PUBLIC DRAFT: NATIONAL PLAN FOR CIVIL EARTH OBSERVATIONS

A Report by the

SUBCOMMITTEE ON U.S. GROUP ON EARTH OBSERVATIONS

COMMITTEE ON ENVIRONMENT

of the

NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

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About this Document

This public draft of the 2023 National Plan for Civil Earth Observations, developed by USGEO, is based on a vision for continued United States global leadership in enabling and leveraging civil Earth Observations to increase access to Earth data, and address global changes. This vision will be achieved by measures to mitigate climate change, strengthen environmental monitoring, and improve human health and safety. Strategic objectives are identified for each goal, along with national priorities and recommendations.

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Executive Summary

Earth observations inform national and local plans for, and responses to, some of the greatest challenges and opportunities of our time – climate change, extreme weather events, food and water security, disaster response, and environmental justice and equity, among others.

To address these societal challenges, the Biden-Harris Administration is investing in civil Earth observation capabilities to better understand, monitor, and adapt to climate and environmental change, using technological advances, accelerating private sector innovation and investment, and nurturing cross-sectoral and international ally and partner capabilities. The nation's civil Earth Observations Enterprise – companies, academia, nonprofits, philanthropies, Tribes, government, non-governmental organizations, and more – enables both public and private sector to produce information, provide services, enable solutions, and expand social and economic benefits to every American, every day. Engagement with a diversity of stakeholders from across the Enterprise is key in understanding user needs to inform Earth Observations planning and actions.

This National Plan for Civil Earth Observations provides a vision for continued United States global leadership in enabling and leveraging civil Earth Observations to increase access to Earth data and address global changes. In developing this plan, USGEO established three overarching principles that guided its approach and support the vision:

1. Improve the integration of Earth observing services across Federal agencies and the broader Earth Observation Enterprise;
2. Ensure integrity of Earth Observations data across the Earth Observations Enterprise, and
3. Ensure the continued availability of foundational United States Government capabilities in atmosphere, land, ice, and ocean Earth Observations, while expanding the use of commercial data and services.

To realize this vision in ways that advance Administration priorities and engage with agency and stakeholder needs, this plan emphasizes three thematic, interconnected goals, objectives and cross-cutting Enterprise Initiatives. The three goals, with corresponding objectives are:

Goal 1. Advance Science-Informed Climate Mitigation and Adaptation Activities: This goal focuses on fostering coordination of observations to support research, inform the development of climate services, and expand access to Earth Observations. Key objectives highlight:

1. Expanding observations for future climate products and services
2. Improving our understanding of the impact of Earth Observations on climate mitigation and adaptation strategies, and
3. Incorporating Earth Observations data into change in Earth systems calculations

Goal 2. Strengthen Environmental Monitoring and Management: This goal focuses on integrating Earth Observations service delivery along the entire value chain, from observation and product processing, through modeling and analysis, to monitoring and forecasting, and finally to decision making, planning, and evaluation. Key objectives highlight:

1. Expanding observations to monitor landscape change,
2. Better connecting biodiversity research and management activities across spatial, temporal, and categorical scales
3. Improving the use of Earth Observations for all aspects of wildland fire preparation, response, and recovery, and
4. Supporting efficient and sustainable use of the nation's natural resources.

Goal 3. Improve Human Health and Safety: In addition to the decision support use of Earth Observations for extreme and severe events, this goal also focuses on the maturing application of Earth Observations to inform public health policy and planning. Key objectives highlight:

1. Reducing disparities in access to public health information
2. Reducing societal exposure to environmental risks and hazards,
3. Understanding the cascading impacts of extreme events on public health, and
4. Improving the nation's ability to monitor and forecast those events.

In addition to these goals, the National Plan engages organizations across the Earth Observation Enterprise through a series of enterprise-level initiatives that focus on:

Initiative A. Sustained Observing and Monitoring System Capacity – Earth observations as a reliable enabling infrastructure, ensuring the availability of observations and derivative products over long timescales,

Initiative B. Equitable Access to & Ethical Use of Earth Observations Data – better utilization, integration, and application of Earth observation data to all parties, regardless of technical capability,

Initiative C. Increased Diversity and Expanded Stakeholder Engagement – networking to ensure voices are heard from a multitude of lived experiences and that people from varied fields, backgrounds, and skillsets can connect, collaborate, and ideate.

Initiative D. Domestic and International Partner Collaboration – bridging the gaps to build comprehensive and effective solution to multifaceted problems that would be difficult to address by any single agency,

Initiative E. Institutional and Workforce Readiness – realignment of both scientific and technical skills needed for an informed workforce to tackle the impacts of a changing climate, and

Initiative F. Continuous Assessment of Earth Observation Systems – understanding of the impact of existing and planned Earth observing systems in fulfilling and advancing needed measurements.

In combination, these initiatives accomplish the National Plan goals to realize ever-increasing benefits of Earth observations for society.

By implementing this congressionally mandated National Plan, the United States will usher in an era of better integrated, ubiquitous, and impactful Earth Observations capabilities, answer urgent questions about our planet's changing environment, and apply Earth science system insights to ensure that humanity continues to thrive.

I. Introduction: Civil Earth Observations and America's Future

This National Plan seeks to significantly advance the coordination across the Earth Observations Enterprise (EOE), increase efficiency and efficacy of future Earth Observation efforts, and promote environmental and economic sustainability. The outcomes are designed to address three challenges facing the world today – climate change[1], environmental degradation, and human health and safety – with advances that will benefit humanity broadly. Information about our environment and climate, how they are changing, and the implications for human health and prosperity shape our everyday lives, often in unseen ways. More detailed and actionable information allows us to better understand and manage our relationship with the planet. Capitalizing on the context, scale, and perspective provided by reliable, consistent, and authoritative Earth Observations enables informed climate mitigation and adaptation actions, enhanced environmental sustainability, and improved public health delivery. This, in turn, strengthens national security, advances national prosperity, and helps cultivate a defensible and resilient digital ecosystem.

This National Plan seeks to cultivate U.S. leadership capabilities to understand, monitor, forecast, and manage changes within the Earth system. It improves coordination across the Earth Observations Enterprise, increasing the effectiveness of future Earth Observations investments and promoting environmental and economic sustainability. Building on current capabilities and filling critical gaps across observing systems enables actors across the EOE to address challenges and craft solutions to interconnected social, economic, and environmental concerns. Objectives identified in the plan support national imperatives to secure food, water, and mineral resources, protect public health, build adaptable and resilient communities, and provide equitable services to underserved communities.

Human-induced climate change is affecting natural ecosystems and human communities in the United States and around the world, such as through shifts in seasonal temperature and precipitation patterns and the more frequent and widespread occurrence of extreme events (e.g., record temperatures, severe storms). These changes impact the nation in many ways, including our national security and ability to produce our own food, manage water supplies and other natural resources.[2] Civil Earth Observations enable better understanding of these threats and inform appropriate action.[3]

Information about the Earth's lands, ocean, and waters is essential to a wide array of management and environmental forecasting systems, including agricultural planning, river forecasting, and ecosystem management. For example, monitoring networks help communities better plan for and respond to the local consequences of global climate change, and understanding water access and availability has implications for health, food production, recreation, and more. Earth Observations can aid the transition to green energy by identifying new sources of critical minerals within the United States and

[1] White House, *Fifth National Climate Assessment (NCA5)* (Washington, DC: White House, November 2023). https://www.whitehouse.gov/briefing-room/statements-releases/2023/11/14/fact-sheet-biden-harris-administration-releases-fifth-national-climate-assessment-and-announces-more-than-6-billion-to-strengthen-climate-resilience-across-the-country/.

[2] White House, *National Security Strategy* (Washington, DC: White House, October 2022). www.whitehouse.gov/wp-content/uploads/2022/10/Biden-Harris-Administrations-National-Security-Strategy-10.2022.pdf.

[3] For example: NOAA. *Monthly Climate Report*. www.ncei.noaa.gov/access/monitoring/monthly-report/; NOAA. *Arctic Report Card*. arctic.noaa.gov/report-card/; NASA. *Global Climate Change—Vital Signs of the Planet*. climate.nasa.gov/; U.S. EPA. *Climate Change Indicators in the United States*. www.epa.gov/climate-indicators; USGS. *National Climate Change Viewer*. www.usgs.gov/tools/national-climate-change-viewer-nccv.

our allies. This improves national security by reducing risks of supply chain disruptions caused by conflict or in cases where countries leverage market dominance, to influence international policy.

