



2024 NATIONAL PLAN FOR CIVIL EARTH OBSERVATIONS

A Report by the
UNITED STATES GROUP ON EARTH OBSERVATIONS SUBCOMMITTEE
COMMITTEE ON ENVIRONMENT

of the
NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

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About this Document

This document was developed by the USGEO Subcommittee in response to the National Aeronautics and Space Administration Authorization Act of 2010 (42 U.S.C. § 18371), which called for the Director of OSTP to establish a mechanism to ensure greater coordination of the research, operations, and activities relating to civilian Earth observation.

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Executive Summary

Earth observations¹ (EO) inform national and local plans for, and responses to, some of the greatest challenges and opportunities of our time—climate change, extreme weather and fire events, food and water security, disaster response, environmental justice and equity, and space weather,² among others.

Civil EO capabilities are crucial for better understanding, monitoring, and adapting to climate and environmental change; using technological advances; accelerating private sector innovation and investments; and nurturing cross-sectoral and international ally and partner capabilities. The nation’s civil Earth Observations Enterprise (EOE)³—federal agencies; state, local, Tribal, and territorial governments; academia; private industries, nonprofit organizations, and philanthropies; federal and national laboratories; enabling infrastructure; and end users of EO data—represents public and private sector endeavors to produce information, provide services, generate solutions, and expand social and economic benefits to every American, every day. Engagement with a diversity of stakeholders from across the EOE is key in understanding user needs to inform EO planning and actions.

This 2024 National Plan for Civil Earth Observations (National Plan) provides a vision for continued United States (U.S.) global leadership in enabling and leveraging civil EO to increase access to Earth data and address global changes. In developing this National Plan, the U.S. Group on Earth Observations (USGEO) established three overarching principles that guide 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 and long-term quality of EO data across the EOE, and
3. Ensure the continued availability of foundational U.S. government capabilities in EO, while expanding the use of commercial data and services.

To realize this vision in ways that advance national priorities and engage with agency and stakeholder needs, this National Plan emphasizes three thematic, interconnected goals—and their associated objectives—and a set of eight cross-cutting enterprise initiatives. The three goals with corresponding objectives are:

Goal 1. Advance Science-Informed Climate Change Mitigation and Adaptation Activities: This goal focuses on ensuring adequacy and coordination of observations to support research, inform and advance climate services,⁴ and expand access to EO. Key objectives highlight:

1. Expanding and improving observations to enable current and future climate products and services,
2. Improving the impact of EO on climate change mitigation and adaptation strategies, and

¹ Earth observations as discussed in this document include information collected from satellite, aerial, and ground-based (in situ and remote-sensing) techniques and sensors for the purpose of studying and monitoring our planet’s physical, chemical, biological, and socioeconomic characteristics.

² Space Weather Operations, Research, and Mitigation Subcommittee. <https://www.sworm.gov/>.

³ *Earth Observations Enterprise* is defined in the *2019 National Plan for Civil Earth Observations* as a multi-sector collection of stakeholders that include “Federal agencies; State, local, Tribal, and territorial governments; world-leading colleges and universities; private industries; nonprofit organizations; and Federal and National Laboratories involved in the collection and dissemination of observations; operation of enabling infrastructure; and end-users of Earth observation data.” (page vii)

⁴ *Climate services* are defined in the *Opportunities for Expanding and Improving Climate Information and Services for the Public—A Report to the National Climate Task Force* as “scientifically-based, usable information and products that enhance knowledge and understanding about the impacts of climate change on potential decisions and actions.” (page 6) <https://toolkit.climate.gov/reports/opportunities-expanding-and-improving-climate-information-and-services-public>

3. Incorporating EO data into social and economic analyses.

Goal 2. Strengthen Environmental Monitoring and Management: This goal focuses on integrating EO and services throughout the entire environmental management value chain, from observation and product processing, through modeling and analysis, to monitoring and forecasting, and to decision-making, planning, and evaluation. Key objectives highlight:

1. Expanding current observations and monitoring for terrestrial, freshwater, and marine ecosystem change,
2. Connecting biodiversity research and management activities across spatial, temporal, and categorical scales,
3. Improving the use of EO 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 use of EO to support decision-making for extreme and severe events, this goal also focuses on maturing applications of EO to inform public health policy, planning, and action. Key objectives highlight:

1. Increasing useful coverage of EO relevant to public health,
2. Reducing exposure to hazards and improving access to healthy natural environments,
3. Characterizing the cascading impacts of environmental hazards on public health, and
4. Enhancing monitoring and forecasting of extreme events and other environmental risks and hazards.

In addition to these goals, the National Plan engages organizations across the EOE 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 and maintenance of consistent observations and derivative products over long timescales including continuity with historical data;

Initiative B. Equitable Access to and Ethical Use of Earth Observations Data — better identification, utilization, integration, and application of EO data for all parties, being inclusive of varied technical capability;

Initiative C. Increased Diversity and Expanded Stakeholder Engagement — networking to ensure engagement on EO includes a multitude of voices and lived experiences, and that people from varied fields, backgrounds, and skillsets can connect, collaborate, and ideate;

Initiative D. Increasing the Integration of Earth Observations into National Security Applications — improving the systems and processes by which stakeholders in the national security community can provide civil decision-makers with relevant, timely, and scientifically accurate EO information;

Initiative E. Domestic and International Partner Collaboration — bridging gaps to build comprehensive and effective solutions to multifaceted problems that would be difficult to address by any single agency or organization;

Initiative F. Strengthened Global and Regional Leadership — embracing U.S. leadership in the Group on Earth Observations (GEO),⁵ enabling regional partnerships and coordinating

⁵ Group on Earth Observations: <https://earthobservations.org/>.

activities in the Western Hemisphere through AmeriGEO,⁶ and fulfilling engagements with GEO Work Programme⁷ activities;

Initiative G. Earth Observations Enterprise Workforce Readiness — developing a skilled, robust, and diverse talent pool across career stages that supports all parts of the enterprise and ensures abundant talent to maximize the value and impact of EO for the Nation; and

Initiative H. Continuous Assessment of Earth Observation Systems — continuously assessing the impact of existing and planned EO systems in fulfilling and advancing needed measurements.

In combination, these initiatives support this National Plan's goals to realize ever-increasing benefits of EO for society.

By pursuing this congressionally motivated National Plan,⁸ the U.S. ushers in an era of better integrated, ubiquitous, and impactful EO capabilities, answers urgent questions about our planet's changing environment, and applies Earth science insights to help humanity thrive.

⁶ AmeriGEO: <https://www.amerigeo.org/>.

⁷ GEO Work Programme: <https://earthobservations.org/organization/work-programme>.

⁸ U.S. Congress. *National Aeronautics and Space Administration Authorization Act of 2010*. 111th Congress, Public Law 111-267, Section 702. www.govinfo.gov/content/pkg/PLAW-111publ267/html/PLAW-111publ267.htm.

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

The *2024 National Plan for Civil Earth Observations* (National Plan) seeks to significantly advance coordination across the Earth Observations Enterprise (EOE),⁹ increase efficiency and efficacy of future Earth Observations (EO) efforts, and encourage environmental and economic sustainability. The outcomes of this National Plan are designed to address three particular challenges facing the world today: climate change,¹⁰ environmental degradation, and threats to human health and safety, with advances that will benefit humanity broadly. Information about how our environment and climate are changing and the implications of these changes 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. This National Plan capitalizes on the context, scale, and perspective provided by reliable, consistent, and authoritative EO¹¹ to inform climate change mitigation and adaptation actions, strengthen environmental monitoring and management, and improve human health and safety. This, in turn, strengthens national security, advances national prosperity, and helps cultivate defensible and resilient technological infrastructure.

This National Plan sustains and expands U.S. leadership to understand, monitor, forecast, and manage changes within the Earth system. It improves coordination across the EOE,¹² increasing the effectiveness of future EO investments, ensuring data are available and easily integrated as determined by fair and transparent arrangements, 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 this National Plan support a number of national imperatives, including the ability to secure food, water, and mineral resources; protect public health, natural resources, and air quality; build adaptable and resilient communities; and provide equitable services to underserved communities.

Climate Change. Human-induced global change is affecting natural ecosystems and human communities in the U.S. and around the world, such as through shifts in seasonal temperature and precipitation patterns and the more frequent, intense, and widespread occurrence of extreme events (e.g., record temperatures, severe storms). These changes impact the Nation in many ways, including through national security, the ability to produce food, and management of water supplies and other natural resources.¹³ Civil EO enable better understanding of these threats and inform appropriate actions.¹⁴

⁹ *Earth Observations Enterprise* is defined in the *2019 National Plan for Civil Earth Observations* as a multi-sector collection of stakeholders that include “Federal agencies; State, local, Tribal, and territorial governments; world-leading colleges and universities; private industries; nonprofit organizations; and Federal and National Laboratories involved in the collection and dissemination of observations; operation of enabling infrastructure; and end-users of Earth observation data.” (page vii)

¹⁰ White House, *Fifth National Climate Assessment (NCA5)* (Washington, DC: White House, November 2023). <https://nca2023.globalchange.gov/>.

¹¹ Earth observations as discussed in this document include information collected from satellite, aerial, and ground-based (in situ and remote-sensing) techniques and sensors for the purpose of studying our planet’s physical, chemical, and biological characteristics.

