities, as well as their development, delivery, and use
- Ensuring the agency implements best practices regarding the scientific integrity of its methods for climate services development and delivery
- Providing guidance and technical assistance within the agency on the effective use of climate services to support program and project implementation
- Tracking agency spending on climate services and evaluating the performance of climate services in supporting an agency's mission and goals to assess the return on investment
- Providing or acquiring training and professional development on climate change to agency personnel

Agency CSCs would be established by various means depending on the scope of the agency's mission and involvement in providing or using climate services, the expertise and capacity available within the agency, and the existing agency organizational structures and roles. The simplest approach, to avoid redundancies and complicating existing coordination mechanisms, would be to use an existing office or program with relevant statutory authorities to fulfill this coordination role. This option is particularly relevant for those agencies that already have a strong role in climate science, science translation, and/or stakeholder engagement and therefore are effectively performing the functions above. Other agencies may learn from successful programs and coordination efforts such as with the USDA Climate Hubs, the USGS CASCs, and NOAA CAPs. A second approach, simple, but less robust is to designate one executive within the agency to take on these functions, either on a full-time basis or as part of other related responsibilities within the agency. This approach is particularly suited for those agencies with important, yet limited, engagement on climate change.

For agencies that lack a single, existing coordinating office or capability, a third approach could be to implement these functions in a matrix system that integrates across relevant agency offices and programs. For example, NOAA has implemented a Climate-Ready Nation Initiative that brings together climate capabilities from across all of its mission lines – from weather to oceans to satellites – to better organize its climate services to address the major U.S. climate risks of droughts and fires, floods, extreme heat, coastal protection and resilient fisheries.⁸² This model demonstrates the opportunity to develop coordination mechanisms that build bridges among different agency components. Each component (and selected point-of-contact) of the agency with climate service capabilities or needs would therefore be responsible for engaging with other components. Nevertheless, some centralized element would remain necessary to maintain situational awareness across the entire agency and for engaging with other agencies.

⁸² NOAA, 2020. Building a Climate Ready Nation. NOAA FY22-26 Strategic Plan. Executive Summary. https://www.noaa.gov/sites/default/files/2022-06/NOAA_FY2226_Strategic_Plan_ExecutiveSummary.pdf

Each of the above approaches to CSC implementation have different implications for agency resources. For most agencies, these approaches could be readily implemented, at least initially, without significant reorganization or a large additional investment. Rather, they would leverage existing personnel, structures, and activities within agencies. In implementing the CSC, agencies would report their selected approach, including the structure and key points of contacts, to USGCRP (see 4.1.2) for synthesis and broader interagency distribution. Each agency would be responsible for maintaining and updating the details of its CSC as needed.

4.2.2 Interagency Leadership and Coordination

Individual agencies are a key component of a national framework, but no single agency can adequately address the challenges, opportunities, and outcomes outlined in Section 2 on its own. This section highlights the importance of interagency coordination to the federal climate services enterprise and provides recommendations for implementing a strong interagency coordination mechanism for the governance of climate services.

The development of a climate services enterprise that addresses the diverse needs that exist across the Federal Government and beyond requires developing services that are tailored to specific regions and sectors, and capable of providing useful services not only for the climate system itself, but also, for climate mitigation, adaptation, and resilience. Moreover, information needs to be provided in ways that meet people where they are, reflecting the importance of having agencies with expertise and capabilities in user engagement and capacity building strongly engaged in developing and delivering climate services in diverse contexts.

Hence, a whole-of-government climate services enterprise is needed to build upon, integrate, and strengthen the collective efforts of agencies. Specifically, an interagency climate service coordination capability is needed to achieve the following objectives:

- Developing a **whole-of-government strategy** and priorities for climate services that leverage the capabilities, and identify needs, across agencies in order to deliver the outcomes outlined in Section 2.3.2
- Enhancing **situational awareness** across the Federal Government regarding available climate service data and products, as well as the programs and personnel associated with service provision
- Establishing **protocols and norms of behavior** within the Federal Government for assessing new federal and non-federal data and products to ensure their scientific credibility and appropriateness of their intended use, avoid duplication, acknowledge credit, facilitate discovery and interoperability, and enhance usability⁸³

⁸³ NSC (2023) A Framework for Federal Scientific Integrity Policy and Practice. Guidance by the Scientific Integrity Framework Interagency Working Group of the National Science and Technology Council. <https://www.whitehouse.gov/wp-content/uploads/2023/01/01-2023-Framework-for-Federal-Scientific-Integrity-Policy-and-Practice.pdf>

- Supporting **implementation of the Federal Data Strategy** (including the tenets of data ethics),⁸⁴ promoting the use of open data standards, and adopting the *Indigenous Knowledge Guidance for Federal Agencies* in the development and use of climate services⁸⁵
- Coordinating feedback to federal agencies and interagency bodies regarding **priority science needs** to advance the development, delivery, and use of climate services
- Coordinating federal climate **training and professional development** programs and curricula
- Coordinating **ongoing evaluation** of the effectiveness of service delivery and using that information to adjust products and services as needed.

4.2.2.1 Principles for Federal Coordination

Effective coordination of climate services will be aided by the adoption of shared principles for how federal agencies work with one another to develop, deliver, and use climate services. These include the following:

- Recognizing the development, delivery, and use of climate services is a shared, whole-of-government responsibility
- Aligning climate service investments to the existing authorities, expertise, technical capabilities, and stakeholder relationships within each agency (Box 4.1)
- Prioritizing the user experience in terms of discoverability, design, and usability of data, products, and tools
- Maintaining internal consistency across the Federal Government with respect to climate data, products, and tools, while maintaining flexibility to meet the diverse needs of agencies and their stakeholders





Consistent with the *Opportunities* report, these principles emphasize the importance of elevating climate services from an ad hoc, opportunistic activity to a more deliberate, strategic, planned enterprise that is coordinated within and across federal agencies. In so doing, federal agencies should strive to ensure those services meet the needs of the Nation and reduce the burden upon users to discover relevant climate data and products, while also endeavoring to avoid duplication of effort and/or the introduction of competing or contradictory information.

⁸⁴ President's Management Agenda (2020) Federal Data Strategy. Data Ethics Framework <https://resources.data.gov/assets/documents/fds-data-ethics-framework.pdf>





⁸⁵ Office of Science and Technology Policy (2022) Guidance for Federal Departments and Agencies on Indigenous Knowledge. Executive Office of the President <https://www.whitehouse.gov/wp-content/uploads/2022/12/OSTP-CEQ-IK-Guidance.pdf>




Box 4.1. Synthesis of select FTAC member agencies’ authorities, capabilities, and applications relevant to the development, delivery, and use of climate services



The following summarizes the authorities, capabilities, and applications of FTAC member agencies with respect to climate services. The information illustrates the diversity of ways in which agencies engage the climate services knowledge value chain (see Section 2.2), as well as how information is shared across agencies. Additional details regarding agency contribution to, and applications of, climate services are provided in agencies’ [Climate Adaptation Plans](#).