Many public health challenges are linked to observable Earth system processes, with the World Health Organization estimating that nearly a quarter of all deaths worldwide are attributable to modifiable environmental factors.[4] For example, air pollutants, such as ozone and particulate matter, increase the amount and seriousness of lung and heart disease and other health problems,[5] and outdoor air pollution is estimated to have caused 4.2 million premature deaths worldwide in 2019.[6]

This 2024 National Plan follows the 2013 National Strategy for Civil Earth Observations[7] and builds on the two prior National Plans.[8] The 2014 National Plan established a framework of sustained and experimental observations for public services and research in the public interest. The 2019 National Plan introduced the EOE, expanded utilization of commercial data, and advanced uptake of Earth Observations data by users and decision-makers.

The 2024 National Plan guides the Earth Observations Enterprise and the nation in addressing near-term challenges and establishing long-term efforts to harness the power of civil Earth observations for the broader benefit of humanity. The plan captures trends and opportunities and specifies actions to achieve U.S. goals in alignment with both national and international concerns.

Civil Earth Observations has progressed significantly in the decade since the inaugural National Plan in 2014. Improved coordination between federal agencies, international partners, private industry, and others developed a robust EOE and evolving Earth Observations infrastructure capable of incorporating new technologies to provide new observation data and products to inform decision-making. This investment supports both national priorities and international obligations (e.g., U.S. membership in the World Meteorological Organization[9]). However, new demands for EO continue to emerge, driven by the need to better understand the impacts of the changing climate and Earth system across diverse scales of decision-making.

Sections II-IV of this plan address some of these demands through the lens of three Administration goals focused on climate mitigation and adaptation, environmental monitoring, and human health and safety. Within each goal, the plan identifies key objectives and activities that, when realized, will yield capabilities supporting societal, scientific, and national security needs across many disciplines and sectors.

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[4] World Health Organization. "Preventing disease through health environments: a global assessment of the burden of disease from environmental risks." 14 March 2016. www.who.int/news/item/14-03-2016-preventing-disease-through-healthy-environments-a-global-assessment-of-the-burden-of-disease-from-environmental-risks.

[5] U.S. EPA. *Research on Health Effects from Air Pollution*. Updated 26 January 2023. www.epa.gov/air-research/research-health-effects-air-pollution.

[6] World Health Organization. *Ambient (outdoor) air pollution*. 19 December 2022. www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health.

[7] White House. *2019 National Plan for Civil Earth Observations*. December 2019. https://usgeo.gov/uploads/Natl-Plan-for-Civil-Earth-Obs.pdf.

[8] *National Aeronautics and Space Administration Authorization Act of 2010*. Public Law 111-267, Section 702 (42 U.S.C. §18371). https://www.govinfo.gov/content/pkg/PLAW-111publ267/html/PLAW-111publ267.htm.

[9] World Meteorological Organization. *Convention of the World Meteorological Organization*. Article 2—Purposes, Section (a). Accessed 6 October 2023. oag.gov.bt/wp-content/uploads/2011/02/Convention-of-the-World-Meteorological-Organization.pdf.

Section V discusses six cross-cutting Enterprise Initiatives that in combination accomplish the National Plan goals to realize ever-increasing benefits of Earth observations for society. Engagement with a diversity of stakeholders from across the Enterprise is a key element of implementing this plan.

Collectively, the Plan's goals, objectives, and initiatives address three of the most critical challenges facing the world today, with advances that will benefit the nation and humanity broadly.

II. Goal 1. Advancing Science-Informed Climate Mitigation and Adaptation Activities

Increasing global average atmospheric and marine temperatures, shrinking glaciers and polar sea ice, and rising sea levels are all evidence of climate change caused by anthropogenic emissions of greenhouse gases.[10] A changing climate includes many deleterious changes in heatwaves, wildfires, droughts, extreme rainfall, coastal flooding, winter storms, and hurricanes that impact both the natural and human world.. These consequences are having—and will continue to have—profound impacts on human lives, ecosystems, and the global economy. There is the potential for these impacts to cascade and compound one another, exacerbating social inequalities, posing geopolitical challenges, and serving as societal destabilization events.[11] The federal government has a significant role to play, and addressing the climate change crisis requires a whole-of-society response.

Close cooperation among USG interagency working groups will foster coordination on observations that underpin and inform research and the development of climate services, as identified by the *Fast Track Action Committee on Climate Services*.[12] Expanded outreach and engagement efforts through member agencies, as well as from USGEO itself will encourage the wider community to access Earth observations facilitates non-traditional uses of datasets for product development, and it facilitates scientific standardization and encourages consensus among international partners on Earth Observations.

This National Plan articulates three Objectives for near-term attention for the EOE to bring Earth observations—data, analyses, solutions—to bear in the collective response to the climate crisis and environmental and societal changes.

Objective 1.1. Expand Observations for Future Climate Products and Services

Earth observations are invaluable resources for assessing the dynamics and impacts of climate and environmental change. Improving our nation's Earth observations capabilities strengthens our capacity to reduce damage to life, health, and property from extreme weather events and other impacts made worse by climate change. One way the EOE can strengthen climate capabilities for the future is to

[10] Intergovernmental Panel on Climate Change (IPCC). 2023. Summary for Policymakers. In: *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 1–34. doi: 10.59327/IPCC/AR6-9789291691647.001.

[11] U.S. Global Climate Research Program (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, 1506 pp. doi: 10.7930/NCA4.2018.

[12] White House. *A Federal Framework and Action Plan for Climate Services*. Product of the Fast Track Action Committee on Climate Services, March 2023, 53 pp. www.whitehouse.gov/wp-content/uploads/2023/03/FTAC_Report_03222023_508.pdf.

remain aware of evolving community end-user needs. This includes continuing to address the range of space/time resolutions, accuracies, and data latencies that end-user applications require, as well as continuing to invest in basic research and technology development to better meet anticipated demands, scientifically and societally. It is critical to maintain our capacity for high-quality Earth Observations to track long-term environmental change at the global scale (e.g., sea level rise and ocean systems, ecosystem function, radiative forcing, albedo, greenhouse gas emissions, land use). An activity to realize this objective includes:

Improve Observations of Greenhouse Gas Emissions to Better Advance Climate Goals: Adequate monitoring of GHG emissions and removals is critical to identifying opportunities to reduce emissions, understanding the efficacy of climate mitigation measures and policies, especially as the U.S. works to reduce its net GHG emissions by 50-52 percent below 2005 levels by 2030. To appropriately inform mitigation actions and assess the efficacy of mitigation policies, the U.S. Government will work to prioritize measurement, monitoring, reporting, and verification (MMRV) of GHG emissions with improved atmospheric Earth observations (e.g., spectral, spatial, and temporal resolution, data latency) to help meet the goals noted above. For example, the EOE could focus on methane emissions, a greenhouse gas that is more than 80 times as potent in trapping heat than carbon dioxide over the first 20 years after it reaches the atmosphere.

Improving Relevant Observations to Address Climate Modeling Needs: It is important that the EOE provides the needed resolutions—spatial, spectral, and temporal—to monitor change, inform decisions, and track progress at regional and local scales, which ultimately improves national capabilities to model and forecast the impacts of climate change. USGEO will assess evolving end-user needs and associated technical requirements, and inform development of new monitoring and observational capabilities critical to climate models and climate response actions community.

Objective 1.2. Improve Evaluation of Observation Impacts on Climate Strategies

Earth observations data supports a range of uses and a diversity of user communities. Widely accessible, available, and trustworthy Earth observations data can help improve understanding, monitoring, and forecasting to support and evaluate mitigation and adaptation strategies. Improving understanding of how Earth observations are used in societal and policy contexts will benefit the EOE by demonstrating utility, identifying user needs, and establishing the impact of integrated Earth observations. An activity to realize this objective includes:

Establish Earth Observations Data Use Metrics: USGEO will coordinate the EOE to establish regular, repeatable, and reliable online use metrics for Earth Observations data to track use of observational and modeled data (e.g., GHG emission and sequestration dynamics, extreme weather events, land-use change) for informing forecasting, policy and planning, and response activities. In addition, developing use metrics enables the EOE to evaluate the impact of datasets for climate change mitigation and adaptation policies and activities, as well as to inform future Earth observations planning.

