National Aeronautics and
Space Administration

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Subcommittee on Space and Aeronautics
Committee on Science, Space, and Technology

U.S. House of Representatives

Statement by:
Dr. Karen St. Germain
Director, Earth Science Division
Science Mission Directorate

117th Congress

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Chairman Beyer, Ranking Member Babin, Members of the Subcommittee and Committee,

While NASA may be best known for space exploration, we are also a global leader in Earth system science, with our first space-based observations of the Earth going back to the 1960s. Over the last three decades, much of what scientists have learned about our changing climate is built on NASA's satellite observations and research in collaboration with other agencies. The vantage point of space turns out to be ideal for observing the Earth as a system, and NASA is the agency that builds the U.S.' civilian space-based observing systems. Today, NASA's Earth Science expertise prioritizes and fields the leading-edge space-based observations that help us understand and adapt to our changing planet. And our Earth science applications directly benefit people across the country and the world. NASA is the only space agency with an integrated, end-to-end program in Earth observing mission development, operations, technology, research, data systems, and applications.

We use these space-based measurements to understand Earth's systems and processes — the interactions between land, ocean, atmosphere, and ice. That understanding is the foundation of our collective ability to see climate changes and predict how our environment might evolve. We provide that data and analysis to policymakers, from Congress to counties and cities, who use it to mitigate and adapt to the changing climate, which is essential to improving our lives and protecting our future.

Over the past 20 years, much of the Earth science community has focused on fundamental observations and modeling to understand climate change and the systemic human-induced and natural influences driving it. Now we are at an inflection point. Changing temperatures are impacting agriculture, transportation, plants, and human disease vectors. Severe weather in the form of droughts, wildfires, hurricanes, hailstorms, tornados, and thunderstorms is taking an increasing number of lives and causing record-breaking economic damage. The U.S. experienced 22 separate billion-dollar weather and climate disaster events in 2020 alone, shattering the previous record of 16 such events in both 2017 and 2011. The total 2020 costs, more than $95 billion, were the fourth-highest since 1980. Climate challenges are also playing out around the world, and were identified by the World Economic Forum as among the greatest risks to global well-being.

The changing climate brings opportunities as well. Growing seasons are increasing in what have historically been cooler areas. Previously frozen rivers and plains are becoming more usable and habitable. With diminishing Arctic sea ice, more efficient shipping routes and greater access to ocean floor resources are likely.

Whether to develop climate change mitigation strategies, plan for coming changes, or manage the climate-induced events that are already happening, decision makers are demanding information that is trusted, scientifically sound, and easily accessible. In the years ahead, the widespread and localized impact of the changing climate will drive increasing demand for data, analysis, and tools to support science-informed decisions that will help us continue to thrive on our changing planet.

NASA Earth Science Today

Today, NASA is flying 23 observing systems in space, including six on the International Space Station. These systems are measuring greenhouse gases in the atmosphere, quantifying the rates of sea level rise and glacial ice melt, watching for the conditions that can lead to wildfires and their cascading effects, and monitoring soil moisture and crop stress, just to name a few of the things we do.

We are even making measurements that can tell us whether our underground aquifers – so critical in times of drought – are either full or depleted. Within the next two years, we will begin the first ever global inventory of fresh surface water, commence with hourly observations of atmospheric pollutants that contribute to greenhouse gas formation; and undertake targeted observations of aerosols in the atmosphere to characterize their type, and their role in warming or cooling of the atmosphere, and their linkages to human health.

While observations are fundamental to our understanding of our planet, they are just the first step in obtaining actionable information. NASA's research and analysis activities advance our comprehensive scientific understanding of Earth's processes and their interactions. Using data from all available sources (including domestic, private-sector, and international partner satellites; data from airborne, ship-based, and ground network instrumentation; and outputs from operational weather models), NASA's Earth Science research program enables scientists to investigate and solve complex scientific questions that cannot be addressed using data from only a single mission or instrument. We infuse the quantitative knowledge we gain into numerical models, which can then be used to predict future conditions and anticipate the effects of different scenarios and approaches on all scales, including global climate change.