¹² For example, working in tandem with the National Spatial Data Infrastructure [Federal Geographic Data Committee, *Advancement of the National Spatial Data Infrastructure*, Accessed March 15, 2024. <https://www.fgdc.gov/nsdi/nsdi.html>].

¹³ 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.

¹⁴ For example: NASA. *Global Climate Change—Vital Signs of the Planet*. climate.nasa.gov/; NOAA. *Monthly Climate Report*. www.ncei.noaa.gov/access/monitoring/monthly-report/; USGS. *National Climate Change Viewer*. www.usgs.gov/tools/national-climate-change-viewer-nccv; U.S. EPA. *Climate Change Indicators in the United States*. www.epa.gov/climate-indicators.

Environmental Degradation. Information about the Earth’s atmosphere, lands, oceans, and waters is essential to a wide array of environmental management and forecasting systems that address environmental degradation. For example, monitoring networks helps communities better plan for and respond to local environmental changes, and understanding water access, availability, and quality has implications for public health, food production, and recreation. EO can aid the transition to clean, renewable energy and help in identifying new sources of critical minerals. EO improve national security by reducing risks of supply chain disruptions caused by armed conflicts or the leveraging of market dominance for political and economic influence.

Human Health and Safety. 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.¹⁵ For example, air pollutants, such as ozone and particulate matter, increase the amount and seriousness of lung and heart disease and other health problems,¹⁶ and outdoor air pollution is estimated to have caused 4.2 million premature deaths worldwide in 2019.¹⁷ Numerous vector- and water-borne infectious diseases relate to environmental factors, and increasing extreme events have societal and economic costs in their impacts on life and property.¹⁸

This 2024 National Plan aligns with the 2013 *National Strategy for Civil Earth Observations*¹⁹ and builds on two prior National Plans published in 2014 and 2019.²⁰ 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 EO data by users and decision-makers. A summary of select major outcomes resulting from these previous National Plans can be found in Appendix A.

This National Plan guides the EOE and the Nation in addressing near-term challenges and establishing long-term efforts to harness the power of civil EO for the broader benefit of humanity. It also captures trends and opportunities and specifies activities to achieve U.S. goals in alignment with both national and international concerns. In addition, this National Plan highlights numerous items that are enabling to EO and a productive EOE, such as access to adequate spectrum resources and a thriving workforce.

Civil EO have progressed significantly in the decade since the inaugural National Plan in 2014. Improved coordination between federal agencies, international partners, private industry, academia, and others developed a robust EOE and evolving EO infrastructure capable of incorporating new technologies to provide new observations, data, and products to inform decision-making. These advances support both national priorities and international obligations. 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. This National Plan recommits to conducting regular assessments of EO systems to inform future Plans.

¹⁵ 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.

¹⁶ U.S. EPA. “Research on Health Effects from Air Pollution.” Updated 26 January 2023. www.epa.gov/air-research/research-health-effects-air-pollution.

¹⁷ World Health Organization. *Ambient (outdoor) air pollution*. 19 December 2022. [www.who.int/news-room/fact-sheets/detail/ambient-\(outdoor\)-air-quality-and-health](http://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health).

¹⁸ U.S. Department of the Treasury. *The Impact of Climate Change on American Household Finances*. September 2023. https://home.treasury.gov/system/files/136/Climate_Change_Household_Finances.pdf.

¹⁹ White House. *National Strategy for Civil Earth Observations*. April 2013. <https://usgeo.gov/uploads/National%20Strategy%20for%20Civil%20Earth%20Observations.pdf>.

²⁰ USGEO. *2014 National Plan for Civil Earth Observations*. July 2014. https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/NSTC/2014_national_plan_for_civil_earth_observations.pdf; and *2019 National Plan for Civil Earth Observations*. December 2019. <https://usgeo.gov/uploads/Natl-Plan-for-Civil-Earth-Obs.pdf>.

Sections II–IV of this National Plan address the challenges of climate change, environmental degradation, and human health and safety by establishing three goals:

- Goal 1: Advance science-informed climate change mitigation and adaptation activities,
- Goal 2: Strengthen environmental monitoring and management, and
- Goal 3: Improve human health and safety.

Within each goal, the National Plan identifies key objectives and activities that, when realized, will yield capabilities supporting societal, scientific, economic, and national security needs across many disciplines and sectors.

Section V discusses eight cross-cutting enterprise initiatives that in combination support the National Plan’s three overarching goals to realize ever-increasing benefits of EO for society. Engagement with diverse stakeholders from across the Enterprise is a key element in pursuing this National Plan.

II. Goal 1: Advance Science-Informed Climate Change Mitigation and Adaptation Activities

Increasing global average atmospheric, marine, and lake temperatures, shrinking glaciers and polar sea ice, and rising sea levels are all evidence of climate change caused by anthropogenic emissions of greenhouse gases.²¹ Climate change drives increases in frequency, severity, and/or spatial extent of heatwaves, wildland fires, droughts, extreme rainfall, coastal flooding, winter storms, and hurricanes, with profound negative impacts on human lives, ecosystems, and the global economy. These impacts have the potential to cascade and compound on one another, exacerbating social inequalities, posing geopolitical challenges, and serving as societal destabilization events.²² While the U.S. federal government has a significant role to play, addressing the climate change crisis requires a whole-of-society response.²³

Closer cooperation among U.S. government interagency working groups²⁴ can foster better coordination on observations that underpin and inform research and the development of climate services (see *A Federal Framework and Action Plan for Climate Services*²⁵) and associated activities.^{26,27} Expanded outreach and engagement efforts through member agencies, as well as from USGEO itself, will encourage the wider community to access EO, facilitate non-traditional uses of datasets for product development while recognizing the need for datasets to be cross-calibrated and intercomparable, promote scientific standardization, and encourage consensus among international partners on EO.

²¹ Intergovernmental Panel on Climate Change (IPCC). 2023. *Climate Change 2023: Synthesis Report*. Geneva, Switzerland, pp. 1–34. doi: 10.59327/IPCC/AR6-9789291691647.001.

²² U.S. Global Climate Research Program (USGCRP). 2018. *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Hayhoe, K., D.J. Wuebbles, D.R. Easterling, D.W. Fahey, S. Doherty, J. Kossin, et al.]. Washington, DC, USA, 1506 pp. doi: 10.7930/NCA4.2018.

²³ USGCRP. 2023. *Fifth National Climate Assessment*. Jay, A.K., A.R. Crimmins, C.W. Avery, T.A. Dahl, R.S. Dodder, B.D. Hamlington, et al. Washington, DC, USA. <https://doi.org/10.7930/NCA5.2023>.

²⁴ U.S. Global Change Research Program. <https://www.globalchange.gov/>.

²⁵ 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.

²⁶ Executive Order No. 14008. *Tackling the Climate Crisis at Home and Abroad*. Federal Register 86, no. 19. (1 February 2021): 7619–7633. <https://www.federalregister.gov/documents/2021/02/01/2021-02177/tackling-the-climate-crisis-at-home-and-abroad>.

²⁷ For example: White House Ocean Policy Committee (OPC). March 2023. *Ocean Climate Action Plan*. https://www.whitehouse.gov/wp-content/uploads/2023/03/Ocean-Climate-Action-Plan_Final.pdf; White House. June 2023. *Congressionally Mandated Research Plan and an Initial Research Governance Framework Related to Solar Radiation Modification*. <https://www.whitehouse.gov/wp-content/uploads/2023/06/Congressionally-Mandated-Report-on-Solar-Radiation-Modification.pdf>.

Goal 1 articulates three objectives for near-term attention to bring EO data, analyses, and solutions to bear in the collective response to the climate crisis and environmental and societal changes. Implementation of Goal 1 objectives will be done in coordination with the EOE and groups such as the U.S. Global Change Research Program (USGCRP), the Interagency Council for Advancing Meteorological Services (ICAMS),²⁸ and the Interagency Modeling and Atmospheric Assessment Center (IMAAC).²⁹

Objective 1.1. Expanding and Improving Observations to Enable Future Climate Products and Services

EO are essential resources for assessing the dynamics and impacts of climate change. Improving our nation’s EO capabilities strengthens our capacity to reduce damage to life, health, and property from extreme weather events and other impacts driven and exacerbated by climate change. One way the EOE can strengthen climate services³⁰ capabilities for the future is to remain aware of evolving community end-user needs. These efforts include continuing to address the range of measurement attributes such as spatial and temporal resolutions, spectral ranges, accuracies, latencies, and derived products and services that end-user applications require, as well as continuing to invest in basic research and technology development to better meet anticipated scientific and societal demands. Maintaining the capacity for high-quality EO to track long-term environmental change from global to community scales is critical (e.g., for sea level rise and ocean systems, ecosystem function, fire regimes, radiative forcing, albedo, greenhouse gas emissions, land use/land cover, the cryosphere, and water fluxes). Activities to realize this objective include:

Improve and Expand Greenhouse Gas Measurement and Monitoring to Better Inform Mitigation Efforts: Adequate monitoring of global, regional, and national greenhouse gas (GHG) emissions and removals is critical to identify opportunities to reduce emissions and increase carbon sequestration and storage, as well as to better understand the efficacy of climate change 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, USGEO will work with the EOE to improve EO to better measure, monitor, report on, and verify GHG emissions, focusing on resolution (e.g., spatial, spectral, temporal), latency, accuracy, and uncertainty.³¹ This National Plan supports EO advancing the *National Strategy to Advance an Integrated U.S. Greenhouse Gas Measurement, Monitoring, and Information System* and advocates for a stronger focus on high-forcing GHGs of interest such as methane.