Objective 1.3. Incorporate Observations into Change in Earth Systems Calculations

Over the last decade, the use of Earth Observations to inform policy has steadily increased. An area that needs attention is integrating Earth Observations into social and economic cost calculations, especially climate-related economic and financial risk.

The costs of climate risk, from more frequent coastal flooding to more severe heat waves, will likely continue to rise in the coming years and negatively impact our health, well-being, security, and the economy. For example, climate change can negatively affect agricultural yields[13] and public health[14] while increasing the likelihood and cost of response to natural disasters.[15] Most economic and social policies do not fully consider more frequent extreme weather and climate-related shocks.

Informing social and economic policy with Earth observations-based climate risk would help make the Nation and economy more resilient to current and future climate change. Through better uses of Earth Observations, the nation could help limit the costs of climate change to our economy and human health, while better informing the economic forecasting. Activities to realize this objective include:

Improve the integration of Earth Observations and Economic Data: Building upon the Executive Order on Climate-Related Financial Risk,[16] USGEO will facilitate connections between Federal producers of Earth observations, and Federal agencies/entities that conduct economic analyses to advance awareness and inclusion of Earth observations in economic policy.

III. Goal 2. Strengthening Environmental Monitoring and Management

Planning, setting policy, and taking actions that account for the complexities of the natural environment—land, oceans, ice, biosphere, and atmosphere—requires a wealth of information about the interconnected natural and human systems. The insights provided by Earth Observations data, modeling, and analyses are not only essential to management and forecasting systems, such as land management, wildlife conservation, agricultural planning, and river forecasting, but also for national security objectives, which depend on timely and accurate Earth Observations data.

Strengthening environmental monitoring and management requires integrating Earth Observations service delivery along the entire value chain, from observations and product processing, through modeling and analysis, to monitoring and forecasting, and finally decision making, planning, and evaluation. Integrating high quality, timely, and actionable Earth Observations data into U.S. government and private sector decision-making will positively benefit both long-term sustainability objectives and national security interests. Intensifying physical effects of climate change will increase risks to U.S. national security through 2040, especially as geopolitical tensions mount over how to respond to climate change. Continued and uninterrupted civil Earth Observations systems is critical for both civil and national security use cases.

This National Plan articulates four Objectives for the EOE's near-term attention to lead in strengthening environmental monitoring and management.

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[13] U.S. EPA. *Climate Change Impacts on Agriculture and Food Supply*. Updated 8 September 2023. www.epa.gov/climateimpacts/climate-change-impacts-agriculture-and-food-supply.

[14] Department of Health and Human Services, Centers for Disease Control and Prevention. *Climate Effects on Health*. Last reviewed 25 April 2022. www.cdc.gov/climateandhealth/effects/default.htm.

[15] Department of Commerce, National Oceanic and Atmospheric Administration, National Centers for Environmental Information (NCEI). 2023. *Billion-Dollar Weather and Climate Disasters*. www.ncei.noaa.gov/access/billions/, doi: 10.25921/stkw-7w73.

[16] Executive Order No. 14030. "Climate-Related Financial Risk." *Federal Register* 86, no. 99. (25 May 2021): 27967–27971. https://www.federalregister.gov/documents/2021/05/25/2021-11168/climate-related-financial-risk.

Objective 2.1. Expand Observations to Monitor Earth Systems Change

Reliable and robust Earth Observations are needed to establish baselines and monitor changes in all types of landscapes across the country, and can underpin and support current U.S. Government initiatives, such as the National Nature Assessment,[17] America the Beautiful,[18] National Natural Capital Accounting,[19] and Nature Based Solutions.[20] Improved tracking of landscape changes would advance future risk assessments of U.S. Earth systems , society, and economy, and would deliver actionable science to underpin climate mitigation and adaptation strategies. Approaches developed in the United States can be used as part of diplomatic aid development to increase international cooperation, improve regional stability, and reduce climate change induced migration.

Projected changes to the environment over the next 50 years are expected to impact the health, productivity, and biodiversity of U.S. terrestrial, wetland, freshwater, and marine ecosystems. Continuous, integrated assessments of the current state and ongoing changes in the natural environment and resources are critical to understanding the causes and consequences of these events and to mitigating their future impacts. However, the U.S. currently lacks an integrated way to track landscape changes, which limits the ability to characterize, forecast, and anticipate future change.

The EOE will need to both sustain and improve observational, and assessment capabilities to monitor, model, and forecast changes to terrestrial, wetland, freshwater, and marine ecosystems. Activities to realize this objective include:

Develop interdisciplinary, integrated national Earth system assessments: Assessment capabilities will focus on integrating Earth Observation capabilities and modeling to support annual reports that identify areas currently experiencing change, the drivers of change, forecast landscapes that will be at risk in the future, and evaluate the impacts of future changes and actions, including climate mitigation and adaptation strategies.

Support America the Beautiful: America the Beautiful is a decade-long initiative and nationwide effort to conserve, connect, and restore American lands, waters, and wildlife. To support the contributions of Earth observations and scientific information to this initiative, USGEO will engage the relevant agencies and the EOE in identifying the essential observations and making them available and useful for greatest impact. These efforts include activities to assess future risk and vulnerabilities to U.S. landscapes, to inform forward-looking conversation and restoration actions.

Benchmark Sites Partnership: Explore the concept for an Earth Observations Enterprise-wide partnership between civil agencies, the Intelligence Community, academia, and the private sector, to

[17] Department of Interior, Office of Policy Analysis. *National Nature Assessment*. Accessed 6 October 2023. www.doi.gov/ppa/national-nature-assessment.

[18] Department of Interior. *America the Beautiful: Spotlighting the work to restore, connect and conserve 30 percent of lands and waters by 2030*. Accessed 6 October 2023. www.doi.gov/priorities/america-the-beautiful.

[19] White House. "Fact Sheet: Biden-Harris Administration Releases National Strategy to Put Nature on the Nation's Balance Sheet." White House press release, 19 January 2023. www.whitehouse.gov/ostp/news-updates/2023/01/19/fact-sheet-biden-harris-administration-releases-national-strategy-to-put-nature-on-the-nations-balance-sheet/.

[20] White House. "Fact Sheet: Biden-Harris Administration Announces Roadmap for Nature-Based Solutions to Fight Climate Change, Strengthen Communities, and Support Local Economies." White House press release, 8 November 2022. www.whitehouse.gov/briefing-room/statements-releases/2022/11/08/fact-sheet-biden-%E2%81%A0harris-administration-announces-roadmap-for-nature-based-solutions-to-fight-climate-change-strengthen-communities-and-support-local-economies/.

compile a systematic time series of high- and moderate-resolution remote sensing images over key sites around the world deemed most vulnerable to environmental shifts and damage due to the impacts of climate change. These sites would be selected to optimally monitor changes in geologic processes, land use/land cover, atmospheric processes, ice and snow dynamics, ocean processes, and others to study environmental and ecosystem changes and early warning of environmental stresses.

Objective 2.2. Connect Activities across Scales from Genetic to Global

Better connecting biodiversity research and management activities across spatial, temporal, and categorical scales is essential to implementing effective management, conservation, sustainable use, and restoration activities. As aided by a range of Earth Observations, robust characterizations of both coarse and fine-scale changes add insights into habitat use, integrity, and connectivity critical for decisions related to conservation, land management, and human health.

Major elements of scale, including temporal, spatial, functional, and phylogenetic, are challenging to integrate with one another. Fine-scale biological observations need to be combined with landscape-level observations to improve modeling and map wildlife movements against habitat, resources, and other environmental data. Improving capabilities for these observations and integrating results across scales would enable more strategic, precise, and cost-effective decisions that mitigate impacts of land-use change, development, and climate, and improve management of resources, habitats, and populations. The EOE has significant opportunities to expand the diversity of EO and the value of EO in the management and conservation of natural resources, supporting sustainability and mitigating threats to biodiversity. An activity to realize this objective is:

Improve the integration of* in situ *and space-based fauna tracking to inform species management: Linking *in situ* and space-based animal movement data with environmental data would provide information on habitat use, integrity, and connectivity critical for decisions related to conservation, land and water management, and human health. Additionally, improving biodiversity mapping will allow for better enforcement to reduce wildlife trafficking and enforce harvesting quotas. USGEO will continue to make connections between producers and consumers of this information to better inform policies and actions related to biodiversity.