Through our observations and our research and analysis program, we advance our understanding of how our home planet is changing, and how those changes will impact everything from our underground aquifers, to the health of our surface vegetation, to the mechanics behind weather dynamics, to air quality, and more. This knowledge underpins cross-agency work undertaken to understand our climate and the entire Earth system, such as the National Climate Assessment developed by U.S. Global Change Research Program (USGCRP). The nation recoups its investment in NASA Earth Science when we make this information available to those who need it, when they need it, and in a form they can use.

Here are just a few examples of how NASA information is already at work, with and through partners, helping our nation's decision makers at every level:

Safe and ample drinking water. Increasing droughts threaten the extent of regional snowpack, water reservoir levels, and groundwater availability for all Americans, especially communities of color, sovereign tribes, and low-income communities. This year, NASA Earth Science will launch OpenET, a partnership between NASA, the Environmental Defense Fund, Desert Research Institute, and Google Earth Engine. Leveraging data from NASA, National Oceanic and Atmospheric Administration (NOAA) and U.S. Geologic Survey (USGS)-operated satellites, this will be the first operational system for measuring freshwater data, scalable down to individual farm fields. Completely accessible and free to the public and covering 17 Western states, OpenET will be a valuable resource to water managers and agricultural producers.

For a broader view, NASA is also launching the Surface Water and Ocean Topography (SWOT) mission in early 2022. A joint partnership with France, with contributions from Canada and the United Kingdom, SWOT will provide the first global survey of Earth's surface water, including detailed observations of the ocean's surface topography, and measurements of how water bodies are changing over time.

Our nation's ability to feed itself. As farmers and livestock producers struggle to adjust to hotter temperatures, more frequent droughts, and rapidly changing flood and storm patterns, we must find more sustainable food-production practices. Since its launch in 2015, the NASA Soil Moisture Active Passive (SMAP) satellite mission has collected soil moisture measurements around the globe with impressive accuracy. Because of the value of this information to farmers, we have made this information freely available to the public through a portal created in partnership with the U.S. Department of Agriculture (USDA) and George Mason University and offering it along with many other NASA datasets through Google Earth.

Safety from extreme weather events. Low-lying homes, businesses, and critical infrastructure, such as military installations and our nation's launch infrastructure, are increasingly at risk from sea-level rise, increased flooding and hurricane-force winds. With the November 2020 launch of the Sentinel-6 Michael Freilich satellite, a joint U.S.-European effort, we are collecting the most accurate data yet on sea level and how it changes over time.

Better sea level measurements add to advances in our knowledge of the entire Earth system and will help decisionmakers in regions throughout our country suffering from the impacts of sea level rise develop flood-risk resilience and disaster response plans. These regions include Virginia's Hampton Roads, home to 1.7 million people, as well as both NASA's Langley Research Center and the world's largest naval facility, Naval Station Norfolk. The only part of our country that has seen more of the impact of sea level rise is the New Orleans region, home to more than a million Americans and NASA's Michoud Assembly Facility. NASA and Americans stand to benefit from these increased capabilities.

Informed policy decisions. NASA measurements provide information for policymakers, including information regarding the efficacy of environmental policies and decisions. NASA provides cutting edge greenhouse gas observations from space. Our Carbon Monitoring System offers a product-oriented overlay that provides actionable results with quantified uncertainty for monitoring, reporting, and verification of carbon stocks and fluxes.

As the nation's civil space agency and with substantial Earth science and applications research programs, NASA-funded research results and NASA personnel were foundational contributors to the fourth National Climate Assessment (NCA4). NASA's observations, advanced Earth system models, and scientific analyses underpinned virtually all of the scientific findings in NCA4 Volume I: Climate Science Special Report, which details how climate change is affecting the physical Earth system and documents the status and current knowledge of physical climate science. NASA also made substantial contributions to the NCA4 Volume II, which focuses on observed and projected impacts, risks, and risk reduction approaches for the United States, and implications of climate change impacts under a variety of mitigation approaches.

The Next Two Decades

Looking further into this decade and beyond, NASA Earth Science is accelerating work in three key areas to advance our understanding of the Earth system processes that influence how and when the specific impacts of climate change are likely to play out, and to rapidly make this information available and usable to those who need it:

- **Space-based Observations**: Increasing our ability to "see" Earth systems by investing in innovative technologies, exploring alternative observation platforms, experimenting with new approaches to industry partnership and commercial services, and continuing to expand international collaboration.
- **Modeling & Informatics**: Integrating these observations and advanced models through frameworks that span timescales from minutes to decades, to further our understanding and prediction of the whole Earth system.
- **Applications & Dissemination**: Dramatically accelerating the uptake of scientific understanding and delivery of information in scalable ways to inform policymakers, managers and the public, aiding decisionmakers at every level, every day.