Optimize Sampling Strategies and Data Quality to Better Address Climate Modeling Needs: The climate modeling community needs input data on a wide range of parameters beyond GHGs (e.g., land use/land cover, hydrological cycling, temperature profiles, sea and ice dynamics) that better align with model input needs. The EOE and USGEO will work together to improve the provisioning of such data, sampled at model-appropriate scales and resolutions (e.g., spatial, spectral, temporal) and of improved quality and usability (e.g., data latency, accuracy, uncertainty). These data are essential to improve monitoring change, informing decisions, and tracking progress at regional and local scales, as well as enhancing national capabilities to model and forecast the impacts of climate change. The EOE and USGEO will continue to

²⁸ Interagency Council for Advancing Meteorological Services. <https://www.icams-portal.gov/>.

²⁹ U.S. Department of Homeland Security, Federal Emergency Management Agency, Interagency Modeling and Atmospheric Assessment Center. <https://www.fema.gov/emergency-managers/practitioners/hazardous-response-capabilities/imaac>.

³⁰ *Climate services* are “scientifically based, usable information, products, and activities that enhance knowledge and understanding about the impacts of climate change on potential decisions and actions.” <https://www.globalchange.gov/our-work/climate-services>

³¹ White House. *National Strategy to Advance an Integrated U.S. Greenhouse Gas Measurement, Monitoring, and Information System*, November 2023, 70 pp. www.whitehouse.gov/wp-content/uploads/2023/11/NationalGHGMMISStrategy-2023.pdf.

work together to assess evolving researcher and end-user needs and associated technical requirements³² to facilitate alignment between the observing and modeling communities and inform community development of new monitoring and observational capabilities.

Objective 1.2. Improving the Impact of Earth Observations on Climate Change Mitigation and Adaptation Strategies

EO data support a range of uses and a diversity of user communities. Widely accessible, available, and trustworthy EO data can help improve understanding, monitoring, and forecasting to support and evaluate mitigation and adaptation strategies. EO are already used in some societal and policy contexts. Integrating an improved understanding of where this occurs productively will benefit the EOE by expanding utility, serving broader user needs, and establishing impacts of integrated EO. An activity to realize this objective is:

Establish Earth Observations Data Use Metrics: This National Plan calls on the EOE, in coordination with USGEO, to establish regular, repeatable, and reliable online use metrics for EO data to track use of observational data and derived estimates (e.g., GHG emission and sequestration dynamics, extreme weather and wildfire events, land-use change, drought) for informing forecasting, policy and planning, and response activities. In addition, developing EO use cases³³ will enable the EOE to evaluate the impact of datasets for climate change mitigation and adaptation policies and activities, as well as to inform future EO planning.

Objective 1.3. Better Incorporate Earth Observations Data into Social and Economic Analyses

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

The costs of climate-related events, from more frequent coastal flooding to more severe heat waves, will likely continue to rise in the coming years and negatively impact human health, well-being, security, and the economy. For example, climate change can negatively affect agricultural yields,³⁴ availability of ecosystem services from the ocean,³⁵ and public health,³⁶ while increasing the likelihood and cost of response to natural disasters.³⁷ Most economic and social policies do not fully consider more frequent extreme weather and climate change-related shocks.

Informing social and economic policy with EO-based climate risk information and data would help make the Nation and economy more resilient to current and future climate change. Through better uses of EO,

³² For example, the U.S. Geological Survey National Land Imaging Program, which “evaluates satellite capabilities to determine effective solutions for addressing civil agency and societal challenges, allowing land managers and policymakers to make informed decisions about natural resources and the environment.” Accessed 15 April 2024. <https://www.usgs.gov/rca-eo>.

³³ For example: NASA. *Assessing Earth Data’s Benefits to Society*. <https://appliedsciences.nasa.gov/what-we-do/socioeconomic-assessments>.

³⁴ 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.

³⁵ Pinsky, M.L., E. Fenichel, M. Fogarty, S. Levin, B. McCay, K. St. Martin, R.L. Selden, and T. Young. 2020. *Fish and fisheries in hot water: What is happening and how do we adapt?* *Population Ecology*, 63(1), pp. 17–26. <https://doi.org/10.1002/1438-390X.12050>.

³⁶ CDC. *Climate Effects on Health*. Last reviewed 25 April 2022. https://www.cdc.gov/climate-health/php/effects/?CDC_AAref_Val=https://www.cdc.gov/climateandhealth/effects/default.htm

³⁷ NOAA National Centers for Environmental Information (NCEI). 2023. *Billion-Dollar Weather and Climate Disasters*. doi: 10.25921/stkw-7w73.

the Nation could help limit the costs of climate change to our economy and human health, while better informing economic forecasting. An activity to realize this objective is:

Improve the Integration of Earth Observations and Economic Data: Building upon the Executive Order on Climate-Related Financial Risk,³⁸ USGEO will facilitate connections between federally produced or acquired EO and federal agencies that conduct economic analyses or assess climate change-related financial risk to advance awareness and inclusion of EO in economic policy.

III. Goal 2. Strengthen Environmental Monitoring and Management

Planning, setting policy, and taking actions that effectively account for the complexities of the planet’s dynamic and interconnected human and biophysical systems require a wealth of diverse types of information. Strengthening environmental monitoring and management requires integrating EO and services throughout the entire environmental management 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, optimized, and actionable EO data into U.S. government and private sector decision-making will positively benefit both long-term sustainability objectives and national security interests. Consistent, continued, and uninterrupted civil EO systems are critical for both civil and national security use cases, as is the efficient coordination of spectrum allocation and use that enable the transmission of large amounts of EO data.

Goal 2 articulates four objectives for the EOE’s near-term attention to lead in strengthening environmental monitoring and management.

Objective 2.1. Expanding Observations to Monitor Terrestrial, Freshwater, and Marine Ecosystem Change

Reliable and robust EO are needed to establish baselines and monitor changes in water resources and all types of landscapes across the country, from wilderness areas to urban expansion and agricultural practices, and can underpin and support current U.S. initiatives, such as the National Nature Assessment,³⁹ America the Beautiful,⁴⁰ National Natural Capital Accounting,⁴¹ and Nature-Based Solutions.⁴² Improved tracking of land use/land cover changes⁴³ would advance future risk assessments of Earth systems, society, and economy, and would deliver actionable science to underpin climate change mitigation and adaptation strategies. Approaches developed in the U.S. can be used as part of diplomatic aid development to increase international cooperation, improve regional stability, and reduce climate change induced migration.

³⁸ 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>.

³⁹ Department of Interior, Office of Policy Analysis. *National Nature Assessment*. Accessed 6 October 2023. www.doi.gov/ppa/national-nature-assessment.

⁴⁰ Department of Interior. *America the Beautiful: Spotighting 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.

⁴¹ 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/.

⁴² 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/.

⁴³ For example, NIST. *FOREST (Forested Optical Reference for Evaluating Sensor Technology)*. Accessed 21 April 2024. <https://www.nist.gov/programs-projects/forest>.

Projected changes to the environment over the next 50 years are expected to further 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.⁴⁴ Better integration across the many methods by which the U.S. tracks ecosystem (terrestrial, aquatic, and marine) changes will ultimately improve the EOE’s ability to characterize, forecast, and anticipate future change.⁴⁵

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: Integrated national environmental assessment reports will be generated by various elements of the EOE and USGEO synthesizing EO data, products, and integrated Earth systems modeling. Environmental changes are accelerated by severe storms, wildfires, and other natural and human drivers. The assessments will identify where and why these changes are occurring, characterize their severity, and identify their potential impacts on the land, water, and ecosystems that underpin our national infrastructure, economy, health, and well-being. The reports should offer future scenarios of natural and human systems change to inform mitigation and adaptation strategies. Methods will include data and modeling that integrate human, ecological and Earth system science processes and an array of Earth observation data, to inform environmental management and natural resource decision-making.

Support America the Beautiful: America the Beautiful is a decade-long initiative and nationwide effort to conserve, connect, and restore 30 percent of American lands, waters, and wildlife by 2030 for the sake of our economy, health, and national well-being. To support the contributions of EO 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 and aquatic environments, to inform forward-looking conservation and restoration actions.

Benchmark Sites Partnership: Explore the concept for an EOE-wide partnership between civil agencies, the intelligence community, academia, and the private sector, to compile time series of high- and moderate-resolution remote sensing and geophysical data, along with ground calibration data, over key sites around the world deemed most vulnerable to environmental shifts and damage due to the impacts of global change. These sites would be selected to leverage long-term monitoring efforts, and optimally monitor changes in geologic processes, land use/land cover, atmospheric processes, water storage and fluxes, ice and snow dynamics, ocean processes, and others. This could allow for long-term study of environmental and ecosystem changes and early warning of environmental stresses.