	<p>The U.S. Department of Defense (DOD) is mandated by numerous Executive Orders, public laws, departmental directives, and via Congressional appropriations to enhance the Nation’s resilience to threats caused by climate change and extreme weather. DOD’s core capabilities relevant to climate services include numerical modeling, forecasting, environmental analysis, and enhanced sensing, data processing, and dissemination technologies for characterizing the environment. Priority needs for climate services to support DOD’s ability to make climate-informed decisions include enhanced information on atmospheric dynamics and coastal inundation.</p>
	<p>The U.S. Department of Transportation (DOT) is authorized to deliver climate services through Executive Orders, Congressional authorizations, and departmental directives. DOT primarily uses climate data and information from other federal agencies to develop resources and tools for state, local, and tribal transportation agencies to facilitate the integration of climate resilience into transportation decision-making. For example, DOT developed a Vulnerability Assessment and Adaptation Framework to help transportation agencies assess the vulnerability of infrastructure to extreme weather and climate impacts and a CMIP Climate Data Tool that translates downscaled climate projections into relevant statistics for transportation planners. DOT is also developing training materials to ensure that staff across the Department have the knowledge to make decisions that are grounded in the best-available scientific understanding of climate change risks, impacts, and vulnerabilities.</p>
	<p>The U.S. Environmental Protection Agency (EPA) is mandated by numerous laws, federal regulations, and Executive Orders to incorporate climate-related vulnerability and risk into agency decisions and to support the monitoring and reporting of greenhouse gas emissions. EPA’s core capabilities relevant to climate services include the provision of technical information on climate change and responses; the synthesis, assessment, and translation of climate science to inform decisions; and the development of climate products and information for the public. EPA facilitates stakeholder engagement regarding the design and implementation of environmental regulatory actions. Priority needs for climate services include access to authoritative climate information that is consistent across the Federal Government.</p>
	<p>The Federal Emergency Management Agency (FEMA) in the U.S. Department of Homeland Security is authorized to deliver and use climate services via Executive Orders and Memos, authorization and appropriation bills, and organizational charters. FEMA provides climate service capabilities through multiple mechanisms. These include its contributions of climate and resilience information to online tools such as the Climate Mapping for Resilience and Adaptation (CMRA) Portal and the Climate Risk and Resilience (ClimRR) Portal; climate-related data analysis as needed in collaboration with stakeholders; and the provision of climate services through programs such as Hazard Mitigation Planning and Building Resilience Infrastructure and Communities (BRIC). In addition, FEMA uses climate data and</p>

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	<p>services from other agencies to meet its goals of building a climate-resilient Nation, to empower risk-informed decision making, and to meet current and emergent threats.</p>
	<p>The General Services Administration (GSA) has authority to use and develop internal-only climate services through multiple Executive Orders and public laws, including the Disaster Resiliency Planning Act of 2022. GSA conducts climate risk screening, assessment, and climate adaptation planning as part of its effort to support mission continuity, secure federal investments, and provide reliable performance over the intended service life of those investments. GSA depends on climate services to ensure climate-informed decisions in asset management, capital planning, and supply chain risk management.</p>
	<p>Although the U.S. Department of Health and Human Services (HHS) does not develop or deliver climate data, its authority to use and apply climate services is inherent in its mission to enhance the health and well-being of all Americans. For example, the Centers for Disease Control and Prevention’s (CDC) Climate and Health Program and the National Institute of Health’s Climate Change and Health Initiative use climate data for research purposes under the Department’s general public health authority and in response to EO 14008. The Department’s climate service capabilities lie in translating climate data for use in public health tools such as the National Environmental Public Health Tracking Networking (CDC) and integrating climate data into tools that assess the health impacts of climate change (NIH). The collection and distribution of climate data by other federal agencies, in particular temperature, precipitation, and greenhouse gas data, is essential to HHS’s climate and health research and enabling health departments and the health and human services sectors more broadly to prepare for and respond to the health impacts of climate change.</p>
	<p>The U.S. Department of Housing and Urban Development’s (HUD) authority to acquire, develop, deliver, or use climate data, information, and services is linked to HUD’s mission to create strong, sustainable, inclusive communities and its role in managing billions of dollars in disaster recovery funding. HUD’s relevant capabilities include data analytics, science translation, application development, risk assessment, stakeholder engagement, and adaptation planning. For example, HUD’s Community Resilience Toolkit can be used to help Community Planning and Development grant recipients understand how natural hazard risks may impact their community. As a user of climate services, HUD benefits from comprehensive and modernized data collection on climate and HUD assets, and, in particular, delivering the requirements of the Federal Flood Risk Management Standard (FFRMS). HUD grantees and staff also need training and education on how to understand how existing climate services can be used to support community needs.</p>
	<p>The National Aeronautics and Space Administration (NASA) pursues a program of Earth observations, research, and applications to better understand the Earth, how it supports life, and how human activities affect its ability to do so in the future. One way in which NASA measures its success is through practical benefits to society. NASA manages the development of all missions that provide Earth observations for the Nation’s civil space agencies, provides a progression of both novel and continuity observations to improve understanding of the global climate system, and is a steward of advancing the knowledge of the Earth system from sea surface and ice height, to land and ocean biodiversity, to atmospheric chemistry, cloud properties, and Earth energy balance. NASA’s core strengths include Earth system observation, open data, data-driven modeling and prediction, climate application development (e.g., Sea Level Change Portal), international engagement (e.g., SERVIR program), and public outreach (e.g., NASA Global Climate Change website), and NASA strives to ensure the availability and the widest possible use of climate information. NASA is working with partners to prototype greenhouse gas monitoring and information</p>