Objective 2.3. Improve Fire Preparation, Response, and Recovery

Fire seasons are growing in intensity and duration across the globe. Effective wildfire management requires improved input across all phases of fire, encompassing mitigation and adaptation (e.g., fuels assessment and management, climate projections), fire prediction (e.g., fire potential and intensity), detection and monitoring (strategic monitoring), firefighting (e.g., tactical fire monitoring, fire behavior modeling, smoke and air quality), post-fire assessment (e.g., burn severity assessment, landslide potential, carbon release) and rehabilitation and restoration (e.g., land cover, ecosystem recovery). For example, civil EO provide a decision-making advantage to incident management teams and land managers tasked with managing active wildland fires that threaten human lives, natural resources, and property. They also provide key information used to assess wildland fire risk and to prioritize and plan wildland fire risk reduction activities in pre- and post-fire management decision making.

Improved observations and models of fuel moisture, soil moisture, and smoke observations and forecasts are critical for determining where to focus wildland fire risk reduction activities and to develop lines of control and improving outcomes for controlling wildland fires. These models can be leveraged as educational tools in fire-prone locations to help landowners and land managers assess fire risks and

mitigate potential threat to safety and damage to critical infrastructure and property. An activity to realize this objective includes:

Provide Access to Modern Tools for Informed Decision Support for Fire Management: While the current paradigm is predominantly oriented towards reacting to wildfire events, the USGEO will work with the broader EOE towards providing the firefighting community with the data, science, and Earth Observations technology required to support more proactive wildfire management activities.[21] In addition to supporting fire weather forecasting and wildfire prediction, the wildfire management community will continue working on improving its data aggregation and analysis capability in support of existing wildfire monitoring and response efforts.

Objective 2.4. Support Efficient and Sustainable Use of Natural Resources

Land and resource managers need to quantify and monitor the extraction, production, and use of natural resources for meeting various human needs, along with maintaining natural environments. They also need to factor in the non-use value of other ecosystem services, such as aesthetic enjoyment, cultural heritage, and preservation, in order to optimize resource allocation and use, maximizing efficiency and sustainability. Effectively managing finite resources requires extensive oversight and analysis to understand the extraction, production, and use of natural resources both legally and illegally. Earth Observations systems support the valuation of natural resources and ecosystem services, which can have broader application on sustainable resource management, encompassing the assessment of use, non-use, option values, ecological optimum use, economic optimum use, and future sustainable use of natural resources.

The EOE should invest in the ability to capture appropriately resolved EO data on the availability and distribution of resources such as timber, water, minerals, and energy by leveraging satellite, aerial, and *in situ* monitoring networks. Further, the EOE can begin to explore and identify data needs for, and potential planning and policy implications of, Natural Capital Accounting (NCA) and the UN System of Economic and Environmental Accounting[22]. For example, there will be an increasing need for timely Earth Observations data, as the Administration informs the transition from research-grade environmental-economic statistics and natural capital accounts to core statistical products.[23] An activity to realize this objective is:

Improve capacity to deliver thematic data: To better support decision makers responsible for natural resources, USGEO will work with the broader EOE to facilitate the development and delivery of relevant, accurate, low-latency thematic data by downstream value-added providers. This information empowers decision makers to optimize resource allocation and use, including for Natural Capital Accounting, thereby maximizing efficiency and sustainability.

IV. Goal 3. Improving Human Health and Safety

[21] U.S. Department of Agriculture (USDA). September 2023. *ON FIRE: The Report of the Wildland Fire Mitigation and Management Commission*. 340 pp. www.usda.gov/sites/default/files/documents/wfmmc-final-report-09-2023.pdf.

[22] United Nations. *System of Environmental Economic Accounting: Introduction to Ecosystem Accounting*. Accessed 6 October 2023. https://seea.un.org/Introduction-to-Ecosystem-Accounting.

[23] White House. *National Strategy to Develop Statistics for Environmental-Economic Decisions: A U.S. System of Natural Capital Accounting and Associated Environmental-Economic Statistics*. January 2023. (Report by OSTP, Office of Management and Budget, and Department of Commerce). www.whitehouse.gov/wp-content/uploads/2023/01/Natural-Capital-Accounting-Strategy-final.pdf.

Earth Observations can be foundational for characterizing, managing, and communicating risks to human health and safety. The application of Earth Observations for human safety, such as informing the preparation, response, and recovery protocols for extreme weather events, is also emerging as a driver for innovation in human health services. While the applications of EO are not as mature or as well-integrated into public health services as other human safety applications, such as drought monitoring and severe weather forecast services, the EOE can help fill that human health operational gap. Doing so would require identifying basic research and development needs, from formulating new observational capabilities and technologies, through implementation, application, and operational support of human health, safety, and well-being.

The EOE can actively inform human health policy and decision making by ensuring fair and just access to environmental resources, to facilitate protection from environmental hazards, and to support environmental decision-making.[24] Due to historic land-use patterns and property policies, the most vulnerable and least well-off communities often face the biggest human health threats (e.g., poor air or water quality, urban heat island effect, access to green/blue space, toxin exposure, flooding) from their surroundings. As we think about the potential for Earth Observations to inform human health and equity concerns, the EOE can work to ensure that data from communities are collected equitably and justly, in coordination with affected communities, and that the data are used to actively assess and resolve equity concerns so that communities can start to address inequities in access to resources.

This National Plan articulates four Objectives for the EOE's near-term attention to lead in improving human health and safety outcomes.

Objective 3.1. Reduce Disparities in Access to Public Health Information

Reliable and repeatable Earth Observations data can often empower communities to effectively address pressing public safety challenges. Integrating Earth Observations and public health data into Earth system models and algorithms will add value to the overall monitoring enterprise, lessen disparities across communities, and provide the information needed to make informed decisions concerning options for improving individual health. For example, information on water quality is needed for all lakes and ponds across the country to alert the public to possible water-borne diseases, while early-warning systems for flash floods and lightning are necessary for citizen safety in both rural areas and cities.

Despite the United States possessing the most dense and advanced *in situ* Earth Observation monitoring network in the world, only a small fraction of the population lives close to current measurement sites that monitor environmental conditions relevant to their daily lives.[25] For example, New York City, with a population of 8.5 million, only has five surface ozone monitors and 12 PM2.5

[24] For example: U.S. EPA. Equitable Development and Environmental Justice. Updated 30 August 2023. www.epa.gov/environmentaljustice/equitable-development-and-environmental-justice; Department of Health and Human Services (HHS). Climate Change & Health Equity, and Environmental Justice at HHS. Last Reviewed 30 March 2023. https://www.hhs.gov/climate-change-health-equity-environmental-justice/index.html; HHS, Centers for Disease Control and Prevention, Agency for Toxic Substances and Disease Registry. Environmental Justice Index. Last Reviewed 20 June 2023. www.atsdr.cdc.gov/placeandhealth/eji/index.html; National Conference of State Legislatures. State and Federal Environmental Justice Efforts. Updated 26 May 2023. www.ncsl.org/environment-and-natural-resources/state-and-federal-environmental-justice-efforts.

[25] U.S. EPA, Outdoor Air Quality Data. *Interactive Map of Air Quality*. Updated 22 August 2023. www.epa.gov/outdoor-air-quality-data/interactive-map-air-quality-monitors.

monitors that operate year-round. Accurate, frequent *in situ* profiles of gases and aerosols, in urban and rural areas, are required to understand the accuracy of high-resolution, space-based observations.

The EOE can work towards addressing the existing disparities in relevant Earth Observations coverage between rural areas and urban neighborhoods, by engaging interested communities/groups, raising awareness of existing coverage, and identifying priorities for expanded observations. An activity to realize this objective is:

Increase spatial density of repeatable and accessible* in situ *and remote sensed observations: Greater use of Earth Observations data, whether *in situ*, airborne, or satellite-based, will require concerted coordination by agencies within the EOE to ensure that adequate standards for calibration and validation are established. In addition, equitable and reliable data-sharing platforms should be established to ensure reliable access to Earth Observations data that can help inform public health decisions.