⁴⁴ For example, (1) NSF. *NEON National Ecological Observatory Network*. https://www.nsf.gov/news/special_reports/neon/; (2) NSF. *LTAR (Long Term Ecological Research)*. <https://lternet.edu/>; (3) NOAA, Fisheries. *Monitoring the Ecosystems in the Northeast*. <https://www.fisheries.noaa.gov/new-england-mid-atlantic/ecosystems/monitoring-ecosystem-northeast>; (4) NOAA. *Global Ocean Monitoring and Observing*. <https://globalocean.noaa.gov/>; (5) USDA, Agricultural Research Service. *LTAR (Long-Term Agroecosystem Research)*. <https://ltar.ars.usda.gov/>. [all accessed 21 April 2024]

⁴⁵ For example, identifying and characterizing the links between nature and the U.S. economy [e.g., White House. 2023. *National Strategy to Develop Statistics for Environmental-Economic Decisions*. www.whitehouse.gov/wp-content/uploads/2023/01/Natural-Capital-Accounting-Strategy-final.pdf].

Objective 2.2. Better Connecting Biodiversity Research and Management Activities Across Spatial, Temporal, and Categorical Scales

Aided by a range of EO, 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, water supplies, and human health. This spatial, temporal, and categorical information would then be used to inform management, conservation, sustainable use, and restoration activities.

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 synoptic land, aquatic, and marine observations to improve modeling and map animal 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- and ocean-use, fire regime, development, and climate changes, 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. Activities to realize this objective are:

Improve the Integration of In Situ and Space-Based Fauna and Flora Monitoring 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.

Improve Integration of In Situ and Space-Based Hydrologic Data to Inform Water Resource Management: Developing in situ hydrologic datasets for calibration of space-based observations will provide the foundation for making accurate observations of water fluxes and water availability for both human and ecosystem applications. National, “wall-to-wall” observation of inland water supplies will improve water resource management decisions both within the U.S. and with internationally shared water resources.

Objective 2.3. Improving the Use of Earth Observations for All Aspects of Wildland Fire Preparation, Response, and Recovery

Fire seasons are growing in intensity, duration, and severity across the globe. Effective wildland fire management requires improved input across all phases of fire, encompassing mitigation and adaptation,⁴⁶ prediction of fire potential and intensity, strategic detection and monitoring (e.g., wildland fire use), firefighting,⁴⁷ post-fire assessment,⁴⁸ and rehabilitation and restoration.⁴⁹ 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 concomitant improved models of amount of fuel in ecosystems, fuel moisture, soil moisture, and vertical and horizontal 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

⁴⁶ *Mitigation and adaptation* include fuels assessment and management, prescribed fire, fire weather and climate projections.

⁴⁷ *Firefighting* includes tactical fire monitoring, fire behavior modeling, smoke and air quality.

⁴⁸ *Post-fire assessment* includes burn severity assessment, landslide potential, and carbon release.

⁴⁹ *Rehabilitation and restoration* include land cover, ecosystem recovery, monitoring for potential contaminants.

for controlling wildland fires. These observations and models can be leveraged as educational tools in fire-prone locations to aid landowners, land managers, and communities to work together to assess fire risks and mitigate potential threats to safety and damage to critical infrastructure and property. An activity to realize this objective is:

Provide Access to Modern Tools for Informed Decision Support for Wildland Fire Management: While the current paradigm is predominantly oriented towards reacting to wildfire events, USGEO will work with the broader EOE towards providing the firefighting community with the actionable information required to support more proactive wildland fire management activities.⁵⁰ In addition to supporting fire weather and smoke forecasting and wildfire prediction, USGEO will collaborate with the wildland fire management community to continue working on improving its data aggregation and analysis capability in support of existing wildfire mitigation, monitoring, and suppression efforts.

Objective 2.4. Support Efficient and Sustainable Use of the Nation’s Natural Resources

Land, water, and natural resource managers need to quantify and monitor the extraction, production, and use of natural resources for meeting various human needs, along with maintaining healthy ecosystems. 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. EO systems support the valuation of natural resources and ecosystem services, which can have broader application on law enforcement as well as sustainable resource management, encompassing the assessment of use, non-use, option values, ecological optimum use, and future sustainable use of natural resources.⁵¹

The EOE should invest in the ability to capture appropriately resolved EO data on the availability and distribution of resources such as timber, water, seafood, 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 Accounts⁵² and the UN System of Economic and Environmental Accounting.⁵³ For example, there will be an increasing need for timely EO data, as the country transitions from research-grade environmental-economic statistics and Natural Capital Accounts to core statistical products.⁵⁴ 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 of relevant, accurate, high-quality, traceable, low-latency thematic data (e.g., soil characteristics, vegetative cover, water content) and make these data available downstream to users and providers. This information empowers decision-makers to optimize resource allocation and use, including for Natural Capital Accounting, thereby maximizing efficiency and sustainability.

⁵⁰ USDA. 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.

⁵¹ For example, USGCRP is undertaking a National Nature Assessment, which will “take stock of U.S. lands, waters, wildlife and the benefits they provide to our economy, health, climate, environmental justice, and national security,” with an anticipated release in 2026. <https://www.globalchange.gov/our-work/national-nature-assessment>

⁵² U.S. Department of the Interior. *Natural Capital Accounting*. Accessed 17 April 2024. <https://www.doi.gov/ppa/integrative/natural-capital-accounting>

⁵³ United Nations. *System of Environmental Economic Accounting: Introduction to Ecosystem Accounting*. Accessed 6 October 2023. <https://seea.un.org/Introduction-to-Ecosystem-Accounting>.

⁵⁴ 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. www.whitehouse.gov/wp-content/uploads/2023/01/Natural-Capital-Accounting-Strategy-final.pdf.

IV. Goal 3. Improve Human Health and Safety

EO are foundational for characterizing, managing, and communicating risks to human health and safety. There is growing recognition of the environmental influences on significant vector- and water-borne infectious diseases and health risks, such as extreme heat and poor air and water quality. As momentum for One Health⁵⁵ grows, the potential for EO to contribute information about environmental conditions increases in opportunity and value. The application of EO to improving human safety—such as through informing preparation, response, and recovery protocols for extreme weather and fire events or marine hazards—is also emerging as a driver for innovation in human health services. By growing applications of EO in public health services, the EOE can help advance human health and safety. Doing so would create opportunities in basic research and development—from formulating new observational capabilities and technologies, through implementation and application, to operational support of human health, safety, and well-being.

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, more vulnerable structures) from their surroundings. All elements of the EOE (e.g., public, private, academic, nonprofit) can actively inform human health policy and decision-making by working together to ensure fair and just access to environmental resources, to facilitate protection from natural and anthropogenic environmental hazards, and to support environmental decision-making.⁵⁶ As we think about the potential for EO 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.

Goal 3 articulates four objectives for the EOE’s near-term attention to lead in improving human health and safety outcomes.

Objective 3.1. Enhancing Earth Observations Relevant to Public Health

Reliable, repeatable, and relevant EO data can often empower communities to effectively address pressing public health challenges. Integrating public health data with EO in Earth system models and algorithms adds value to the overall monitoring enterprise, lessens disparities across communities, and provides the information needed to make informed decisions concerning options for improving individual health.⁵⁷ For example, information on water quality is needed for 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 U.S. possessing a dense and advanced in situ EO monitoring network, there remain important data gaps. And, where observations exist, there are challenges in the integration and use of the rapidly growing volume and variety of data. For example, over the last decade, many urban areas in the U.S. have

⁵⁵ *One Health* is a collaborative, multisectoral, and transdisciplinary approach—working at the local, regional, national, and global levels—with the goal of achieving optimal health outcomes recognizing the interconnection between people, animals, plants, and their shared environment. https://www.cdc.gov/one-health/about/?CDC_AAref_Val=https://www.cdc.gov/onehealth/basics/index.html

⁵⁶ 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.

⁵⁷ For example, HHS, CDC. Agency for Toxic Substances and Disease Registry. *Environmental Justice Index*. <https://www.atsdr.cdc.gov/placeandhealth/eji/index.html>.

added hundreds to thousands of air sensors measuring fine particulate matter (PM_{2.5}) operated by the public and relatively fewer official air quality stations operated by the government for regulatory purposes. Meanwhile, many rural areas lack PM_{2.5} observations altogether. For other pollutant types, such as nitrogen dioxide, ground-level observations of any type are sparse compared to what exists for PM_{2.5}. Policy options identified by the Government Accountability Office (GAO), such as improved data management and sharing, could support expanded air sensor data use.⁵⁸ In addition, accurate and frequent in situ profiles of gases and particles, in urban and rural areas, inform the integration and use of high-resolution, space-based observations of air quality.

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

Increase Spatial Density of Repeatable and Accessible In Situ and Remotely Sensed Observations and Enhance Ground-Based Networks: USGEO will work with underrepresented communities and the broader EOE to inform the distribution and improve the coverage of EO data used to inform public health response. In addition, USGEO, working with the broader EOE, will support efforts to enhance ground-based sensor networks in both rural and urban environments, especially environmental justice communities, to help improve our understanding of potential health stressors like noise, heat, air pollution and poor air quality;⁵⁹ water pollution and poor water quality (e.g., harmful algal blooms⁶⁰); pollen; and chemicals and toxins (e.g., higher-risk pesticides).