	<p>capabilities. It will also enhance data visualization and tools as part of its new Earth Information Center. NASA applies climate data internally to plan operations and ensure the resiliency of facilities, and it provides climate information and tools to enable more than a dozen other agencies to meet their missions. NASA is also developing innovative and practical tools and techniques to use the latest climate projections for extreme weather, sea-level rise, coastal and riverine flooding, wildfires, air quality, energy, and water resources to support decisions that build resilience.</p>
	<p>NIST is designated by Congress as the Lead Agency for the National Windstorm Impact Reduction Program (NWIRP). NIST coordinates the NWIRP research and implementation activities for the four NWIRP agencies – FEMA, NIST, NOAA, and NSF. The National Construction Safety Team (NCST) Act authorizes NIST to establish teams to investigate building failures that could happen due to climate-related extreme weather events. The results of these failure studies inform improved design and codes for buildings. NIST has also been directed to work with NOAA and other appropriate Federal and non-Federal parties to identify a consistent and authoritative set of climate information that emphasizes forward looking climate data and projections that should be utilized in the standard-setting process. In addition, the NIST Greenhouse Gas Measurements Program develops tools and standards for measuring greenhouse gas emissions to support emissions management across sectors and industries.</p>
	<p>The National Oceanic and Atmospheric Administration (NOAA) is directed to provide comprehensive weather and climate services by a number of legislative authorities. These include the National Climate Program Act of 1978, the Weather Research and Forecasting Innovation Act of 2017, the National Integrated Drought Information System Act Reauthorization Act of 2019, and the Flood Level Observation, Operations, and Decision Support (FLOODS) Act of 2022. Language referenced in the House Committee on Appropriations report for the FY2023 Omnibus “recognizes NOAA’s role as the lead Federal agency providing climate services and supports the expansion of NOAA’s efforts to provide climate services, information, and outreach as part of its Climate Ready Nation initiative.” NOAA’s core capabilities in support of the delivery of climate services range from operational observations and provision of data to fundamental research into climate monitoring and event attribution, model development and projections, social and interdisciplinary science, delivery of forecasts and warnings, and the coproduction of knowledge and decision support tools with stakeholders. NOAA currently maintains most of the Nation’s sustained climate observing networks as well the Nation’s permanent archive of weather, climate, atmospheric and oceanographic data, and ensures the continuity and integrity of the historical climate record. NOAA is committed to open and equitable access to data and information and supports operational best practices in service delivery. NOAA has fostered the growth of a private sector industry to meet specialized business and public sector needs. It also sponsors place-based programs to develop trusted relationships with decision makers and prioritize equitable engagement with frontline, underserved communities.</p>
	<p>The National Science Foundation (NSF) has multiple authorities to perform and disseminate scientific research and initiate programs that strengthen research potential and education programs. NSF focuses its efforts on the scientific underpinnings that lead to robust climate services through investments that support research infrastructure, observations, and modeling. For example, through the U.S. Antarctic Program, NSF manages all U.S. scientific research and related logistics in Antarctica and the Southern Ocean, enabling the collection of long-term climatic data by NSF-supported researchers and other federal agencies. NSF-funded researchers often use climate data and projections in their research activities and/or</p>

	<p>develop and disseminate new scientific findings on climate and Earth System processes and phenomena.</p>
	<p>The U.S. Department of Agriculture’s (USDA) overarching authorities on the application of climate services to address climate change are codified in the Global Climate Change Prevention Act of 1990 (Title XXIV of the Food, Agriculture, Conservation, and Trade Act of 1990 P.L. 101-624) and managed by the Climate Change Program Office (CCPO) located within the Office of the Chief Economist. This Act directs CCPO to coordinate policy analysis, long range planning, research, and response strategies related to climate change and to ensure that recognition of the potential for climate change is fully integrated into research, planning, and decision-making processes of the Department. Examples of USDA’s work on climate services include USDA’s regional Climate Hubs, activities of meteorologists in the World Agricultural Outlook Board, the Natural Resources Conservation Service’s Snow Survey and Water Supply Forecasting Program, and Soil Climate Analysis Network (SCAN) Pilot Program. In addition, numerous climate-related tools have been developed and supported by the U.S. Forest Service, the National Institute for Food and Agriculture’s partnership with the National Cooperative Extension System, and department-wide activities on climate change adaptation coordinated by CCPO.</p>
	<p>The U.S. Geological Survey (USGS) in the Department of Interior, has general authorities and requirements to deliver data to the public. Accordingly, the USGS implements a systems-based approach for understanding the impacts of climate change on natural systems, and delivers that information at scales and timeframes relevant to decision-makers. The agency’s unique interdisciplinary approach explores past climate, monitors current change, documents factors influencing change, and projects future conditions of the Nation’s lands, waters, and biota. USGS, in cooperation with other agencies, provide information and services that support the department’s broader mission to enable climate-informed, adaptive management of the Nation’s fish, wildlife, lands, and waters.</p>

4.2.2.2 A Pathway for Interagency Coordination

In considering options to better coordinate the development and delivery of climate services across the Federal Government, and cognizant of the principles and goals described above, the FTAC considered a number of desired characteristics of an effective interagency coordinating body:

- Authority to provide interagency coordination with a proven track record of success
- Capacity to provide strategic direction for climate services
- Close links to the underlying biophysical and social sciences relevant to climate change, climate services, and their use
- Visibility to federal and non-federal stakeholders
- Recognized external advisory mechanism with access to a diversity of relevant expertise
- Participation by key federal agencies involved in both development and use of climate services
- The ability to inform diverse response options from climate mitigation, to adaptation and resilience

The USGCRP satisfies all of the above criteria and is the most promising mechanism for coordinating climate services under a national framework. An alternate option of creating a new, bespoke coordinating entity was considered and rejected because of the challenges in standing up a new entity, especially when the Congressional mandate to USGCRP in the GCRA clearly includes the provision of information about climate change to the public. No other existing interagency body satisfies all of the above criteria. This section describes the attributes of USGCRP that make it appropriate as well as the steps that would be required to make this pathway effective.

As reported in Section 1, the USGCRP has been coordinating global change research since it was created in 1990. Despite language in the GCRA identifying USGCRP's mission as producing ". . . *information readily usable by policymakers attempting to formulate effective strategies for preventing, mitigating, and adapting to the effects of global change,*"⁸⁶ the scope of USGCRP has historically been focused on scientific research. At the time of the USGCRP's inception, this emphasis on research was a logical prioritization given the state of scientific understanding of climate change. More than 30 years later, significant scientific challenges remain. Yet, intensive effort is also now being invested in responding to climate change, a mission which is broader than USGCRP's historic purview. For example, USGCRP's new decadal strategic plan, released in December 2022, emphasizes the importance of engaging the American public to translate the Nation's investments in climate research into useful and useable information (Box 4.2).⁸⁷

The engagement of the USGCRP in the coordination of climate services would not be a novel development. To date, a range of climate data, information, and products have been produced under the auspices of the USGCRP, including the *National Climate Assessments* (which are mandated under the GCRA),⁸⁸ the *Latin America and Caribbean Initiative* (LACI),⁸⁹ the pending *National Nature Assessment*,⁹⁰ as well as the *Climate Resilience Toolkit*.⁹¹ Such products have elevated the public visibility of USGCRP as a body that provides coordination across the Federal Government on climate and global change knowledge generation and communication. Moreover, various regional and applied science activities of federal agencies are already included in the USGCRP budget crosscut and are featured in the *Our Changing Planet* series that reports on the activities of USGCRP.⁹²