The 2017 Earth Science Decadal Survey by the National Academies of Science, Engineering, and Medicine laid out ambitious, but critically necessary, research and observation guidance for the work NASA should undertake by 2028. NASA is developing the mission concept for an Earth System Observatory consisting of an array of

space-based satellites, instruments, and missions that will deliver the highest priority data identified in the Decadal Survey, including data to improve scientific understanding in the following areas:

- **Aerosols:** Answering the critical question of how aerosols affect the global energy balance, a key source of uncertainty in predicting climate change
- **Cloud, Convection, & Precipitation:** Tackling the largest sources of uncertainty in future projections of climate change, air quality forecasting, and the prediction of severe weather
- **Mass Change:** Providing drought assessment and forecasting, associated planning for water use for agriculture, as well as supporting natural hazard response
- **Surface Biology & Geology:** Understanding climate changes that impact food and agriculture, habitation, and natural resources, by answering open questions about the fluxes of carbon, water, nutrients, and energy *within* and *between* ecosystems and the atmosphere, the ocean, and the solid Earth
- **Surface Deformation & Change:** Quantifying climate change-driven sea-level and landscape changes, hazard forecasts, and disaster impact assessments, including dynamics of earthquakes, volcanoes, landslides, glaciers, groundwater, and the Earth's interior

Together, these observations will create a 3D view of our Earth, from atmosphere to bedrock. Change is coming not just in what we are doing, but also in how we are doing it. NASA Earth Science is approaching the development of observing systems with new principles, including:

- Open science and diversity: A more diverse workforce, conducting science that is open and accessible to all, creates a stronger end result. This will also help NASA make our science and data more accessible at regional and local scales, as a way of reaching communities that often have fewer means to mitigate environmental degradation, such as low-income neighborhoods and tribal nations.

- Partnership with commercial companies: The precision manufacturing and digital technology enabled by commercial forces and private investment opens pathways to miniaturization and modularization of instruments and spacecraft, as well as advances in quantum computing and artificial intelligence.
- New business models: Focusing on innovation to increase opportunities for access to space, and leveraging ideas and talent at companies, universities, and other research institutions will augment and enable our core observation capabilities through competed tech demonstrations.

NASA's partnership with the Indian Space Research Organisation (ISRO) to deploy synthetic aperture radar is a good example of how we are tying these principles together. Called NISAR (NASA-ISRO Synthetic Aperture Radar), this mission will exploit new innovations in radar to gather an unprecedented, detailed view of Earth, measuring some of our planet's most complex processes. Data from NISAR on ecosystem disturbances, ice-sheet collapse, and natural hazards such as earthquakes, tsunamis, volcanoes and landslides, will assist how we manage both hazards and natural resources in the future. The data will be open and accessible to the public. The science from NISAR will inform us on the evolution and state of Earth's crust, helping us better understand our plant's processes and changing climate. This three-year mission is planned for launch in 2023.

Just as a rapidly changing environment presents challenges, the rapid pace of innovation and private sector investments presents opportunities to enable science-informed decisions throughout the public and private sector. Dramatic advances in precision manufacturing and digital technology, driven largely by industry, have enabled miniaturization and modularization of instruments and spacecraft, in some cases lowering launch costs. Together, these innovations are creating new ways to observe Earth at the time and spatial scales the nation will need to build resilient communities, support sustainable agriculture, assess air quality and biodiversity, and manage water resources.

More observations and commercially available computing power are unleashing advances in modeling, machine learning, and informatics, which accelerate our predictive capability. NASA is improving our predictive models for the ocean, land, atmosphere, and cryosphere processes, as well as for the interactions between them – which is the key to improving longer-range forecasting. Technology-based efforts like these enable *open science*, which will provide the immediate access and transparency necessary to inform policy development and management approaches, especially in communities most impacted by climate change.