Improve Urban Heat Early Warning: USGEO will work with the EOE and other appropriate interagency efforts⁶¹ to improve urban heat early warning systems by prioritizing the development of standards to facilitate interoperability of varying data types. Examples of information to integrate include weather predictions, urban heat island models, and measurements of green infrastructure. Improving these heat early warning systems would enable communities to better serve citizens during times of extreme heat⁶² and can inform national efforts to mitigate heat-related human health impacts.⁶³

⁵⁸ U.S. Government Accountability Office. 2024. *Air Quality Sensors: Policy Options to Help Address Implementation Challenges*. <https://www.gao.gov/products/gao-24-106393>

⁵⁹ For example, U.S. Environmental Protection Agency. *American Rescue Plan* (Community Air Monitoring Award Selections). Accessed 21 April 2024. <https://www.epa.gov/arp>.

⁶⁰ The ability to monitor harmful algal blooms and pathogens is a high priority and needed for all U.S. waters ranging from coastal systems, estuaries, lakes, reservoirs, rivers, and streams supported by the Harmful Algal Bloom and Hypoxia Research and Control Act of 1998. <https://www.epa.gov/habs/harmful-algal-bloom-and-hypoxia-research-and-control-amendments-act-habhrca>.

⁶¹ For example: U.S. Global Change Research Program, Interagency Crosscutting Group on Climate Change and Human Health (CCHHG). Accessed 19 September 2024. <https://www.globalchange.gov/our-work/interagency-groups/cchhg>; National Integrated Heat Health Information System (NIHHIS). Accessed 19 September 2024. <https://www.heat.gov/>; U.S. Department of Health and Human Services (HHS), U.S. Centers for Disease Control and Prevention (CDC). *Heat & Health Tracker*. Accessed 19 September 2024. <https://ephtracking.cdc.gov/Applications/heatTracker/>.

⁶² 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/.

⁶³ Department of Commerce, NOAA. *National Integrated Heat Health Information System*. Accessed 6 October 2023. www.heat.gov.

Objective 3.2. Reducing Exposure to Hazards and Improving Access to Healthy Natural Environments

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, water pollution and poor water quality, and toxic chemicals. 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.^{64,65} Additionally, access to healthy natural spaces can positively impact human physical health, reducing overall population incidence of asthma, some cancers, heart disease, and Type II diabetes.⁶⁶

EO 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 the relationship between public health and the environment in order to use that understanding to improve public health outcomes. An activity to realize this objective include:

Improve Access to and Integration of Earth Observations and Public Health Data: This National Plan calls on the EOE, in collaboration with USGEO, to improve integration of EO 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. In addition, the EOE should support equitable and reliable data-sharing platforms to ensure reliable access to EO data that can help inform public health decisions.

Objective 3.3. Characterizing the Cascading Impacts of Environmental Hazards on Public Health

Natural hazards exacerbated by ecosystem degradation and extreme weather events amplified by climate change have cascading impacts on public health and safety. These complex relationships require intersectoral collaboration and EO can play a significant role.

Flooding caused by hurricanes, atmospheric rivers, and derecho storms often degrades water quality, which can exacerbate the spread of 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 face increasing challenges as they strive to mitigate the effects of air pollution, poor water quality, and urban heat islands on vulnerable populations.

Improved understanding of these events and their impacts can increase awareness and help prioritize solutions that address public health risks. The EOE can play an important role in supporting decision-

⁶⁴ USDA, Forest Service. 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.pdf.

⁶⁵ Department of Health and Human Services, Office of the Surgeon General. *Our Epidemic of Loneliness and Isolation, 2023*. Washington, DC. 82 pp. <https://www.hhs.gov/sites/default/files/surgeon-general-social-connection-advisory.pdf>.

⁶⁶ 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.2020.110169>.

making to reduce health risks, for example as part of existing interagency efforts that monitor the human-animal-environment nexus via the One Health⁶⁷ concept.⁶⁸ Efforts include reducing risks domestically and internationally, including cases where the U.S. government aids other nations in times of crisis. The EOE should increase collaboration between public health agencies and organizations that design EO systems, provide data, and enable use and analysis of these data. An activity to realize this objective includes

Improve Environmental Risk Exposure Monitoring: This National Plan calls on the EOE, in collaboration with USGEO, to work to sustain and further develop satellite-based, airborne, and in situ Earth observational and analytical capabilities with ever-increasing spatial, spectral, and temporal accuracy of air and water quality data. This will enable end users to better monitor, forecast, and provide early warning for societal exposure to environmental risks and hazards such as extreme weather events, persistent wildfire smoke events, and harmful algal blooms.⁶⁹

Objective 3.4. Enhancing Monitoring and Forecasting of Extreme Events and Other Environmental Risks and Hazards

The negative societal impacts of disasters (e.g., wildland fires, hurricanes, flash floods, extreme temperatures, oil spills), can be reduced with more informed preparedness efforts, intuitive warning products, and faster and more efficient response, supported by EO 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. Between 2020–2023, the nation experienced over two-thirds of the total number of billion-dollar events (Consumer Price Index-adjusted) compared to the previous decade (2010–2019).⁷⁰ Likewise, the increased risks of weather and climate events occurring abroad impacts U.S. interests through increased migration, disruption to supply chains, and abilities of the military to respond globally. While collaborative research done by the government, academia, and the private sector continues to observe phenomena that were unobservable 30 years ago (e.g., atmospheric rivers, wildfire intensity, cloud-cloud lightning detection), the opportunity exists to further improve monitoring, modeling, and forecasting of severe weather and climate extremes to better support prediction and response to such phenomena and protection of life and property.

Opportunities include identifying ways to reduce data latency,⁷¹ increase density of observations (e.g., surface and ocean monitoring), and replace aging observing systems such as those that monitor extreme weather. Efforts to better observe the planetary boundary layer, smoke, and other pollutants in the vertical dimension could lead to increased forecasting skill. Additionally, because of processing considerations, data assimilation⁷² often does not include the most current surface observations that are key for emergency responders to make decisions that are timely and locally relevant. Activities to realize this objective include:

⁶⁷ One Health is a collaborative, multisectoral, and transdisciplinary approach — working at the local, regional, national, and global levels — with the goal of achieving optimal health outcomes recognizing the interconnection between people, animals, plants, and their shared environment. <https://www.cdc.gov/onehealth/basics/index.html>

⁶⁸ For example, U.S. Global Change Research Program. *Interagency Crosscutting Group on Climate Change and Human Health*. <https://www.globalchange.gov/our-work/interagency-groups/cchhg>; HHS, CDC. *Federal One Health Coordination*. <https://www.cdc.gov/onehealth/what-we-do/federal-coordination.html>. Both accessed 21 April 2024.

⁶⁹ For example: NOAA, CoastWatch, Great Lakes Regional Node. *Color Producing Agents — Chlorophyll*. Accessed 18 April 2024. <https://coastwatch.glerl.noaa.gov/satellite-data-products/cpa-chlorophyll/>.

⁷⁰ NOAA NCEI. 2023. *Billion-Dollar Weather and Climate Disasters*. doi: 10.25921/stkw-7w73

⁷¹ *Data latency* is the “total time elapsed between when data are acquired by a sensor and when these data are made available to the public.” <https://www.earthdata.nasa.gov/learn/backgrounders/data-latency>

⁷² *Data assimilation* is “a technique by which numerical model data and observations are combined to obtain an analysis that best represents the state of the atmospheric phenomena of interest.” <https://www.aoml.noaa.gov/hrd/themes/0/>

Address At-Risk Capabilities and Opportunities for Improvement: USGEO will work with the EOE to identify key surface, subsurface, air, and space-based EO capabilities at risk and coordinate the development of plans to reduce risk and address continuity of key ones. For example, the EOE can work to improve products and services by introducing new capabilities to measure environmental parameters, such as winds and precipitation, while improving spatial and spectral resolutions.

Reduce Data Latency: Agencies, in consultation with interagency groups as appropriate, should identify areas where improvements to data latency and accessibility would significantly improve health and safety outcomes. In those instances, U.S. government expertise will be leveraged to identify potential platforms, observing systems, and data sources that positively impact human health and safety.

Increase Observation Density: Agencies, in consultation with interagency groups as appropriate, should coordinate and integrate environmental observations from federal and commercial systems to better support health 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 discussed within the goals, this National Plan identifies eight cross-cutting initiatives to address needs and opportunities common across the three goals. The initiatives are of equal importance and appear in no particular order.

Initiative A – Sustained Observing and Monitoring System Capacity

Continuous, high-quality EO serve critical roles in creating numerous economic and societal benefits, supporting the products and services of multiple public and private sector organizations. EO constitute an enabling infrastructure where organizations can reliably expect that the observations or derivative products will continue to be available over long timescales and provide continuity with historical data, though they may not be increased or continually improved. Where continuity is assured, EO serve as foundational elements in value chains that deliver products, services, and science to decision-makers that contribute climate change mitigation and adaptation, environmental monitoring and management, human health and safety, 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.”⁷³ 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 U.S. 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 and observations (both remote and in situ) to be able to guide their ongoing sustainment and, when necessary, reinvigoration.