Objective 3.2. Reduce Exposure to Environmental Risks and Hazards

The environment around where someone lives and works impacts their health. A harmful environment can expose people to potential health stressors like noise, heat, air pollution and poor air quality, and chemicals and toxics (e.g., pesticides, PFAS). There is also a growing body of evidence that human physical and mental health is connected to how much exposure to nature each individual experiences; the amount of green space and the diversity of species in the local area where each person lives affects mental health, such as rates of depression and anxiety.[26, 27] Additionally, the amount of nature a person experiences also impacts their physical health, such as the likelihood of developing asthma, some cancers, heart disease, and Type II diabetes.[28]

Earth Observations data can be used in conjunction with public health data to further investigate the connections between human health and the environment. The information needed to fully inform the public, community planners, natural resource managers, public health officers, and policymakers on how to reduce exposure to environmental risks and hazards is lacking. The EOE can work with the public health community to help improve our understanding of relationship between public health and our environment.

An assessment of this relationship should be facilitated by examining the value of a human health and environmental data observation network across the United States, enabled by collecting specific health

[26] U.S. Department of Agriculture (USDA), Forest Service. February 2018. "*Urban Nature for Human Health and Well-Being*.": *A research summary for communicating the health benefits of urban trees and green space*. FS-1096. www.fs.usda.gov/sites/default/files/fs_media/fs_document/urbannatureforhumanhealthandwellbeing_508_01_30_18.pdfWashington, DC. 24 pp. www.fs.usda.gov/sites/default/files/fs_media/fs_document/urbannatureforhumanhealthandwellbeing_508_01_30_18.pdf.

[27] Department of Health and Human Services, Office of the Surgeon General. *Our Epidemic of Loneliness and Isolation, 2023*. [Core Writing Team, Julianne Holt-Lunstad and Susan Golant (eds.)]. Washington, DC. 82 pp. https://www.hsdl.org/c/view?docid=878151.

[28] For example: Jimenez, M.P. et al. 2021. "Associations between Nature Exposure and Health: A Review of the Evidence." *Int J Environ Res Public Health*, May 2021, 18(9), 4790. doi: 10.3390/ijerph18094790. www.ncbi.nlm.nih.gov/pmc/articles/PMC8125471/; White, M.P. et al. 2020. "Blue space, health and well-being: A narrative overview and synthesis of potential benefits." *Environ Res*, December 2020, 191. 110169. https://doi.org/10.1016/j.envres.2020.110169https://doi.org/10.1016/j.envres.2020.110169.

and environmental parameters in the same locations to develop a database for examining possible linkages. Activities to realize this objective include:

Improve integration of Earth Observations and public health data: USGEO will support the EOE to improve integration of Earth observational and modeled data with more traditional survey-based environmental risk and public health data and associated health impacts and outcomes, particularly related to urban heat stress, poor air quality, and communicable diseases.

Enhance Ground-Based Networks: The U.S. Government, working with the broader EOE, will support ways to enhance ground-based sensor networks in and around urban environments, including/especially environmental-justice communities, to help improve our understanding of potential health stressors like noise, heat, air pollution and poor air quality, pollen, and chemicals and toxins (e.g., pesticides, PFAS).

Objective 3.3. Characterize the Cascading Impacts of Hazards on Human Health

Natural hazards exacerbated by ecosystem degradation and extreme weather events amplified by climate change, such as hurricanes, fires, and extreme heat, have cascading impacts on public health and safety. These complex but causal relationships require intersectoral collaboration, and Earth Observations can play a significant role.

Hurricanes and the resultant flooding degrade water quality, which can result in water-borne diseases. The smoke from wildland fires causes hazardous air quality that can endanger vulnerable populations and is increasingly affecting the general population. Extreme heat causes heat-related morbidity and mortality and contributes to droughts that threaten our food supply. Public health authorities struggle to mitigate the impact of air pollution, poor water quality, and urban heat islands on vulnerable populations.

Improving understanding of these events and their impacts can increase awareness and prioritize solutions that address public health risks. The EOE can play an important role in supporting decision-making to reduce health risks. This includes reducing risks domestically and internationally, including cases where the U.S. Government aids other nations in times of crisis. The Enterprise should ensure greater collaboration between public health agencies and organizations that provide access to Earth Observations missions and data streams. Activities to realize this objective include:

Improve Environmental Risk Exposure: The EOE will work to sustain and further develop satellite-based, airborne, and *in situ* Earth observational and analytical capabilities to monitor and forecast societal exposure to environmental risks and hazards, such as extreme weather events and other natural hazards, while aiming to increase spatial and temporal accuracy of air and water quality data.

Improve Urban Heat Early Warning: The EOE will work towards improving urban heat early warning systems that use, for example, weather predictions, urban heat island models, and measurements of green infrastructure, by prioritizing developing standards for the interoperability of data of different

types. This would enable communities to better serve citizens during times of extreme heat[29] and can inform national efforts to mitigate heat-related human health impacts[30].

Objective 3.4. Support Monitoring and Forecasting of Extreme Events

The negative societal impacts of disasters such as wildfires, hurricanes, heat waves, and freezes can be reduced with more informed preparedness efforts and faster and more efficient response, supported by Earth Observations data before, during, and after these events. As climate change accelerates, the number of billion-dollar weather and climate events has steadily increased since records began in 1980. The period of 2020-2022 has seen almost half (60) of the total number of events (Consumer Price Index (CPI)-adjusted) from the decade of 2010-2019.[31] Likewise, the increased risks of weather and climate events occurring abroad impacts U.S. interests through increased migration, disruption to supply chains, and reduces the ability of our military, which is deployed globally, to respond. While collaboration of government, research, and the private sector continue to observe phenomena (e.g., atmospheric rivers, wildfire intensity, cloud-cloud lightning detection) unobservable 30 years ago, many improvements need to continue to be made in the monitoring, modeling, and forecasting of severe weather and climate extremes to ensure continued protection of life and property.

Key Earth Observations capabilities to monitor extreme weather are at risk due to aging systems and decades-old technology. The network of surface and ocean observations are unable to fully support expanded climate monitoring and research. Data latency is often too high and barriers to access too great for forecasting and prediction. The planetary boundary layer is under-sampled in the vertical dimension, limiting forecasting skill. Additionally, data assimilation often does not include near real-time surface observations that are key for emergency responders to make decisions that are timely and locally relevant.

Maintaining and improving relevant Earth Observations capabilities are essential for supporting public safety, national security, economic growth, and national research objectives. Continued national investment in land, ocean, and atmosphere observing systems, such as ocean and coastal platforms, weather radars, and additional non-federal surface observing sources, is essential to supporting our understanding of atmosphere and ocean interactions, improving our understanding of how the ocean is changing, and advancing observation and warning capabilities. Lowering latency and access to surface observation data and ensuring greater assimilation will ensure improved integration into prediction and forecast models, seasonal prediction, and the long-term observation record. Activities to realize this objective include:

Observation Continuity and Improvement: USGEO will identify for the EOE key surface, upper air, and space-based Earth Observations capabilities at risk and coordinate the development of plans to assure their continuity. The EOE should work to improve products and services by introducing new capabilities to measure environmental parameters such as winds and precipitation, while improving spatial and

[29] White House. "Fact Sheet: Biden-Harris Administration Takes Action to Protect Communities from Extreme Heat Fueled by the Climate Crisis." White House press release, 11 July 2023. www.whitehouse.gov/briefing-room/statements-releases/2023/07/11/fact-sheet-biden-harris-administration-takes-action-to-protect-communities-from-extreme-heat-fueled-by-the-climate-crisis/.

[30] Department of Commerce, NOAA. *National Integrated Heat Health Information System*. Accessed 6 October 2023. www.heat.gov.

[31] Department of Commerce, National Oceanic and Atmospheric Administration, National Centers for Environmental Information (NCEI). 2023. *Billion-Dollar Weather and Climate Disasters*. www.ncei.noaa.gov/access/billions/, doi: 10.25921/stkw-7w73.

vertical resolutions. These observations also help advance national security objectives and must continue to be maintained and evolve with technological advancements.

Reduce Data Latency: Agencies will identify areas, where improvements to data latency and accessibility would significantly improve health outcomes, and in those instances, U.S. Government expertise will be leveraged to identify potential platforms and observing systems that positively impact human health and safety.