NASA is planning to undertake these new observations as aggressively as we can, leveraging our resources as well the capabilities of our commercial, academic, interagency, and international partners. We are modernizing our data systems in partnership with the private sector to dramatically increase access to data and foster an open science ecosystem where we can quickly learn from these observations and make them readily available to decision-makers at every level.

NASA is leveraging the growing private sector investments in Earth science, including new constellations of commercial small satellites that gather Earth imagery, radio occultation measurements, and other environmental data. And we are investing in innovative observing system technologies and mission concepts. The Earth Science Technology program competitively awards targeted technology development and demonstration grants that will enable future observations, while the Earth Venture Program funds competitively-selected, cost-capped instruments and missions led by our academic research partners around the country. Future missions will also open many of the instruments and spacecraft for competitive selection.

Conclusion

The unique vantage point of sustained, trusted, space-based observations provides critical information to advance our understanding of Earth systems, addressing the multitude of components that interact to shape our present and future environment. Through strong collaboration with NOAA, USGS, USDA, and commercial and international partners, we deliver the benefits of our technology, observations, research, and applications to enable humanity to thrive.

At the end of this decade, another billion people will be living on our planet, putting more pressure on our Earth's systems. NASA is moving with urgency, focus, and in concert with the science community, our sister agencies in the federal government, our international partners, the private sector, our research associates in academia, and, of course, at the direction of Congress and the Administration, to meet the unrelenting challenge of a changing climate.

But know that we at NASA are relentless as well. We are accelerating our science, our partnerships, and new ways to do business. We are doing this because it is our mission, a mission we take to heart. Climate change demands science equal to the challenge it presents, and NASA will provide the space-based data needed to understand, mitigate, and adapt to our changing planet.

Thank you for the opportunity to discuss NASA's Earth Science program; I would be pleased to respond to any questions you might have.

Karen M. St. Germain, PhD

Deputy Assistant Administrator, Systems

Dr. Karen St. Germain is the Deputy Assistant Administrator, Systems (DAAS), for NOAA's Satellite and Information Service. She guides the ongoing development and deployment of NOAA's two major satellite programs (the Joint Polar Satellite System and Geostationary Operational Environment Satellite – R series), the COSMIC-2 mission, and the Space Weather Follow-On. She also leads the development of the next-generation capabilities that will replenish and augment these systems in the future.

Prior to becoming the DAAS, Dr. St. Germain served as the Director of the Office of Systems Architecture and Advanced Planning (OSAAP) where she led enterprise-level mission architecture development and systems engineering to enable NESDIS to become a flexible, stable and responsive civil space agency in support of NOAA's mission. Dr. St. Germain is a leader in enterprise-level planning and multi-organizational programs of national significance. She is also an expert in major systems acquisition, with particular proficiency in transitioning new technology into operational systems.

Dr. St. Germain developed a deep understanding of the NESDIS mission as NOAA's lead for all aspects of system performance during the development of the successful Suomi-NPP system, from 2006 to 2011. In 2011, Dr. St. Germain accepted a position in the Space, Strategic and Intelligence Systems (SSI) Office, Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (OUSD AT&L). There, she the DoD 2014 Strategic Portfolio Review for Space, a special assignment task for the Deputy Secretary of Defense to develop a strategy and implementation plan for adapting to evolving challenges in the space domain. Dr. St. Germain also led the Remote Sensing and Prompt Strike Division within SSI, where she was responsible for acquisition shaping and oversight of DoD strategic missile warning and space-based environmental monitoring portfolio, and the Program Director of the Conventional Prompt Global Strike Program.

Before joining NOAA, Dr. St. Germain had a successful research career at the University of Massachusetts, the University of Nebraska, and the Naval Research Laboratory. She has performed research aboard ice-breakers in the Arctic and Antarctic, flown through hurricanes and tropical storms on NOAA's P-3 airplanes and measured glacial ice on a snowmobile traverse of the Greenland ice sheet. She also led the modeling and calibration of the WindSat Coriolis mission, the first space-borne radiometer to measure ocean surface wind direction.

Dr. St. Germain holds a Bachelor of Science degree in electrical engineering from Union College (1987) and a Doctor of Philosophy degree in Electrical Engineering from the University of Massachusetts (1993). She is also a Distinguished Graduate of the National War College, National Defense University where she earned a Master of Science degree in National Security Strategy in 2013.