While non-federal sources provide increasing opportunities to acquire observations, there are some observations that are in the U.S. government’s interest to provide. In these cases, many systems initially planned to collect observations for research in the public interest are now relied on to provide sustained observations for public services. This arrangement complicates dependencies and can impact abilities to advance research, technology development, and innovation. Mechanisms are needed to clarify organizations’ roles for types and stages of EO, balancing public service priorities with research priorities, especially as needs evolve and as technologies advance from instrument research to instrument operations.

⁷³White House. 2014. *National Plan for Civil Observations*. July 2014. https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/NSTC/2014_national_plan_for_civil_eart_h_observations.pdf. This Plan also defined a framework that classifies both *Experimental* and *Sustained* observations.

This matter highlights the need for sufficient coordination on the national level. While the 2019 National Plan called for a framework to address how agencies share information on planned missions, this must be expanded in the coming years to ensure enterprise continuity and contingency planning for sustained EO.

In addition, availability of spectrum for collecting observations and transmitting data is a critical part of the enabling infrastructure for the EOE to sustain. Continued access to adequate spectrum resources must be ensured to enable the public and economic benefits of EO. Similarly, cybersecurity remains important for all Earth observation capabilities. To realize the vision of this Plan, cybersecurity is viewed as a cross-cutting priority to ensure continued, reliable, and trustworthy access to EO data.

Addressing these challenges will ensure continued access to impactful observations on which the EOE relies. As is outlined in this 2024 National Plan and forthcoming Earth Observations Assessments, continuity of these observations is essential for long-term climate records and to mitigate the highest risks to life and property, the planet, and our economic prosperity. 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 EOE⁷⁴ to develop this Framework. The Framework is to provide the structure for scoping, governance, and other factors toward ensuring continuity for sustained observations. At a minimum, the Framework will apply to the *Sustained Observations for Public Services* identified in the 2014 National Plan.⁷⁵ 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 feasibility, affordability, reliability, innovation, partnership, openness, ownership, and governance.

In addition to measurement continuity, the Continuity Framework also needs to encompass calibration⁷⁶ continuity. Research and monitoring activities are supported by an expanding portfolio of EO data from U.S., international, and commercial systems. Greater use of EO data, whether in situ, airborne, or satellite-based, will require concerted coordination by stakeholders within the EOE to ensure that adequate standards for calibration and validation are established and sustained over the lifetime of the observations. High-quality calibration⁷⁷ and validation are essential to account for the differences among missions, over time, to achieve consistent measurements of environmental variables that support sustained and improved environmental services.

Understanding that observing systems ultimately collect measurements, in accordance with the Framework, federal agency-level plans 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

⁷⁴ For example: Keck Institute of Space Studies (KISS) Continuity Study Team. 2024. *Toward a US Framework for Continuity of Satellite Observations of Earth's Climate and for Supporting Societal Resilience*. Earth's Future, 12(2). <https://doi.org/10.1029/2023EF003757>.

⁷⁵ 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

⁷⁶ *Calibration* is meant to encompass those processes that work to ensure measurements remain consistent and that systematic differences among technologies do not influence desired geophysical measurements.

⁷⁷ Calibration approaches include on-board measurements, use of terrestrial reference sites, solar, lunar and other calibration approaches, depending on the nature location of the system (e.g., space, in situ).

address considerations of system maintenance and upgrades,⁷⁸ data continuity and consistency, cross-system calibration and validation, and other lifecycle issues. The Framework allows for, and should strongly consider, ways to incorporate the provision of data by non-federal sources, such as from commercial, philanthropic, and international entities.

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

Data Asset Review: In support of the observation Continuity Framework, USGEO will undertake a parallel effort to review currently collected and curated federal EO data. This analysis will support the identification of common approaches to archiving, discovering, and retrieving EO data. An assessment of federal data management system approaches for processing, storage, and dissemination will be conducted. With a view towards increasing efficiency, interoperability, and cost reduction, it will enable departments and agencies that collect EO 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.

Spectrum Assurance: Critical to the ability to sustain observing and monitoring capacity is the availability of unique spectrum bandwidth. Access to adequate spectrum resources to collect observations (from both U.S. and international partner assets), especially by highly-specialized satellites, and to transmit data is integral to vital government services and commercial ventures. The judicious and efficient use of spectrum for EO and the EOE ensures the delivery of timely, relevant, and actionable information tied to our global competitiveness and sustained economic growth. USGEO will work with the National Telecommunications and Information Administration (NTIA), in accordance with the 2024 National Spectrum Strategy Implementation Plan,⁷⁹ to improve coordination and planning, and ensure that EO and EOE equities are being appropriately accounted for in agency-level plans and allocation decisions.

Initiative B – Equitable Access to and Ethical Use of Earth Observations Data

As the U.S. maintains and grows its investments in collecting EO data, there is an opportunity to increase the return on investment. Better identifying, standardizing, utilizing, integrating, and leveraging the information being collected and improving our ability to provide equitable access to internally consistent data will make EO more useful to all parties, regardless of technical and financial capability. This includes the diverse opportunities for data collection and analysis through participatory science⁸⁰ (e.g., community science, citizen science) that are supported by federal agencies⁸¹ under a variety of funding mechanisms, such as the Crowdsourcing and Citizen Science Act.⁸²

⁷⁸ For example, *Information Technology: Agencies Need to Continue Addressing Critical Legacy Systems, Before the Subcommittee on Cybersecurity, Information Technology, and Government Innovation, Committee on Oversight and Accountability, House of Representatives*. 118th Congress (2023) (submitted statement of Kevin Walsh, Director, Information Technology and Cybersecurity at GAO, released May 10, 2023). <https://www.gao.gov/assets/gao-23-106821.pdf>.

⁷⁹ U.S. Department of Commerce, National Telecommunications and Information Administration. *National Spectrum Strategy Implementation Plan*. 12 March 2024. www.ntia.gov/sites/default/files/publications/national-spectrum-strategy-implementation-plan.pdf.

⁸⁰ U.S. General Services Administration. *About CitizenScience.gov*. Accessed 18 April 2024. <https://www.citizenscience.gov/about/#>.

⁸¹ For example: U.S. Environmental Protection Agency. *Participatory Science for Environmental Protection*. Accessed 18 April 2024. <https://www.epa.gov/participatory-science>; U.S. Department of Commerce, NOAA. *Volunteer Opportunities*. Accessed 18 April 2024. <https://www.noaa.gov/work-with-us/volunteer-opportunities-citizen-scientists>.

⁸² Crowdsourcing and Citizen Science Act of 2017, 15 U.S.C. §3724 (2017). <https://uscode.house.gov/view.xhtml?req=granuleid:USC-prelim-title15-section3724&num=0&edition=prelim>.

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 EO investments. Increased opportunities to leverage EO 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 datasets, and redundancy in data sources. Additionally, there are challenges in discerning which data are most appropriate, reliability of non-authoritative data, continuity of data streams, and reduced transparency. Overcoming these challenges is paramount to ensuring and advancing diversity, equity, inclusion, and accessibility (DEIA)⁸³ and environmental justice⁸⁴ principles within the EOE. Increasing data accessibility allows for more communities to benefit from EO data and engages more contributors to the community.

As data volumes scale, data analysis will become increasingly dependent on automated and cloud-enabled computing and software as a service model. The use of artificial intelligence/machine learning (AI/ML) is 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/ML also introduces ethical and trust concerns, as well as transactional issues around provenance, verification, and reliability. Following Executive Order 14110, *Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence*,⁸⁵ the EOE can build on the National Institute of Standards and Technology (NIST)-led guidance on engagement in AI-standards development activities to chart beneficial EO pathways with AI/ML.⁸⁶ Activities to advance this initiative include:

Democratize Data Access: USGEO will continue supporting the transformation of federal EO data systems towards open science, reducing redundant infrastructure and services, and will establish shared architectures, where appropriate, that reduce costs 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 EO services, such as common interface for search, discovery, and access to products and services. The intent is to realize operational efficiencies and maximize the extension of these interfaces to commercial and international EO data sources. USGEO will also 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 EO investments by removing barriers to understanding. Such data infrastructure and industry standards should incorporate 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 determined by fair and transparent arrangements. USGEO will also promote better coordination of research and development activities and operational services between the federal government and the private sector. These efforts will increase access to commercial data by

⁸³ For example, Executive Order No. 14035. *Executive Order on Diversity, Equity, Inclusion, and Accessibility in the Federal Workforce*. 86 FR 34593, no. 2021-14127. (25 June 2021): 34593–34603. <https://www.federalregister.gov/documents/2021/06/30/2021-14127/diversity-equity-inclusion-and-accessibility-in-the-federal-workforce>.

⁸⁴ For example, White House, *Justice40*. Accessed 19 September 2024. <https://www.whitehouse.gov/environmentaljustice/justice40/>.

⁸⁵ Executive Order No. 14110. *Executive Order on the Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence*. 88 FR 75191, no. 2023-24283. (01 November 2023): 75191–75226. <https://www.federalregister.gov/documents/2023/11/01/2023-24283/safe-secure-and-trustworthy-development-and-use-of-artificial-intelligence>.

⁸⁶ NIST. *AI Standards: Federal Engagement*. Updated 5 April 2022. <https://www.nist.gov/artificial-intelligence/ai-standards-federal-engagement>.

other federal agencies and state and local governments as well as by Tribal and territorial entities, academia, and others.