An increased climate services coordination role would necessitate expansion of the USGCRP's current responsibilities. At present, USGCRP is led by the Subcommittee on Global Change Research (SGCR) of

⁸⁶ Public Law 101-606, November 16, 1990. Global Change Research Act. <https://www.govinfo.gov/content/pkg/STATUTE-104/pdf/STATUTE-104-Pg3096.pdf>

⁸⁷ USGCRP, 2022. The U.S. Global Change Research Program 2022–2031 Strategic Plan. U.S. Global Change Research Program, Washington, DC, USA. https://downloads.globalchange.gov/strategic-plan/2022/USGCRP_2022-2031_Decadal_Strategic_Plan.pdf

⁸⁸ USGCRP, 2018. Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018

⁸⁹ For more information, see <https://www.globalchange.gov/LACI>

⁹⁰ For more information, see <https://www.globalchange.gov/nna>

⁹¹ For more information, see <https://toolkit.climate.gov/>

⁹² Our Changing Planet is USGCRP's annual report to Congress. It responds to the Global Change Research Act mandate to provide an overview of the Program's progress in delivering on its strategic goals as well as a summary of agency expenditures under USGCRP's budget crosscut. The FY22 edition of *Our Changing Planet* is available at <https://www.globalchange.gov/browse/reports/our-changing-planet-fy-2022>.

the NSTC's Committee on Environment, which is overseen by OSTP. The SGCR is comprised of principals from the 14 USGCRP member agencies.⁹³ Operational activities of USGCRP are achieved through the National Coordination Office (NCO), which is funded with contributions from the USGCRP member agencies through a distributed cost budget. In addition, a number of interagency working groups (IWGs) are convened under the auspices of USGCRP to facilitate focused coordination around specific topics.

To effectively integrate the coordination of climate services into the scope of USGCRP, changes would potentially be needed to its structure and operations. The FTAC discussed a number of potential options for these structural and operational shifts and Section 5 describes the steps necessary to obtain consensus around the path forward.

One option could be to expand the mission of USGCRP into the climate services domain using the existing USGCRP structure – comprised of the SGCR and the NCO. This could include broadening the leadership of the SGCR by establishing a second co-chair, one focused on the generation of climate change research and another on the application of climate change science to provide climate change services. This approach could also consider changes to the principals associated with the SGCR to incorporate relevant expertise and ensure service-oriented programs from relevant agencies are represented. This approach would maintain the current structure of USGCRP, but requiring the SGCR to coordinate both research and services could prove disruptive to USGCRP's research coordination efforts while simultaneously limiting its capacity to effectively elevate services.

The FTAC considered an alternate option to coordinate federal climate services, specifically to create a new NSTC subcommittee notionally referred to here as the Subcommittee on Global Change Services (SGCS) that would parallel the SGCR. As with the SGCR, a SGCS would be comprised of representatives from USGCRP member agencies, drawn from agency divisions and offices with expertise and responsibilities relevant to climate services. This approach could enable the SGCR to continue to focus on research coordination while creating a parallel process for overseeing the coordination of services. Both subcommittees would provide oversight for the NCO, which would expand its responsibilities to support interagency coordination efforts. This could necessitate re-tasking existing personnel or, depending on the scope of coordination needs, recruitment of additional personnel to effectively manage that coordination. Under this option, the leadership of the two subcommittees could differ from one another in order to ensure a distribution of responsibility and authority across the activities. Regardless of the coordination option chosen, the leadership should rotate across agencies on a regular schedule and a mechanism would be needed to maintain coordination between the two subcommittees, independent of the NCO.

⁹³ The chair of the SGCR rotates among agencies. That role is currently held by NOAA.

Box 4.2. Climate Services in the USGCRP Decadal Strategic Plan

The most recent USGCRP *Decadal Strategic Plan*, published in 2022, outlines the program’s priorities in the years ahead. Those priorities are largely oriented toward the fundamental global change and Earth system sciences that address key uncertainties and shape our understanding of global and climate change processes. Nevertheless, the plan represents an unprecedented recognition that a diverse community is dependent on such scientific advances for policy development, planning, financial investment, and risk management. Accordingly, engaging with that community and translating science into useable and useful information and products tailored to different user contexts is consistent with USGCRP’s Congressional mandate and represent a mechanism for maximizing the return on investment in science.

Brief excerpts from the *Decadal Strategic Plan* that illustrate this emphasis on services are provided below.

“ . . .development and provision of tools and synthesis products that inform actions to conserve biodiversity and employ nature-based solutions to address multiple threats.” (pg. 13)

“ . . .increase research into the behavioral, societal, economic, and cultural aspects of global change to improve our understanding of risks and ability to develop effective responses to global change.”(pg. 17)

“ increase efforts to understand community-level needs, information use, impacts, and responses.” (pg. 18)

“training Federal employees on the available information and tools that are appropriate to agency sectors and stakeholders” (pg. 20)

“ . . . prioritize standardized, centralized, and built-to-purpose climate information, tools, and services as determined through its collaboration with the [regional science organizations].” (pg. 20)

“ . . .prioritize people- and place-based engagements that can be scaled up and scaled out to inform a broad range of activities.” (pg. 20)

“ . . . informing key mitigation and adaptation decisions at various scales to avoid or reduce risks from climate and global change.” (pg. 24).

“Increased engagement with decision-makers will enable USGCRP-supported research and USGCRP science products to better identify and address data, information, and product needs.” (pg. 24)

Both of the above options would necessitate a process to engage agencies that are not currently USGCRP members, but still have significant roles in providing or using climate services. Examples include the U.S. Department of the Treasury, GSA, and HUD. In addition, both options would necessitate reevaluation of the USGCRP’s existing IWGs. Some of the IWGs, such as the Indicators Interagency Working Group (IndIWG) and the Federal Adaptation and Resilience Group (FARG), already span the spectrum from research to services, but their work on services could be strengthened. Additional IWGs may be needed to provide a mechanism for convening agencies to address the broader coordination needs identified previously.

The FTAC noted that these different options have important implications for federal agencies. Any extension of USGCRP more directly into the coordination of climate services would place additional

demands on agencies in terms of their commitment of personnel to engage in USGCRP interagency activities. Although agencies routinely identify their global change research investments, no separate, comprehensive estimates exist regarding what agencies collectively invest specifically in climate services. Nevertheless, agencies would have to allocate resources to supporting these coordination activities at the same time as they are working to enhance their own efforts on the development and delivery of services. In addition, these options would increase the scope of work for the NCO and create a need for additional personnel, expertise, and resources to effectively support climate services.

The relative magnitude of agency investments in services likely differs from those associated with research. However, distinguishing between the two in practice can be difficult, because the boundary is not always clear. The development of clear guidance for agencies on how to identify their service-oriented programs and products will be necessary for tracking the scale and scope of their climate service activities and their alignment to USGCRP.