Increase Observation Density: Agencies will coordinate and integrate ocean and land surface observations from Federal and commercial systems to better support human quality-of-life and safety efforts. Specifically, the EOE can work to increase the spatial and temporal density of observations and improve big data assimilation.

V. Enterprise Initiatives

In addition to the objectives identified for the Goals, there are also several challenges and opportunities common across all three goals. These cross-cutting areas have been integrated below into a set of enterprise initiatives for the EOE to address.

Initiative A – Sustained Observing and Monitoring System Capacity

Continuous, high-quality Earth observations serve critical roles in creating numerous economic and societal benefits, supporting the products and services of multiple public and private sector organizations. Earth observations constitute an enabling infrastructure where organizations have reliability that the observations or derivative products will continue to be available over long timescales, if not increased and continually improved. Where continuity is assured, Earth Observations serve as foundational elements in value chains that deliver products, services, and science to decision makers that contribute to public safety, climate change monitoring, adaptation, and mitigation, long-term planning, and more.

The 2014 National Plan defined sustained observations as "measurements taken routinely that Federal agencies are committed to monitoring on an ongoing basis for public services or for Earth-system research in the public interest."[32] Sustained long-term monitoring of the Earth system is central to observing and understanding our changing environment, its impacts on the population and the economy, and for the United States to continue to have a strong research foundation and well-informed decision-support systems for environmental management. To achieve this, it is necessary to identify the most critical capabilities observations (both remote and *in situ*) to be able to guide their ongoing sustainment and, when necessary, reinvigoration.

Many systems initially planned for Earth-system experimental observations are now used as sustained observations for public services, and mechanisms need to be established to identify the right organization(s) to continue to fund and operate these systems, balancing public service priorities with research priorities as needs evolve, and as technologies advance from instrument research to instrument operations. This highlights the lack of sufficient coordination on the national level. While the 2019 National Plan called for a framework to address how agencies share information on planned

[32]White House. 2014. *National Plan for Civil Observations*. July 2014. https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/NSTC/2014_national_plan_for_civil_earth_observations.pdf.

missions, this must be expanded in the coming years to ensure enterprise continuity and contingency planning for sustained Earth observations.

Addressing these challenges will ensure continued access to impactful observations on which the Earth Observation Enterprise relies. As is outlined in this National Plan and the forthcoming Earth Observations Assessment, continuity of these observations is essential to counter the highest risks to life and property, the planet, our economic prosperity, and long-term climate record measurements. Activities to advance this initiative include:

Earth Observations Continuity Framework: This National Plan calls for the formation of a national Earth Observations Continuity Framework. OSTP, working through USGEO as the organizing entity, will work with stakeholders and the EOE to develop this Framework. The Framework is to provide the structure for scoping, governance, and other factors toward ensuring continuity for the Sustained Observations. Observations, The Framework will initially apply to the Sustained Observations for Public Services identified in the 2014 National Plan[33]. The Framework should be in place by the time of the next National Plan. In addition, future National Plans should revise, as necessary, the set of Sustained and Experimental Observations to support routine exercising of the Continuity Framework.

This Continuity Framework is measurement-based rather than observing-system-based. The guiding interest is in the data or information products based on the environmental, social, geophysical, or other parameters associated with the observation priorities. As additional guidelines, the development of the Framework must consider issues of: Reliability, Innovation, Partnership, Openness, Ownership, and Governance.

In addition to measurement continuity, the Continuity Framework also needs to encompass calibration continuity. Research and monitoring activities are supported by an expanding portfolio of Earth observation data from U.S., international, and commercial systems. Calibration processes ensure that measurements remain consistent and that systematic differences among technologies do not influence desired geophysical measurements. The accuracy of Earth observation systems varies as a function of cost, technological maturity, purpose, and other factors. Calibration approaches include on-board measurements, use of terrestrial reference sites, solar and other calibration approaches, depending on the nature location of the system (e.g., space, *in situ*). Calibration is essential to account for the differences among missions, over time, to achieve consistent measurements of environmental variables that support sustained and improved environmental services. Maintaining calibration continuity is essential to ensuring foundational Earth observation data sets provide the maximum value to the Earth Observations Enterprise.

Understanding that observing systems ultimately collect the measurements, Federal agency-level plans stemming from the Framework must account for cross-platform alignment and interaction, avoiding siloed approaches of satellite, *in situ*, ground-based, or other systems. The Framework and ensuing plans must address considerations of system maintenance and upgrades, cross-system calibration and validation, and other lifecycle issues.

The Continuity Framework supports priority setting for the construction of a national portfolio of sustained observations.

[33] Tier 1 – Weather and seasonal monitoring and prediction, Dynamic land-surface monitoring and characterization, Elevation and geolocation, and Water level and flow; Tier 2 – Ecosystem and biodiversity resource surveys, Environmental quality monitoring, Geo-hazard monitoring, and Space weather monitoring

Data Asset Review: In support of the observation continuity framework, USGEO will undertake a parallel effort to review currently collected Earth Observations. This analysis will support the identification of common approaches to archiving, discovering, and retrieving Earth Observations data. An assessment of federal data management system approaches for processing, storage, and dissemination will be conducted. With a view to increasing efficiency, interoperability, and cost reduction, it will enable departments and agencies that collect Earth Observations data to identify how key datasets might be harmonized into common products. It would also be appropriate for external input to inform foregoing efforts, and provide a focus for improving tools for decision support and societal benefit.

Initiative B – Equitable Access & Ethical Use of Earth Observations Data

As the U.S. maintains and grows its investments in collecting Earth Observations data, there is an opportunity to increase the return on investment. Better utilizing, integrating, and leveraging the information that is being collected and improving our ability to provide equitable access to data will make Earth Observations useful to all parties, regardless of technical capability.

Readily accessible and usable data for purposes from research and policy analyses to management and business operations can maximize the societal and economic benefits of both government and private sector Earth Observations investments. Increased opportunities to leverage Earth Observations source investments made for one purpose to serve others can spur innovation and cross-disciplinary insights across the EOE for multiple applications. With commercial sector advances, the sources of data continue to expand. Yet these advances introduce challenges including equitable access to data, compatibility between data sets, redundancy in data sources, reliability of non-authoritative data, continuity of data streams, and reduced transparency. Overcoming these challenges are paramount to ensuring diversity, equity, inclusion, and accessibility (DEIA) principles within the EOE. Increasing data accessibility allows for more communities to benefit from Earth Observations data and engages more contributors to the community.

As data volumes scale, data analysis will become increasingly more dependent on automated services. The use of AI/ML will be key to increasing the efficiency and effectiveness of data analysis, spurring innovation, and increasing the number of people able to access and utilize information. However, the use of AI also introduces ethical and trust concerns, as well as transactional issues around provenance, verification, and reliability. Following Executive Order on the Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence, the EOE can build on the NIST-led guidance on engagement in AI-standards development activities to chart beneficial Earth Observations pathways with AI/ML.[34] Activities to advance this initiative include:

Democratize Data Access: USGEO will support the transformation of federal EO data systems towards Open Science, reducing redundant infrastructure and services, and establish shared architectures that reduces cost for collection, archive, processing, and dissemination of products. USGEO will encourage the adoption of best practices based on open specifications and standards for sharing federally managed Earth Observations services, such as common interface for search, discovery, and access to products and service that will realize operational efficiencies and should maximize the extension of these interfaces to commercial and international Earth Observations data sources. USGEO will also

[34] Department of Commerce, National Institute of Standards and Technology (NIST). *AI Standards: Federal Engagement*. Updated 5 April 2022, Accessed 6 October 2023. https://www.nist.gov/artificial-intelligence/ai-standards-federal-engagement.

support the development of industry standards for commercial data integrity, analysis-readiness, interoperability, reusability, and equitable access for researchers that will simplify data discovery and provide open access for algorithms and methods for Earth observing data and models to maximize the societal benefit of Earth Observations investments by removing barriers to understanding. Such data infrastructure and industry standards will be developed with DEIA principles, and EOE should pay particular attention to ensure that underserved communities have access to these data and can benefit from these investments.

Expand Commercial Data Access: USGEO will promote license strategies that allow access to data beyond the purchasing agency, when appropriate, as well as better coordination of research and development activities and operational services between the federal government and the private sector. This will enable access to commercial data for other Federal agencies, state and local government departments, as well Tribal and Territorial entities to help understand the impacts of climate change, manage land and natural resources, and more effectively address community health and safety.