Promote Ethical AI/ML: Building on a NIST-developed AI Plan, the EOE should develop standards regarding AI/ML and EO, 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 EO 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 EO-based value and societal benefits. Diversity here spans numerous factors, such as race, ethnicity, gender, career stage, academic classification, and geography or jurisdiction. 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. 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, state, and local levels. Driven by advances in both observation and information technology, there is emerging awareness of the broader applicability of EO data beyond traditional EOE stakeholders:

- **Indigenous Peoples** – Consulting and collaborating with Tribal Nations and Indigenous Peoples to ensure Indigenous Knowledge (IK) is appropriately considered and applied in a manner that is respectful and mutually beneficial for Tribal and Indigenous communities is a priority.⁸⁷ These efforts include examining the roles of culture, gender, religion, and spirituality to enhance community cohesion and unity, which can provide additional insight on the perceived impacts of climate change and best climate change mitigation and adaptation practices.
- **Environmental Justice** – Underserved communities bear a heavier burden due to many factors, including environmental contamination and climate change. The EOE has an important role in improving the national capability to support these communities.

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 lead dialogues monitoring the emerging needs associated with private sector provisioning of EO data and information services to federal agencies. The dialogues support 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 partnerships 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. This co-development can include engaging with users and considering potential uses of EO data to inform the planning of future systems. In building relationships with Indigenous communities and an understanding of 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 EO information. Activities to advance this initiative include:

⁸⁷ White House. 2022. *Guidance for Federal Departments and Agencies on Indigenous Knowledge*. 2022 OSTP-CEQ Memorandum. Washington, DC. <https://www.whitehouse.gov/wp-content/uploads/2022/12/OSTP-CEQ-Indigenous-Knowledge-Guidance.pdf>.

Promote Diversity to Enable Innovation: 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, EOE leaders can use their standing, influence, and leadership positions in their communities to signal and model the value of diversity, equity, and inclusion. This National Plan calls on the EOE, working with USGEO as an enabling entity, to address pathways for greater diversity and create a sense of belonging for all individuals and the innovations these can unlock.

Promote Engaging within the Enterprise: Strong engagement within the EOE supports improved coordination and prioritization of topics of collective interest, which in turn improves availability and quality of EO and better enables their use for generating societal and economic benefits. USGEO will establish an Engagement Working Group to further advance federal connections and communications with the EOE and stakeholders, supporting progress on common EOE priorities, such as workforce development, open innovation, and EO impacts.

Strengthen Engagement with Underrepresented Communities: In the coming years, the EOE will need to pursue lasting partnerships and collaborative frameworks for effective engagement with underrepresented communities for increasing diversity, inclusion, and innovation from research and product development to application generation and impacts. Better engagement with these communities and authentic inclusion in the EOE can elevate opportunities for more equitable use and more equitable benefits of EO. This activity calls on the EOE, working with USGEO, to pursue an action plan for engagement with communities currently underrepresented within the EOE, following DEIA, environmental justice, and co-production principles, to broaden the communities effectively employing EO in addressing their needs and effectively articulating their priorities for observations within the EOE.⁸⁸

Promote Earth Observations Resource Discoverability: EO can play vital roles in identifying opportunities to map, monitor, and better inform communities that have historically or otherwise faced under-resourced or inequitable treatment, including assessing human health impacts. Science-informed products and services need to be responsive to and usable by end users, such as city and emergency managers and entities directly supporting underserved communities. Working in coordination with USGEO, the EOE should promote the discoverability of EO resources beyond the EOE’s traditional audiences and stakeholders, whereby addressing equity concerns while also broadening the benefits of EO to help underserved communities and state, local, Tribal, and territorial governments to meet their needs.

Including Indigenous Knowledge: USGEO will promote approaches to integrate IK into the EOE in ways that are mutually beneficial to Tribes and the USG. IK can offer a unique perspective on the local impacts of climate change, weather extremes, and fire on a selected community or geographic area. There are significant opportunities to elevate traditional and IK in the EOE, and mechanisms for Tribal consultation and the strengthening of nation-to-nation relationships for EO can be established.⁸⁹ By including IK with EO, the spatial and temporal aspects of our changing planet can be more clearly depicted alongside the human experience. These efforts need to be done in a way that ensures equitable consideration, access, and

⁸⁸ For example, environmental justice principles can be found in “Environmental Justice, Data, and Research Plan.” <https://www.whitehouse.gov/wp-content/uploads/2024/07/NSTC-EJ-Research-Plan-July-2024.pdf>

⁸⁹ For example, read about the Exchange for Local Observations and Knowledge of the Arctic (ELOKA) on page 31 of the OSTP memo: *Guidance for Federal Departments and Agencies on Indigenous Knowledge.* <https://www.whitehouse.gov/wp-content/uploads/2022/12/OSTP-CEQ-IK-Guidance.pdf>.

interoperability of EO data; respects data sovereignty; and confirms that products align with the FAIR,⁹⁰ CARE,⁹¹ and TRUST⁹² 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 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. EO-related coordination and communication, however, are not limited to the federal level. They can also include state, local, Tribal, and territorial governments as well as measures to engage and partner with the private, philanthropic, and nonprofit/NGO sectors. Coordination and communication are relevant at all phases of the process from planning and conceptualization to development, distribution, and use of products and results.

As EO services become more broadly adopted with U.S. government agencies, those same services are becoming increasingly dependent on international partner contributions (and vice versa) and the increased availability of commercially provided data. As collaboration extends beyond domestic entities to international partners and organizations, issues of governance, provenance, and methods across the international EOE are central to maximizing EO investments through the integration of EO systems, data, and services. However, an unintended consequence of federal acquisition practices for EO 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:

Disentangle Data Ownership from Applications: USGEO will develop guidance for agencies to allow EO data to stand alone and be accessed by multiple user communities, both domestic and international. By separating EO from specific applications, maintaining foundational software that enables user communities continued access to these data, and incorporating a “one dataset, many uses” approach—as appropriately determined by fair and transparent arrangements—coordination efforts can become more streamlined and adaptable. Moreover, this approach will encourage the wider community to access EO to facilitate non-traditional uses of datasets for product development.

Initiative E – Strengthened Global and Regional Leadership

The U.S. is committed to free and open sharing of EO data and products, supporting sustainable development and societal benefits at home and around the world. Through its membership in the intergovernmental Group on Earth Observations (GEO), the U.S. collaborates with hundreds of countries and organizations to advance the availability and use of EO.

The U.S. has given special attention to the AmeriGEO regional partnership, which coordinates activities in the Western Hemisphere. Through AmeriGEO, partners in the Americas collaborate on five thematic

⁹⁰ The FAIR Data Principles are Findable, Accessible, Interoperable, and Reusable. See Wilkinson et al. 2016. *The FAIR Guiding Principles for scientific data management and stewardship*. Scientific Data, 3, 160018. <https://doi.org/10.1038/sdata.2016.18>.

⁹¹ The CARE Principles for Indigenous Data Governance, in conjunction with existing FAIR open data principles, are “people and purpose-oriented, reflecting the crucial role of data in advancing Indigenous innovation and self-determination,” and includes Collective Benefit, Authority to Control, Responsibility, and Ethics. <https://www.gida-global.org/care>.

⁹² The TRUST Principles for digital repositories are guided by the following principles: Transparency, Responsibility, User focus, Sustainability, and Technology. See Lin et al. 2020. *The TRUST Principles for digital repositories*. Scientific Data 7, 144. <https://doi.org/10.1038/s41597-020-0486-7>.

priorities: water, disaster risk reduction, human health, agriculture, and biodiversity. Capacity development and climate change are cross-cutting themes in the AmeriGEO partnership. AmeriGEO fosters regional trust and cooperation through the use of EO and applied science to address environmental challenges, which in turn benefit national security interests. U.S. and EOE engagement in AmeriGEO facilitates international coordination and provides a cohesive environment where organizations across countries can leverage each other's investments for added value.

This National Plan continues the U.S. commitment to GEO and advancement of AmeriGEO. U.S. global and regional leadership can promote increased openness and data sharing. Activities to advance this initiative include:

AmeriGEO Expansion: This National Plan calls on U.S. efforts to enable AmeriGEO to be an increasingly productive and supportive partnership. The U.S. can support AmeriGEO to increase participation from Caribbean nations and encourage active participation by all members. In addition to sustaining and evolving its existing data and training platforms, AmeriGEO can increase engagement with GEO Work Programme activities that have not yet been introduced to the region. The U.S. can support AmeriGEO as it strengthens its engagement with Indigenous peoples and other underserved communities, including to increase their resilience to disasters and climate change.