Further deliberations among federal agencies and the White House are needed to develop a more specific operational plan for evolving USGCRP into an interagency body that can effectively coordinate climate services (see Section 5).

4.2.2.3 Connecting with Other Federal Interagency Bodies

The USGCRP is one of a number of interagency bodies that are relevant to the development, delivery, and use of climate services, and therefore it is important to recognize those other bodies and articulate how they would be engaged in climate services going forward. Under the aforementioned framework, USGCRP would facilitate engagement with these other interagency bodies. Example bodies include elements of the NSTC, including other subcommittees within the Committee on Environment, such as Ocean Science and Technology (SOST); Resilience Science and Technology (SRST); and the U.S. Group on Earth Observations (USGEO).

The Interagency Council for Advancing Meteorological Services (ICAMS) is another key interagency body relevant to climate services. In addition to committees focused on meteorological observations, research and innovation, and cyber infrastructure, ICAMS also has a committee on services that spans weather, climate, hydrological, ocean, and related environmental services for sea, air, and land. Given the proposal above to direct USGCRP to facilitate interagency coordination on climate services, there is a need to distinguish between the roles of USGCRP and ICAMS moving forward with respect to climate research and services, and to ensure close coordination (Box 4.3).

A range of other interagency activities that exist across the Federal Government in support of particular science/policy issues may also be relevant to climate services. For example, the National Drought Resilience Partnership (NDRP), the Interagency Working Group on Environmental Justice (EJIWG), the Interagency Sustainability Working Group (ISWG), and the Renewable Energy Working Group (REWG) all of these have potential contributions to make in the climate services arena. Climate service activities are also relevant to the National Climate Task Force and its interagency working groups on priority climate hazards (wildfire, drought, flood, coastal resilience, and extreme heat).

Box 4.3. Defining the Roles of USGCRP and ICAMS with Respect to Climate Research and Services

Expanding the role of USGCRP to include interagency coordination of climate services necessitates reconciling the role of USGCRP with that of other interagency bodies, particularly ICAMS. Since 1990, USGCRP's research mission under the GCRA has focused on Earth system processes spanning seasonal to multi-decadal timescales. The outputs of that research have been translated into climate services providing data on baseline climate conditions as well as projections of future changes in temperature, precipitation, and sea-level rise for future decades. This includes tools in the [Climate Resilience Toolkit](#) such as the [National Risk Index](#), [Wildfire Risk to Communities](#), the [Sea-Level Rise Viewer](#), the [Climate Explorer](#), and the [Climate Mapping for Resilience and Adaptation](#) Portal. As described in its strategic plan and budget cross-cut, USGCRP also convenes agencies to coordinate development of new approaches, for example improved ways to downscale climate information to enhance its local relevance, and approaches to co-produce knowledge at the regional scale. These efforts demonstrate that USGCRP is already engaged in and successful at coordination of some climate services, particularly with respect to long-term climate and global change processes.

ICAMS is a new interagency body and is in the process of developing its first strategic plan for advancing the Nation's meteorological research, innovation, and services. The authorizing legislation for ICAMS, the [Weather Research and Forecasting Innovation Act of 2017](#) (or Weather Act) was intended to achieve "*advances in observational, computing, and modeling capabilities to support substantial improvement in weather forecasting and prediction of high impact weather events.*" The Weather Act's focus on "high impact weather" and subseasonal to seasonal forecasting innovation is consistent with the *Opportunities* report and the National Climate Task Force's interagency working groups that focus on drought, wildfire, extreme heat, flooding, and coastal resilience. One component of the legislation (Section 402) directed OSTP to establish an Interagency Committee for Advancing Weather Services (ICAWS) to "*improve coordination of relevant weather research and forecast innovation activities across the Federal Government.*" When this provision of the Weather Act was implemented by OSTP in the previous administration, the concept of ICAWS was expanded from weather services to meteorological services. Meteorological services were defined broadly to span local weather to global climate. The resulting interagency body was renamed the Interagency Council for Advancing Meteorological Services (ICAMS). This expansion of the original vision created potential overlap with the Earth system science mission and activities of USGCRP.

Going forward, a focus by ICAMS primarily on coordinating research, innovation, and services for high-impact weather and subseasonal to seasonal applications, although a narrower scope than the existing ICAMS charter, would align with the original Weather Act legislation. It would also help to distinguish ICAMS from USGCRP, which would maintain its legislative mandate. Examples of observational and prediction services aligned with this framing of ICAMS include the National Integrated Drought Information System [current drought conditions](#), National Weather Service [6-10 Day Outlooks](#) and [90-Day Seasonal Outlooks](#), [aviation weather](#), and [Consolidated Sea-Surface Temperature Forecasts](#).

Although distinguishing between weather and climate time scales is a convenient way of clarifying the respective roles and responsibilities of USGCRP and ICAMS, in practice some overlap between the two is unavoidable and can even be beneficial. For example, NOAA's [Atlas-14](#) point precipitation frequency estimates are maintained by the National Weather Service and provide valuable information on extreme rainfall probabilities based on years of observations. As such, Atlas-14 represents both high impact weather while providing an important climatological baseline for climate change studies and risk assessments. Meanwhile, advances in scientific understanding and prediction of high-impact weather can have downstream benefits for Earth system modeling of long-term changes in climate. Coordination between USGCRP and ICAMS will continue to be important to prioritize research investments and ensure users of weather and climate services have a seamless experience in discovering and using data, products, and tools. This clarification of the complementary, yet distinct, roles of ICAMS and USGCRP would be helpful to both interagency organizations, particularly as ICAMS proceeds with developing its strategic plan.

4.2.3 Domestic Partnerships

In addition to the federal elements of an operational framework, an extensive community of climate service providers and users exists outside the Federal Government which is nevertheless important for enhancing federal efforts. This section acknowledges the need for the Federal Government to effectively engage with this community to expand its impact and empower other actors.

Included in this community of non-federal actors are SLTT governments, non-profit and civic boundary organizations, community organizers, professional/scientific societies, private sector information providers and technology vendors, and university faculty and extension agents (see Figure 2.2). Their efforts on climate action are enabled by credible, federal data, products, and tools, and the science enterprise that continues to advance them. The community plays a critical role in both enhancing the dissemination of federal services and for bridging between federal services and the needs of local decision-makers and practitioners. It also plays a role in developing standards and guidance for services and information, providing training and building capacity, and building networks and registries for expertise.

