Hold for Release
Until
Presented by Witness

National Aeronautics and
Space Administration

December 1, 2022

**Committee on Commerce, Science,
and Transportation**

United States Senate

Statement by:

Dr. Kate Calvin
NASA Chief Scientist

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INTRODUCTION

"When we look down at Earth from space, we see this amazing, indescribable, beautiful planet. It looks like a living, breathing organism." These are the words of astronaut Ron Garan, who spent six months looking down at Earth from the International Space Station in 2011. They capture how inspiring it is to observe Earth from space. Garan is one of many NASA astronauts whose relationship with our home planet has been transformed by his time in space. When people see our Earth as a blue marble from space, they see it is finite, fragile, and interconnected.

Space is the best vantage point we have for both seeing and studying our changing planet. Earth observations gathered from space are the basis for so much of the scientific data and information that tells us what we know about Earth and how it is changing. In the years ahead, we will need Earth observations more than ever, for science *and* for inspiration, as we grapple with the growing impacts of climate change on our planet. Earth observations are key to helping society understand and effectively respond to changes in climate and are increasingly used in a range of societal applications.

Earth Observations as the Foundation

NASA has been observing and measuring Earth from space for over 60 years, beginning with the launch of the world's first dedicated Earth science mission in 1960. The TIROS-1 weather satellite only lasted 78 days, but it was a precursor mission to today's Earth observing satellites. Twelve years later, NASA's launch of the first Landsat satellite in 1972 marked the start of a continuous record of land measurements from space that continues unbroken to this day. Fast-forward to 2022 and there are over 1,000 Earth observing satellites in orbit today, with more being launched each month. These satellites have different capabilities, sizes, and architectures, and are hosted and operated by a range of entities, including other U.S. government agencies, other governments, and a growing private sector.

Through decades of Earth observing missions and innovation, NASA started a revolution and laid the groundwork for the golden age of Earth observations we see ourselves in today. Today, NASA operates a fleet of over two dozen Earth observing satellites and instruments hosted on the International Space Station (ISS). We continue to push the state-of-the-art in Earth remote sensing from space and take critical measurements of nearly every component and constituent of the changing Earth. We also build and launch environmental satellites for our federal agency partner NOAA, and we work in close partnership with USGS through the interagency Sustainable Land Imaging program to design, develop, and launch USGS' Landsat series of land imaging satellites. And NASA is pleased to see the success of an industry we have supported emerging as a robust partner across a number of areas related to earth observation. .

Earth observations from space are the foundation of much of what we know about our Earth systems. Datasets from Earth observing satellites like NASA's long-running Terra, Aqua, and Aura satellites and the more recently launched Gravity Recovery and Climate Experiment (GRACE-FO), ICESat-2, and Sentinel 6-Michael Freilich, underpin climate research, and they are key to developing and testing and verifying Earth system models.

We also work with people on the ground around the world to solve problems as they unfold. Earth observations are the foundation for a range of applications, including weather prediction, disaster response and recovery, wildfire response, land use planning, water resource monitoring, agricultural support, food security, air quality monitoring, and aviation safety. For example, OpenET is a program that uses publicly available NASA-USGS Landsat data to provide information to farmers and ranchers on evapotranspiration, so they can estimate the amount of water being taken up or used by their fields and crops and that will usually need to be replaced through irrigation or rainfall. This enables them to use water more efficiently and better plan irrigation.

Together with our other government partners, we are measuring, studying, and informing the world about our changing Earth. We are disseminating the data and knowledge collected for the benefit of humankind. And we are researching the new technologies and paving the way for the next generation of Earth observation missions. Our latest endeavor is NASA's Earth System Observatory (ESO), a series of missions in development that will launch later this decade that will give us a 3D holistic view of the changing globe.

Innovating the Next Generation of Earth Observations

The ESO responds to the top recommendations from the National Academies of Sciences, Engineering, and Medicine's 2017 Earth Science and Applications from Space Decadal Survey, including missions targeting the Academies' priorities for observation: aerosols, clouds, convection and precipitation; mass change, surface biology and geology, and surface deformation and change. Formulation activities are underway for the first four major ESO missions targeting these designated observables. NASA just received recommendations from an ESO Independent Review Board (IRB), which took a close look at ESO's science goals, management and programmatic structures, and preliminary mission architectures. The IRB reviewed technical concepts formulated by NASA for the ESO to ensure their robustness,

considered the ESO's ability to achieve NASA's plans, and checked to ensure lessons learned regarding large missions were incorporated into this effort.

In October, NASA announced the first mission opportunity within the new Earth System Explorer Program, another priority from the 2017 Decadal Survey. For the Earth Explorer missions, NASA is seeking submissions of proposals for a medium-sized PI-led mission that will investigate one or more targeted observables identified by the Decadal Survey. With a focused programmatic scope, Explorer missions can be developed relatively quickly and complement the science goals of the larger Earth System Observatory. They will allow investigators to propose gathering high priority observations, including, for example, greenhouse gases, that are not part of the ESO suite of missions.

NASA continues to innovate in the measuring and monitoring of greenhouse gases from space, building on the legacy of our Orbiting Carbon Observatory-2 (OCO-2) and OCO-3 missions, which are able to measure vertical columns of carbon dioxide concentrations in Earth's atmosphere and track how CO_2 concentrations vary globally and how they are changing over time. NASA's new Earth Surface Mineral Dust Source Investigation (EMIT) mission, which launched successfully in July, has demonstrated the crucial capability of detecting the presence of methane, a potent greenhouse gas. Since July, the EMIT science team has identified more than 50 methane super-emitters globally.