Promote Ethical AI/ML: Building on a NIST-developed AI Plan, the EOE should develop standards regarding AI/ML and Earth Observations, ensuring that algorithms are built with diversity and inclusion principles and do not skew against any background or geographic area. OSTP, working through USGEO as the organizing entity, will work with stakeholders and the EOE to address AI/ML-standards relative to issues and trends facing the Enterprise. The intent is to advance impactful and ethical uses, expand the size and diversity of the Earth Observations data user community, and help keep pace with growing information flows.

Initiative C – Increased Diversity and Expanded Stakeholder Engagement

Increasing diversity and inclusion and expanding engagement are of strategic importance to the EOE. Ideas and innovation span all sectors of society. The EOE must be welcoming so those ideas and innovations can turn into Earth Observations-based value and societal benefits. Diversity here spans numerous factors, such as race, ethnicity, gender, career stage, academic classification, and more. The more voices that are heard from a variety of lived experiences, the greater the range of feedback and the more robust and resilient our solutions can be. The greater the networking opportunities, the more occasions for people with varied fields, backgrounds, and skillsets to connect, collaborate, and ideate. This diversity in inclusion and in stakeholder engagement can support efforts in co-design and co-development to thrive in the EOE.

In recent years there has been a significant increase in awareness of the potential of EO at the national, and local levels. Driven by advances in both observation and information technology, there is emerging awareness of the broader applicability of Earth Observations data beyond traditional EOE stakeholders:

- **Indigenous Peoples** – Collaborating with holders of Indigenous Knowledge (IK) through social science approaches, including examining the roles of culture, gender, religion, and spirituality to enhance community cohesion and unity, can provide additional insight on the perceived impacts of climate change and best climate mitigation and adaptation practices[35].

[35] White House. *2021 OSTP-CEQ Memorandum* (Washington, DC. White House 2021). https://www.whitehouse.gov/ceq/news-updates/2022/12/01/white-house-releases-first-of-a-kind-indigenous-knowledge-guidance-for-federal-agencies/

- **Environmental Justice** – Underserved communities bear a heavier burden due to many factors, including environmental contamination and climate change, and improving national capability to support these communities is a focus of the Earth Observation Enterprise.

There is growing recognition of the need for an improved engagement of stakeholders by the EOE, especially of underserved and underrepresented communities. The EOE should continue to spearhead dialogues monitoring the emerging needs associated with private sector provisioning of Earth Observations data and information services to Federal agencies through continued and expanded outreach to key industry associations and science organizations in the interest of shared learning and partnerships. It is important for the U.S. Government to nurture its linkages, shared learning, and partnership across the diverse entities of the EOE in efforts to build a more diverse and inclusive EOE.

There is increasing attention to co-design and co-production (also known as co-development) in the engagement among stakeholders, user communities, and researchers. In building relationships with Indigenous communities and Environmental Justice issues, the EOE can advance its use of co-development approaches in support of advances and increased capacity, which can enhance usability and relevance of Earth Observations information. Activities to advance this initiative include:

USGEO to create an Engagement Working Group: This National Plan calls for the EOE to strive to better reflect the diversity of the country, tapping the intellectual, innovative, and imaginative power in that pluralism. Towards this end, Enterprise leaders can use their standing, influence, and leadership positions in their communities to signal and model the value of diversity, equity, and inclusion. This Plan calls on the EOE, working through USGEO as the organizing entity, to address pathways for greater diversity and creating a sense of belonging for all individuals.

Strengthen Engagement with Local & Tribal Communities: USGEO will develop a strategy for engagement beyond federal stakeholders according to DEIA principles to better understand both their needs and use of Earth Observations data. In the coming years, the United States will need to leverage new and creative partnerships and collaborative frameworks by advancing the collection, use, and application of Earth Observations. Engagement with communities is necessary to facilitate their preparedness for and adaptation to extreme weather events and the curation of data that are most useful to the public. Better elevation and consideration of knowledge and capabilities of local communities, Tribal governments, and other under-represented stakeholder groups into the co-production of regional and national research, planning, and implementation activities is key to the broad, equitable use of Earth Observations.

Promote Earth Observations Resource Discoverability: Earth Observations can play a vital role in identifying opportunities to map, monitor, and better inform places where inequities in society have led to inequities in many aspects of life, including human health impacts. Science-informed data, knowledge, and product services need to be responsive to, and usable by, end users, from city and emergency managers to NGOs directly supporting underserved community needs. USG Earth Observations will promote the discoverability of Earth Observations resources beyond the EOE's traditional stakeholders to inform human health and equity concern and providing the Earth Observations resources to meet the needs of State, local, Tribal, and territorial governments, and underserved communities.

Incorporating Indigenous Knowledge (IK): USGEO will promote approaches to integrate IK into the EOE. IK can offer a unique perspective of the local impacts of climate change and weather extremes of a selected community or geographic area. There are significant opportunities to elevate traditional and Indigenous Knowledge in the EOE, and mechanisms for Tribal consultation and the strengthening of

nation-to-nation relationships for Earth Observations can be established. By integrating IK with the spatial and temporal resolution of Earth observations, a clear image of the spatial and temporal aspects of our changing planet coupled with the human experience can be depicted. This needs to be done in a way that ensures that equitable access and interoperability of Earth Observations data and products align with the FAIR, CARE, and TRUST principles.

Initiative D – Domestic and International Partner Collaboration

Interagency communication and coordination will play an increasingly important role in addressing the needs and challenges faced by the nation in meeting the increasing demands for useful, accessible, and inclusive data and information. Interagency collaboration bridges the gaps created by traditional agency silos and enables the leveraging of diverse expertise, resources, and perspectives from organizations with different priorities, resulting in more comprehensive and effective solutions to multifaceted problems that would be difficult to address by any single agency. Earth Observation-related interagency coordination and communication, however, are not limited to the federal level but can also include State, local, and Tribal governments, as well as measures to engage and partner with the public, private and non-profit/NGO sectors. Coordination and communication are relevant at all phases of the process from planning and conceptualization to development and distribution of results and products.

However, even as Earth Observations services become more broadly adopted with U.S. Government agencies, those same services are becoming increasingly dependent on international partner contributions (and vice versa). As collaboration extends beyond domestic entities to international partners and organizations, issues of governance, provenance, and methods across the international EOE is central to maximizing Earth Observations investments through the integration of Earth Observation systems, data, and services. However, an unintended consequence of federal acquisition practices for Earth Observations data is the tight coupling between the agencies that develop, deploy, operate, and maintain an observing system and the users who require the resultant data products. This coupling acts as a barrier to broader awareness and application of EO data assets. Activities to advance this initiative include:

Decouple Data Ownership: USGEO will develop guidance for agencies to allow observations to stand alone and be accessed by multiple user communities, both domestic and international. By separating observations from specific applications and incorporating a “one dataset, many uses” approach, coordination efforts can become more streamlined and adaptable. Moreover, this approach will encourage the wider community to access Earth observations to facilitate non-traditional uses of datasets for product development.

Initiative E – Institutional and Workforce Readiness

A foundational aspect of the preparation to tackle the impacts of a changing climate is the realignment of both scientific and technical skills to include general data science skills and scientific communication, for an informed workforce. Specialized knowledge and experience from all communities, and especially underserved and underrepresented ones, is needed to both produce and use Earth Observing data and information. With emerging Earth Observations capabilities, building technical capacity to use, analyze, and interpret remote sensing and other geospatial data sources will be fundamental. Activities to advance this initiative include:

Invest in the Next Generation Workforce: USGEO will lead an effort with DOL to engage the EOE in developing a workforce readiness plan using DEIA principles. Strengthening the scientific, technical, communication, and policy development skills of the next generation workforce to increase the awareness of the societal benefits of Earth Observations and improve equitable science education is an EOE priority. Part of this includes creating a more diverse and inclusive Earth Observations workforce to maximize the societal benefits to all communities, especially with regards to Indigenous communities and environmental justice. To this end, the EOE should advance Education and Outreach to emphasize Earth Observations skills in educational and workforce development activities to provide the foundation for future growth.