While the Federal Government already has multiple points of connection with non-federal climate service providers and users, enhancing engagement will enable the Federal Government to more effectively empower non-federal actors on climate service development and delivery. Furthermore, it will enable the Federal Government to elicit ongoing feedback regarding its climate service priorities, investments, and delivery. Agencies and USGCRP should coordinate to explore the need for a **National Climate Services Partnership (NCSP)** with this non-federal community, to use the convening power of the Federal Government to facilitate greater sharing of knowledge, best practices, and technical capabilities. This partnership could be implemented as a knowledge network among federal and non-federal organizations, largely focused on enhancing communication among partners via webinars, workshops, conferences, and ad hoc engagement.

The NCSP would largely be maintained by individual agencies supporting activities under the NCSP that are aligned with their mission and stakeholder communities. Hence the NSCP would not be a single, centralized outreach initiative, but rather a mechanism for maintaining situational awareness and promoting and accelerating whole-of-government engagement with the non-federal community. That interagency knowledge sharing suggests a potential role for the USGCRP (4.1.2) in helping to identify common challenges and best practices across the Federal Government. Key categories of partners would include: a) SLTT governments, particularly low-capacity and disadvantaged communities; b) those organizations associated with federally-funded regional organizations; c) private firms involved in developing or applying services; and d) colleges and universities, particularly minority serving institutions (MSIs).

4.2.4 International Partnerships

In addition to their domestic activities, federal agencies are routinely engaged with international partners to coordinate efforts on climate change research and services, share knowledge, and build capacity. As described here, FTAC deliberations acknowledged the importance of thinking beyond the boundaries of the United States and contributing to international efforts on climate services. The

President's Emergency Plan for Adaptation and Resilience (PREPARE), which represents a whole-of-government effort to help more than half-a-billion people in developing countries adapt to and manage the impacts of climate change, serves as the strategic coordination mechanism for the Federal Government's international adaptation and resilience efforts. A central pillar of PREPARE is enhancing climate information services, including increasing the co-production and use of climate information, as well as building capacity to equip decision makers with the skills, knowledge, networks, and outlooks needed to use that information to prepare for and respond to climate impacts.

Multiple agencies are active in PREPARE's climate information services work. For example, USGCRP contributes to the core support of several international organizations such as the World Climate Research Programme (WCRP), Future Earth and START. Various agencies, such as NOAA and NASA, also support the projects that are implemented as part of these programs (e.g., support for international program offices), activities under the World Meteorological Organization (WMO), including engaging with WMO bodies on climate services (such as the Global Framework for Climate Services), and through regional and bilateral climate information programs. USDA is planning to launch an International Climate Hub, modeled after its domestic hubs, to provide information and resources tailored to the specific needs of stakeholders in different global regions.

Continuing to support such international activities is important for not only enhancing the impact of federal climate services, but also building capacity and collaboration with international partners. Opportunities exist for expanding current and future climate services to enhance the relevance of federal investments to international stakeholders and support climate adaptation and mitigation planning. For example, federal investments in developing data and tools for projecting future climate and sea-level rise for the United States are often used to generate data and tools for other nations and the world.

4.2.5 External Advisory Committee

As identified by the FTAC, the final core component of a federal framework for climate services is a mechanism for the Federal Government to elicit external guidance and advice on climate services. Currently, USGCRP receives such advice through the NASEM's Committee to Advise the U.S. Global Change Research Program.⁹⁴ That advisory mechanism could continue to operate in support of an expanded USGCRP that more explicitly facilitates the coordination of climate services. However, its role would have to expand to provide advice not only on climate research, but also climate services development, delivery, and use. Alternatively, if expanding the charter of the existing Committee to Advise the U.S. Global Change Research Program to consider climate services would overburden the committee or impede its ability to provide constructive advice on both climate research and services, a separate advisory committee could be established. This could take the form of a federal advisory committee under the terms of the Federal Advisory Committee Act.⁹⁵

⁹⁴ National Academies of Sciences, Engineering, and Medicine, Advice for the U.S. Global Change Research Program. <https://www.nationalacademies.org/our-work/advice-for-the-us-global-change-research-program#:~:text=The%20Committee%20to%20Advise%20the,as%20a%20portal%20to%20relevant>

⁹⁵ 5 U.S.C. app., October 6, 1972. Federal Advisory Committee Act, <https://www.gsa.gov/cdnstatic/FACA-Statute-2013.pdf>

5 Recommendations and Next Steps to Implement a Coherent Federal Approach to Climate Services

The preceding sections articulate how climate services should be defined within the Federal Government, the challenges and opportunities associated with federal efforts, and the core components of a framework for a more effective and user-oriented federal system of climate services. This final section identifies the next phase of actions needed to translate the framework for climate services into a functioning and effective enterprise.

To that end, this report emphasizes the critical role that federal Departments and agencies must play in building a more effective and comprehensive climate services enterprise. At the same time, greater coordination among the agencies is also needed to develop an ambitious strategy, enhance consistency and avoid duplication, and build a strong climate services community of practice across the Federal Government. USGCRP has the authority under the GCRA to inform decision-making on climate as well as the credibility to ensure climate services remain grounded in the best-available science. For USGCRP to successfully place climate services on a more equal footing to global change research will necessitate a significant shift in how the USGCRP is structured and in how it operates. Resolving the details regarding how that shift is implemented will necessitate further deliberations among the agencies, USGCRP, and the White House. The USGCRP has proven itself to be an adaptive organization, evolving over time to successfully meet the changing needs of the Nation.

While this report describes the framework for advancing the Nation's climate services, building that framework will necessitate implementing a range of recommended actions or next steps. Some of these recommendations are associated with developing individual components of the framework, such as partnerships or interagency coordination. Others are oriented toward building broader capacity for climate service delivery within the Federal Government or addressing long-standing challenges experienced by stakeholders. These recommendations are grouped into four categories. Each recommendation is comprised of a brief description which includes, where possible, potential actors that could take the lead on its implementation. However, these recommendations should be revisited once a more detailed operational plan has been developed.

Recommendation 1: Enhance Engagement and Partnership with Federal and Non-federal Producers and Users of Climate Services

Recommendation 1.1: Launch a Climate Services Summit that brings together federal and non-federal producers and users of climate data and tools. This action would drive the development of a summit that would bring both federal and non-federal producers and users together to share knowledge on the development, and dissemination of climate services. Such an event could be held as a stand-alone activity, or integrated into an existing meeting such as an additional day or a group of sessions at large-scale meetings of researchers and/or practitioners. This could include meetings of relevant scientific societies, but could also be associated with more practitioner-led events focused on specific sectors or regions. Alternatively, the Summit could be a series of smaller touchpoints or sessions at relevant practitioner/science-related conferences that ultimately lead up to a larger Summit.

Recommendation 1.2: Use public/private partnerships to enhance access to, and use of, non-federal climate service capabilities. This action would incentivize the use of authoritative, non-federal (including the private sector as well as not-for-profit organizations) climate data and information for federal planning, assessment, and decision-making. Doing so would necessitate establishing a process for discovering and evaluating existing and emerging non-federal capabilities to ensure they are fit-for-purpose including considerations such as credibility, accessibility and openness, and consistency and interoperability. This action could be extended into more ambitious programs, including hackathons or other challenges that would invite non-federal actors to develop capabilities to address high-priority climate service challenges.