NASA also announced earlier this year a new contract for commercial data acquisition with GHGSat, Inc., of Canada, which uses satellites to collect methane and carbon dioxide measurements that can help identify greenhouse gas sinks and sources. Following in the footsteps of NASA's other commercial data vendors, including Planet, Maxar, and Spire, GHGSat will provide their data to NASA for evaluation to determine the utility for advancing NASA's science and application goals.

The data and information provided by EMIT, commercial missions like GHGSat, and future missions like these, can help decision-makers better identify, understand, and address methane emissions.

Ensuring Continuity of the Global Climate Record

With a number of NASA's flagship Earth research satellite missions, including Terra, Aqua, and Aura, reaching end-of-life over the next few years, an important ongoing conversation has emerged across the Earth observations community about how to ensure the continuity of the data provided by missions on which the research and applications communities have relied for decades. These conversations include questions about the roles that other federal agencies, as well as our international partners, and private sector, can play.

With a new budget line in the FY 2023 Budget, NASA is pursuing key climate continuity measurements and advancing open science by leveraging cutting edge data science techniques. In addition, the first Earth Venture Continuity (EVC) mission, Libera, was selected in February 2020 and will maintain the 40-year data record of the balance between the solar radiation

entering Earth's atmosphere and the amount absorbed, reflected, and emitted. NASA plans to announce an opportunity and solicit proposals for a second EVC mission in 2023.

NASA plays an essential role in supporting continuity of data records provided by our interagency partners' satellites, including in building and launching NOAA's environmental satellites, on a reimbursable basis for NOAA, and helping develop future satellite architectures for both NOAA and USGS. NASA develops and maintains critical continuity data records using reprocessed NOAA operational satellite measurements merged with those of NASA and other agency and international partners, allowing detection and characterization of both short-term variability and long-term trends in essential quantities, such as Earth radiation, ozone, and aerosol concentrations. NASA provides flight program management expertise and a focus on innovation to partnered missions, driving Federal science through new approaches and observation technologies.

For example, NASA has been working closely with USGS to finalize the next-generation system architecture for the Landsat Next satellite and will begin formulation activities for the mission activities shortly. NASA's goal has been striking a balance between incorporating the latest land imaging technologies with ensuring Landsat's continuous long-term record of land imagery and data within the budget that the Administration and Congress can provide. Landsat Next, now expected to launch as a "triplet" configuration of three platforms, will join Landsat 8 and Landsat 9 on orbit in adding to the continuous long-term record of land imaging that began with the first Landsat in 1972.

We also expect to expand our commercial interaction working with the private sector to add their capabilities to our own to benefit American citizens. NASA's pioneering data purchases have allowed us to see what small commercial satellite operators can provide now and what they might in the future, as well as better set the terms of future procurements and licensing of data for science. We hope our work in this area will support this industry as it grows.

Earth Observations for Earth Action

As part of a growing emphasis on providing actionable data and information to a broad range of users, NASA is planning to launch an Earth Information Center (EIC) next year. The EIC will provide a wide range of Earth and climate data and information to the public and stakeholders, but the initial focus will be on prototyping capabilities for a greenhouse gas monitoring and information system that will integrate data from a variety of sources with a goal of making GHG data more accessible and usable to Federal, State, and local governments, researchers, the public, and other users.

To implement this effort NASA is collaborating with other agencies including the Environmental Protection Agency (EPA) to enhance greenhouse gas monitoring and make greenhouse gas data more accessible to a broad range of users. NASA will work jointly with other agencies to develop the greenhouse gas monitoring and information system. The greenhouse gas monitoring and information system will support regular updates to national gridded greenhouse gas anthropogenic activity-based data. The system will also combine EPA's anthropogenic emission data with atmospheric-based data on natural emissions and fluxes, and enable the identification

and quantification of emissions from large anomalous events, leveraging aircraft and satellite data.

Through open-source science, NASA provides knowledge, resources, tools, and technologies to benefit humanity. This provides opportunities for those outside of NASA to create new applications using NASA observations, as well as leverage existing applications. For instance, it can help other government agencies or NGOs as they address societal or environmental challenges and make decisions in a range of sectors. NASA is also continuing to improve our engagement with the public on Earth science and share information about our planet that can only be fully unlocked by observing it. NASA is also innovating its partnerships, with the goal of exploring new paths to applications and impact. NASA capabilities mean opportunities for engagement with a wide range of sectors, from agriculture to oil and gas. We are looking at ways to engage with philanthropies, state agencies, and to connect with citizens broadly through open science as well as targeting our outreach through the lens of environmental justice.

CONCLUSION

Increasingly, we see our work in Earth observations through the lens of its importance to global climate change. Each climate tipping point presents its own multi-faceted ecological or societal challenge. For each, we ask how science and Earth observations can inform responses, by individuals, nations, and the world. The global climate observing system from space is critical because only from space can we track the status over time of each of these climate tipping points and other Earth system changes holistically all around the world. Our monitoring could provide the first and most clear warning signs that a climate tipping point is near or has been reached.

And as always, we look to Congress for guidance on priorities and partnerships, noting congressional interest in science relating to everything we do. We thank you for this opportunity to share something of our approach to Earth observation and look forward to your questions.