Initiative F – Increasing the Integration of Earth Observations into National Security Applications

Civil EO data has been and continues to be essential to the national security community. Many regions of the world that drive national security concerns tend to be data sparse, and EO contributes to closing intelligence gaps. Specific examples include estimating radioactive plumes caused by nuclear disasters,⁹³ identifying mobility hazards from rain-induced landslides,⁹⁴ contributing to finding new sources of critical minerals necessary for advanced technology⁹⁵ such as used in modern military and weapon systems, and aiding in Arctic domain awareness for navigating around sea ice. These systems provide a means for the U.S. government to support partner nations in times of international crisis. Intensifying physical and biological effects of climate change will increase risks to U.S. national security through 2040 and beyond, especially as geopolitical tensions mount over how to respond to climate and water supply changes. The EOE should evaluate EO capabilities and data delivery to ensure that stakeholders in the national security community can provide decision-makers relevant, timely, and scientifically accurate information to address environmental security concerns. Activities to realize this objective include:

Improve Awareness of National Security Needs: The national security community should continue to engage with the EOE to communicate national security requirements that could be augmented via existing civil EO. Organizations such as the Civil Applications Committee⁹⁶ can serve as a model for cooperation where national security practitioners can provide feedback to the EOE community during development of EO tools and data. This feedback can be in the form of analysts serving as a part of a review team to help evaluate EO tools and data usability and understandability. For example, integrating insights from the

⁹³ For example: NOAA Fisheries. *Science & Data, Fukushima Radiation in U.S. West Coast Tuna*. Accessed 27 March 2024. <https://www.fisheries.noaa.gov/west-coast/science-data/fukushima-radiation-us-west-coast-tuna>.

⁹⁴ For example: NASA, Landslides @NASA. *Together, we can build a clearer picture of landslides*. Accessed 27 March 2024. <https://gpm.nasa.gov/landslides/index.html>.

⁹⁵ For example: ESRI, Arcwatch, January 2020, *Mineral Exploration from Space*. Accessed 27 March 2024. <https://www.esri.com/about/newsroom/arcwatch/mineral-exploration-in-the-hyperspectral-zone/>.

⁹⁶ Gerald Ford established the Civil Applications Committee or CAC (<https://doi.org/10.3133/fs20223002>) to oversee and facilitate Federal civil agency access to and use of military and intelligence overhead capabilities. The CAC consists of 13 civil agencies, 7 agency members from the Intelligence Community and Department of Defense, and oversight provided by the Office of the Director of National Intelligence, the White House Office of Science and Technology Policy, and the National Geospatial Intelligence Committee.

National Intelligence Estimates from the Office of the Director of National Intelligence into EOE operations, can motivate continued resource allocation for civil EO systems.

Explore Processes to Distribute Interim EO Products: Timeliness is key when using civil and commercial EO systems in support of national security. The EOE should remain flexible in recognizing that imperfect information is generally better than no information in supporting national security needs. Interim and partial solutions to scientific problems in areas of national security interest can be acceptable in times of crisis. The community could recommend processes to share interim tools and data to provide actionability. Product versioning to allow for rapid updates will ensure traceability and improve confidence in national security stakeholders on obtaining the most scientifically sound, yet timely information.

Initiative G – Earth Observations Enterprise Workforce Readiness

A vibrant and skilled workforce supports efforts across the entire EOE. All sectors of the Enterprise rely on and benefit from a robust, sustained, and diverse talent pool across all career stages. Serving all parts of this National Plan, this initiative focuses on efforts to ensure abundant talent to maximize the value and impact of EO for the Nation. The initiative underscores the role of geospatial education and training at all levels to attract, develop, and retain EO professionals. It supports efforts to strengthen the nation’s workforce development system for EO and improve skill building programs, including with data science and scientific communication, for advancing the value and impact of EO for society and the economy.

The Administration recognizes the role of workforce development efforts in improving the uptake and use of EO data in public services, scientific research, and commercial activities, among others. Particular attention must be given to include and advance underserved and underrepresented groups, leading to an EOE that better reflects the Nation. With emerging EO capabilities and increasing integration across sectors, building technical capacity to use, analyze, and interpret EO and other geospatial data and tools will be fundamental. Activities to advance this initiative include:

Workforce Readiness Strategy: This National Plan calls on the EOE, in consultation with USGEO, to develop and implement a workforce readiness strategy, fully incorporating DEIA and environmental justice principles. The goal of this activity is to ensure the long-term availability of abundant EO expertise and to expand the nation’s role as an international and economic leader with EO and geospatial data and tools. USGEO will support the EOE in developing this strategy, engaging appropriate federal departments (e.g., Department of Labor, Department of Education) and the National Academies to apply their expertise and leverage smart practices. Efforts could include reviewing labor categories, education assistance programs, foundational competencies, workforce labor market data, reward structures, and recruitment and retention practices. The strategy should include ways to strongly engage Historically Black Colleges and Universities, Minority Serving Institutions, Tribal Colleges and Universities, and community colleges in workforce development. The strategy should also examine venues to support recruitment opportunities (e.g., identify internship opportunities and hands-on work experience), address local and regional industry needs, and serve as hubs for refresher courses to maintain competencies and credentials. Lessons from the strategy should inform the next National Plan.

Career Pathways and Roadmaps: Career pathways and roadmaps provide guidance to assist Americans of all ages in considering industries of interest and employment opportunities as well as the skills, education, training, and credentials to pursue them and advance. The EOE should develop and maintain career pathways and roadmaps for interested user communities. Toward this end, this National Plan calls on USGEO to develop career pathways and roadmaps for common federal roles applying EO, leveraging creative partnerships and outreach efforts to share the information broadly.

EOE Workforce Development: Coordination of workforce development policies and practices across governments, educators, employers, and others is needed. In supporting the workforce activities listed above and additional ones needed by the EOE, this National Plan calls for the initiation of an inter-sectoral coordinating effort focused on the EOE workforce to improve collaboration on workforce development

practices. Building on existing Administration efforts, USGEO could convene an event focused on the EOE workforce to identify common concerns and interests and to identify appropriate next steps.

Initiative H – Continuous Assessment of Earth Observation Systems

The 2013 National Strategy for Civil Earth Observations articulates 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.

This National Plan recommits to the 2013 National Strategy in conducting observing system assessments to support considerations of continuity, fulfillment, and advancement of measurements. It also calls for regular assessments of EO systems that support the EOE and enable benefits to the Nation and the world. The assessment process will be completed in five cycles, with each cycle focusing on a small group of “societal benefit areas.” The five cycles will be completed over an appropriate period of time, followed by an integrated account after every fifth cycle. The individual assessments and integrated account will support the formulation of future National Plans for Civil Earth Observations. Activities to advance this initiative include:

Continuous Earth Observations Assessment: USGEO will engage with the EOE and external stakeholders to design, conduct, and continually improve the assessment process initiated by the National Strategy. This regular assessment process will focus on assessments of selected thematic benefit areas during a particular “cycle” and a summary account at the end of cycle 5. A notional list of topical areas for each cycle is listed below.

Cycle 1: Agriculture and Forestry, Climate;

Cycle 2: Disasters, Ecosystems (Terrestrial and Freshwater), Ocean and Coastal Resources and Ecosystems;

Cycle 3: Human Health, Water Resources, Weather;

Cycle 4: Biodiversity, Energy and Mineral Resources; and

Cycle 5: Reference Measurements, Space Weather, Transportation.

The assessments and summary account 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 EO data, information, and products as possible alternatives to federally maintained systems, and the results will be shared publicly to the extent appropriate. They should also support analyses of where federal systems provide foundational, continuous, and consistent information as enabling infrastructure.

These efforts will set the Nation on a course for regular assessments of Earth observing systems.

VI. Conclusion

Civil EO benefit every person, every day. EO 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 critical societal needs such as water availability and quality, air quality, and food security. This National Plan furthers the efficiency, efficacy, and equitable impact of

the science, information, and operational services derived from increasingly diverse, disaggregated and evolving EO capabilities and assets.

This National Plan guides federal implementation and coordination of EO 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 philanthropies; state, local, Tribal, and territorial governments; and our international partners. Going forward, USGEO will capture major outcomes from the pursuit of this National Plan to reflect the progress of its implementation in the next National Plan, similar to what is reported in Appendix A.

When successfully implemented, this 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.
- c)** Improve assessment, monitoring, and forecasting of climate change, environmental management, and human health and safety.
- d)** Advance the use of science and data products from the observations to inform planning and decision-making more effectively across all sectors.
- e)** Accelerate development of an EOE workforce highly skilled in observing technology, data analytics, and application development to better leverage EO data in addressing pressing societal and economic challenges.

Pursuing this National Plan will help ensure the realization of sustainable, long-term, and global societal benefits from the nation's investment in EO. The National Plan positions the U.S. to remain a global leader in EO that benefit all life on Earth.

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
EO	Earth observations
EOE	Earth Observations Enterprise
EOP	Executive Office of the President
FAIR	findable, accessible, interoperable, and reusable
GAO	Government Accountability Office
GEO	Group on Earth Observations
GHG	greenhouse gas/gasses
IK	Indigenous Knowledge
ML	machine learning
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 Activities from Previous National Plans

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 (EOE) and articulated three goals and numerous actions to enhance the portfolio of Earth observations (EO), engage with the Enterprise, and increase the impact of EO. Select examples of achievements and activities resulting from the 2019 National 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. Dialogue 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. The 2014 National Plan identified observation priorities for public services and for research in the public interest, and presented eight actions to improve coordination, support data access, and encourage commercial solutions. Select examples of achievements and activities resulting from the 2014 National 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 planning 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-Sentinel 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-Observations 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 forward that focused on addressing these challenges by improving the discoverability, accessibility, and usability of EO data.

AmeriGEO Creation

Fulfilling an action to strengthen international collaboration, the U.S. was a leader in forming AmeriGEO in 2014 together with other countries in the Americas. Annual symposia enabled exchanges within the Hemisphere that initially focused 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.