Recommendation 1.3: Develop guidance for federal agencies on the effective use of co-production methods for the design and dissemination of climate services. This action would develop guidance on the use of co-production tools and methods that reflects the diversity of missions and expertise among federal agencies. That guidance would be used to inform processes for the future development, delivery, and use of climate services. USGCRP's Climate Engagement and Capacity-Building Interagency Working Group (CEC-IWG) and/or the Social Sciences Coordination Committee (SSCC) could take a leadership role in the development of guidance and integrating learning and practice from different agencies.

Recommendation 2: Strengthen Governance, Leadership, and Oversight of Federal Climate Services

Recommendation 2.1: Direct USGCRP to facilitate coordination among agencies specifically regarding climate service development, delivery, and use. This action would assign responsibility for initial interagency coordination of climate services to USGCRP. USGCRP would facilitate convenings and deliberations among agencies on those dimensions of climate service for which interagency coordination is needed to maintain consistency and effectiveness. Those dimensions could include a) developing a whole-of-government strategy for climate services, including defining clear agency roles and requirements for operational climate services; b) enhancing situational awareness of federal climate services and capabilities; c) establishing protocols and norms of behavior; d) supporting consistent implementation of the Federal Data Strategy; e) identifying priority science needs to advance services; f) coordinating training and professional development programs; and g) coordinating ongoing evaluation of climate service performance. OSTP, in partnership with the existing SGCR, would be responsible for implementing any necessary changes in the structure and operation of USGCRP to enhance its effectiveness to achieve agreed coordination needs.

Recommendation 2.2: Establish or identify a climate service coordinator position(s) or capability within each federal agency, leveraging, where possible, existing capabilities and organizational structures for the development, delivery and/or use of climate services. An intra-agency climate service coordination function can facilitate a) identification of climate service needs spanning climate resilience and adaptation as well as climate mitigation; b) engagement with fellow agencies or external stakeholders; c) tracking agency capabilities in climate services; d) evaluating gaps in agency capacity; and e) providing technical assistance to programs and users within the agency and/or external agency

stakeholders. Individual agencies would have responsibility for identifying whether their activities warrant a climate service coordinator and how best to provide that capability.

Recommendation 2.3: Develop a decadal strategic plan and interim implementation progress reports on federal climate service efforts. This action would deliver a strategic planning process for climate services that routinely identifies gaps in existing scientific knowledge and services as well as opportunities for, and investments in, new service development. Initial steps would include engaging in an inclusive process for developing the strategy and ensuring it complements other relevant strategic plans for USGCRP and ICAMS. This action would be led by the USGCRP, with input from member agencies to maintain consistency with agency plans.

Recommendation 2.4: Develop an operational definition of climate services for the Federal Government. This action would develop an operational definition of climate services that can be used to clearly identify whether a particular program, project, or activity constitutes a climate service in the context of the Federal Government. The development of clear guidance for agencies on how to identify their service-oriented programs and products will be necessary for tracking the scale and scope of their climate service activities. As reflected in Section 2.2, key criteria for distinguishing between outputs of climate research and climate services include a) the intended purpose (e.g., advancing knowledge versus informing decisions), and b) the ability to use the information on demand to support decision making. Development of such a definition would be led by the USGCRP, with input from member agencies to ensure the definition and associated criteria are robust to the diversity of agency services and can be used effectively for federal planning and budgeting.

Recommendation 2.5: Develop a federal data policy governing the design and development of climate services. This action would develop whole-of-government guidance regarding the development and use of climate data and products intended for public use in planning and decision making. This policy should a) be consistent with the Federal Data Strategy and the Information Quality Act; b) promote the use of open data standards; and c) integrate guidance on the use of Indigenous Knowledge in the development and use of climate services. The policy would span multiple considerations, including the following:

- Definitions of consistent application of metadata standards, appropriate data formats, practices for maintaining data interoperability and analysis ready data for AI/ML applications, and the crediting of data sources and providers.
- Processes for the application of open data standards and the conditions under which data are, or are not, made publicly available and the mechanisms for doing so.
- Methods for the consistent application of scenarios, model ensembles, and uncertainty characterization in the development and delivery of climate services.
- Mechanisms for maintaining climate data, product, and tool quality assurance to ensure services are scientifically credible and sanctioned for use by the Federal Government.
- Best practices for ensuring equity and inclusion in data acquisition and use including processes for providing services to disadvantaged and minority communities and for enhancing the appropriate use of Indigenous traditional and local knowledge in the development, and delivery of climate services.

- Federal processes for ensuring the discoverability of data, products, and tools including operationalization of a “no wrong door” approach across the Federal Government.

This action could be implemented by USGCRP.

Recommendation 3: Develop Common Infrastructure and Processes for the Development and Delivery of Climate Services Across the Federal Government

Recommendation 3.1: Identify and/or develop common platforms and system architectures for supporting the development and delivery of existing and new climate services. This action would expand existing, or develop new, common platforms that can be routinely used to support the hosting, design, and development of climate products and tools. For example, the GeoPlatform has been recommended as a common infrastructure that could be exploited by multiple federal agencies for the hosting, publishing, and discovery of geospatial data assets and tools.⁹⁶ Data.gov/Climate provides metadata and access for a much broader array of climate-related data developed and maintained by the Federal Government. More importantly for users, however, is the development of flexible platforms for the construction of built-for-purpose portals and applications that integrate access to multiple, disparate federal (and potentially non-federal) data with tools for data synthesis, analysis, and interpretation. Platforms are also needed that provide gateways to the rich landscape of data, products, and tools that exist. Climate.gov, for example, is one existing gateway that provides an entry point to various federal resources including those within the U.S. Climate Resilience Toolkit. Continuing to leverage such existing assets across agencies to enhance discovery of, and access to, climate services will benefit federal and non-federal users. Platform-development efforts would be led by agencies with relevant expertise and infrastructure, and coordinated by the USGCRP in partnership with the Federal Geographic Data Committee (FGDC).

Recommendation 3.2: Develop and maintain an inventory of climate service data, products, and tools. This action could generate a whole-of-government approach to the identification and reporting of federally-recognized climate services spanning those associated with climate resilience, climate adaptation, and greenhouse gas mitigation. It could leverage existing efforts to develop inventories in support of various agency and White House initiatives and be constructed around a common typology of services that is consistently applied across agencies and regularly updated to support real-time situational awareness of available services. Each federal agency would be responsible for identifying its own climate services and reporting on sponsored services in response to a standard template or data call. USGCRP and the USGCRP NCO could be responsible for routine collection and consolidation of information across agencies and maintaining a comprehensive inventory.