Initiative F – Continuous Assessment of Earth Observation Systems

The National Strategy for Civil Earth Observations articulated the use of assessments of existing and planned Earth observing systems for planning around fulfillment and advancements of needed measurements, accounting for future needs and technologies. The organization of assessments around benefit areas is designed to consider the relative impact of observations from multiple sources, as well as the need for measurement continuity for societal benefits that depend on sustained, long-term, and accurate measurements. These assessments are intended to inform the formulation of periodic National Plans for Civil Earth Observations (2013 Strategy).

This plan recommits to the 2013 National Strategy in conducting observing system assessments to support considerations of continuity, fulfillment, and advancement of measurements. This plan calls for continuous assessments of Earth Observations systems that support the Earth Observations Enterprise and enable benefits to the nation and the world. A continuous assessment process will focus on specific "benefit areas" annually over a four-year period, with an integrated account combining individual assessments every five years. The individual assessments and integrated account will support the formulation of National Plans for Civil Earth Observations. Activities to advance this initiative include:

Continuous Earth Observations Assessment: USGEO will engage with the Earth Observations Enterprise and external stakeholders to design, conduct, and continually improve the assessment process initiated by the National Strategy. This continuous assessment process will include annual assessments of selected thematic benefit areas and an integrated account combining individual assessment every five years:

Year 1: Climate, Agriculture & Forestry (including wildfires)

Year 2: Disasters, Ecosystems, Water Resources

Year 3: Coastal/Ocean Resources & Ecosystem; Energy & Mineral Resources; Human Health

Year 4: Biodiversity; Transportation; Weather

Year 5: Space Weather; Reference Measurements;

The assessments and integrated accounts should include efforts to document user satisfaction with products; reveal linkages and dependencies; identify observing system gaps; support public-private partnerships; consider international and other sources, partnerships, and commitments; and enable cross-agency interactions. The assessments and accounts should support analyses for Federal planning around acquisition and sharing of commercial and other sourcing of Earth observations data, information, and products as possible alternatives to Federally maintained systems. They should also support analyses where Federal systems provide foundational information as enabling infrastructure.

These continuous assessments will set the nation on a course for continuous assessments of Earth observing systems.

VI Conclusion

Civil Earth observations benefit every person, every day. Earth observations are an essential infrastructure for U.S. and global economic and public well-being, with functions supporting America's public and national security interests. The Earth's environment is changing, impacting water availability and quality, heat events, air quality, food scarcity, and more. The 2024 National Plan furthers the efficiency, efficacy, and equitable impact of the science, information, and operational services derived from increasingly diverse, disaggregated and evolving remote sensing capabilities and assets.

The 2024 National Plan guides federal implementation and coordination of Earth Observations activities, conducted through the budget and program-planning of the relevant federal agencies. This National Plan provides a sustainable and coordinated vision to inform industry, academia, nonprofits, and State, local, Tribal, and territorial governments.

When successfully implemented, this 2024 National Plan will:

- **a)** Focus the nation's efforts on collecting and equitably providing data products, actionable Earth science, and services to the benefit of humanity,
- **b)** Promote the use of Earth observational information routinely, seamlessly, and intelligently throughout the public, nonprofit, and private sectors, and
- **c)** Improve assessment, monitoring, and forecasting of climate change, ecosystem dynamics, and public health conditions, and
- **d)** Advance the use of science and data products from the observations to inform planning and decision-making more effectively across all sectors.

Implementing this National Plan will help ensure the realization of sustainable, long-term, and global societal benefits from the Nation's investment in EO. The plan positions the United States to remain a global leader in Earth observations that benefit humanity.

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Abbreviations and Acronyms

AI	artificial intelligence
CARE	Collective benefit, Authority to control, Responsibility, and Ethics
CPI	consumer price index
DEIA	diversity, equity, inclusion, and accessibility
DOL	Department of Labor
E.O.	Executive Order
EOE	Earth Observations Enterprise
EOP	Executive Office of the President
FAIR	findable, accessible, interoperable, and reusable
GEO	Group on Earth Observations
GHG	greenhouse gas/gasses
IK	Indigenous Knowledge
ML	machine learning
MMRV	measurement, monitoring, reporting, and verification
NASA	National Aeronautics and Space Administration
NCA	National Capital Accounting
NDC	Nationally Determined Contributions
NGO	non-governmental organization
NIST	National Institute of Standards and Technology
NSTC	National Science and Technology Council
OSTP	Office of Science and Technology Policy
PFAS	per- and polyfluorinated/polyfluoroalkyl substances
PM	particulate matter
STEM	science, technology, engineering, and math
TRUST	Transparency, Responsibility, User focus, Sustainability, and Technology
USGEO	U.S. Group on Earth Observations

Appendix A: Summary of Previous National Plans Activities

The following items are select major outcomes resulting from the two previous National Plans.

2019 National Plan

The 2019 National Plan established the Earth Observations Enterprise and articulated three goals and numerous actions to enhance the portfolio of EO, engage with the Enterprise, and increase the impact of Earth Observations. Select examples of achievements and activities resulting from the 2019 Plan include:

Commercial EO Data Purchases

With the advances in commercial EO, USGEO led the EOE in an examination of issues, agency practices, and policies around commercial EO and geospatial data. Dialog sessions, a Federal Request for Information, and a Tabletop Exercise on Data Licensing Challenges all contributed to the 2022 report *United States Government Commercial Earth Observations Data Purchases.* Addressing two 2019 National Plan actions, this document presented 13 recommended practices on EO purchases.

AmeriGEO Expansion

Fulfilling a 2019 National Plan action, the U.S. amplified its efforts with this regional association focused on the Americas. USGEO enabled efforts to create a first-ever AmeriGEO Implementation Plan, launch an AmeriGEO DataHub, and host an Inter-American Academy of Geosciences & Applications. The U.S. successfully advocated to initiate a fifth benefit area focused on public health. Membership in AmeriGEO grew to 20 countries by 2023.

Framework for Interagency Coordination

In 2021, USGEO developed a Framework for interagency coordination of EO investment decisions. This Framework addresses situations when an agency is considering a major change to its observing portfolio, such as a new system, change in capabilities, change in sourcing, or decommissioning. The process provides a forum for discussions on any impacts and courses of action to mitigate the impacts.

Earth Observations Assessment

In 2023, USGEO initiated a partial refresh of the previous assessment focused on the Climate and Agriculture/Forestry societal benefit areas. This activity is intended to advance a routine cycle of assessment updates.

2014 National Plan

The 2014 National Plan established a framework of Sustained and Experimental Observations. This Plan identified observation priorities for public services and for research in the public interest. The Plan presented eight actions to improve coordination, support data access, and encourage commercial solutions. Select examples of achievements and activities resulting from the 2014 Plan include:

Coordination on Satellite Needs

In 2015, the U.S. Government initiated the routine collection of agencies' satellite observation needs for NASA to consider as part of its satellite systems engineering and budgeting activities. This biennial process created the first-ever, whole-of-government approach to addressing agencies' civil Earth observation satellite needs. USGEO completed four rounds of this successful process through 2023. These efforts led to the popular Landsat-Sentential Harmonized Data Products, uplifting of NASA

commercial data licenses, and expansion of downlink capabilities for a NASA radar mission, among other advances.

Earth Observations Assessment

In 2016, USGEO completed a rigorous assessment of the relative reliance of Federal civil agencies on Earth observing systems for public services, products, and research. This Assessment identified the Global Positioning System and Landsat as the two most impactful systems across the 13 societal benefit areas examined.

Common Framework for Earth-Observation Data

The *Common Framework* released in 2016 provided guidance to data producers in Federal agencies for improving and standardizing their data-management practices. At a time when increasing data volumes introduced management challenges, the *Framework* was a collective step focused on improve forward toward addressing these challenges, by improving the discoverability, accessibility, and usability of EO data.

AmeriGEO Creation

Fulfilling an action to strengthen international collaboration, the United States was a leader in forming AmeriGEO in 2014 together with other countries in the Americas. Annual symposia enabled interchanges within the Hemisphere, with initially focus on four areas – food security, disasters, biodiversity and ecosystems, and water resources. Nine initial members grew to 15 by 2019.

GEO Associate Category

In 2018, the U.S. successfully advocated for a new Associates category of member in the international Group on Earth Observations (GEO). This change enabled commercial and non-governmental, not-for-profit, and civil society organizations to join as official GEO collaborators. This GEO Associates category grew to 19 members by 2023.