⁹⁶ Federal Geographic Data Committee, 2021. Advancing the Nation’s geospatial capabilities to promote Federal, State, local, and Tribal climate planning and resilience—A report to the National Climate Task Force: Federal Geographic Data Committee, 10 p., <https://www.fgdc.gov/resources/key-publications/2021-climate-mapping-report>.

Recommendation 4: Enhance the Capacity of the Federal Government and Non-federal Partners to Develop and Deliver Climate Services

Recommendation 4.1: Conduct an evaluation of the Federal Government’s training and professional development needs with respect to climate including the capacity to effectively develop, deliver, and use climate services. This action would commission an evaluation and needs assessment regarding the Federal Government’s training and professional development programs with respect to climate, including articulation of the common needs across agencies as well as agency-specific needs that are aligned to specific agency missions or sectors. This action would be led by the Office of Personnel Management, consistent with EO 14057, in partnership with USGCRP, specifically the Climate Engagement and Capacity-building IWG.

Recommendation 4.2: Launch a specific training program or capability that builds capacity among federal personnel to discover and use available climate services. If the evaluation in Recommendation 4.1 identifies gaps in training and professional development, this action would build capacity in the effective use of climate services to enable federal users to more effectively support their own climate inquiries and analyses. This includes specific training in use cases that integrate an array of relevant climate data, products, and tools applied to different sectoral and geographic contexts. It also includes training in fundamental building blocks that support climate services such as mapping techniques, scenario analysis, and the assessment of vulnerability and risk. Training for specific services would be provided by the agency sponsoring that service, although opportunities may exist for interagency coordination in the provision of cross-cutting general trainings needed to support the effective use of a given service in support of a federal policy initiative, such as the development of federal adaptation plans.

Recommendation 4.3: Expand guidance and outreach for navigating federal funding opportunities that support climate service development and implementation. This action would expand support for stakeholders in SLTT governments, as well as civic and boundary organizations, in identifying and accessing existing funding programs relevant to the provision of climate services. This would include development of a common entry point for identifying funding opportunities across the Federal Government. In so doing, this action should leverage other efforts to enhance access to federal funding, such as the Mitigation Framework Leadership Group (MitFLG), the Nature Based Solutions IWG, and the Green Infrastructure Federal Collaborative to avoid duplication. In addition, to the extent possible, this action would expand technical assistance associated with funding programs to better support the needs of communities in accessing funding, particularly low capacity and disadvantaged communities. This action would be led by individual agencies that are best-positioned to scale existing programs and partnerships to meet the needs of their stakeholder communities. However, interagency coordination through USGCRP could assist in facilitating knowledge sharing across agencies.

6 Conclusions

The Federal Government’s response to Section 211(d) of President Biden’s Executive Order 14008, marked an important step forward in accelerating the Nation’s capacity to develop and deliver useful climate services to the American people. In addition to outlining a vision and core principles for federal

climate services, that response highlighted the urgency of building an effective system of services to meet growing demand among planners and decision-makers from all walks of life. The objective of the FTAC was to take yet another step forward by developing a framework and allied set of actions that elevate the Nation's climate services to a level that is commensurate with the magnitude of the climate crisis. In so doing, the FTAC approached its work by focusing first and foremost on the needs of users and the diverse challenges different users experience in planning and implementing responses to climate change. This led the FTAC to broaden what constitutes climate services in the context of the Federal Government and raise awareness of the diversity of knowledge that is needed to support climate action.

In addition, the FTAC generated a range of concrete actions that collectively build a strong foundation for future development and growth of the federal climate services enterprise. One of the priorities is to enhance coordination of climate services on behalf of the Federal Government, in line with existing authorities. Such coordination will ultimately generate value for federal agencies as well as SLTT governments, communities, and businesses through more informed planning, improved risk management, and greater insight into what works. Meanwhile, the implementation of other actions recommended by the FTAC will enhance partnerships between the Federal Government and non-federal stakeholders of climate services, enhance the discovery and usability of available climate services, and increase the capacity of individuals both within and outside of the Federal Government to effectively use climate services. More work lies ahead to build consensus on the implementation steps of the FTAC's framework. But the sooner that work begins, the sooner the stakeholders across the Nation can benefit from the Federal Government's enhanced commitment to climate services.

Abbreviations

BIL – Bipartisan Infrastructure Law [Infrastructure Investment and Jobs Act]	IRA – Inflation Reduction Act
CAP – Climate Adaptation Partnerships Program	ISWG – Interagency Sustainability Working Group
CASC – Climate Adaptation Science Centers	IWG – Interagency Working Group
CDC – Centers for Disease Control and Prevention	LACI – Initiative for Enhancing Capacity for Climate Risk Assessment and Catalyzing Partnerships to Inform Decisions in Latin America and the Caribbean
CAP – Climate Adaptation Partnership	NASA – National Aeronautics and Space Administration
CEC-IWG – Climate Engagement and Capacity-Building Interagency Working Group	NASEM – National Academies of Sciences, Engineering, and Medicine
CEQ – Council on Environmental Quality	NIST – National Institute of Standards and Technology
CMRA – Climate Mapping for Resilience and Adaptation Portal	NCO – National Coordination Office [USGCRP]
CSC – Climate Services Coordinator	NCSP – National Climate Services Partnership
DOD – Department of Defense	NIH – National Institutes of Health
DOE – Department of Energy	NOAA – National Oceanic and Atmospheric Administration
DOT – Department of Transportation	NRDP – National Drought Resilience Partnership
EJIWG – Interagency Working Group on Environmental Justice	NSTC – National Science and Technology Council
EO – Executive Order	OMB – Office of Management and Budget
EPA – Environmental Protection Agency	OSTP – Office of Science and Technology Policy
FARG – Federal Adaptation and Resilience Group	REWG – Renewable Energy Working Group
FEMA – Federal Emergency Management Agency	SGCR – Subcommittee on Global Change Research
FGDC – Federal Geographic Data Committee	SGCS – Subcommittee on Global Change Services
FTAC – Fast Track Action Committee	SLTT – State, Local, Tribal, and Territorial
GCRA – Global Change Research Act [of 1990]	SSCC – Social Sciences Coordination Committee
GDP – Gross Domestic Product	USDA – U.S. Department of Agriculture
GFCS – Global Framework for Climate Services	USGCRP – U.S. Global Change Research Program
GSA – General Services Administration	USGS – U.S. Geological Survey
HHS – Department of Health and Human Services	WMO – World Meteorological Organization
ICAMS – Interagency Council for Advancing Meteorological Services	
ICAWS – Interagency Council for Advancing Weather Services	
IndIWG – Indicators Interagency Working Group	