

Thriving on our Changing Planet

Developing a Decadal Strategy for Earth Observations from Space

Waleed Abdalati

Cooperative Institute for Research in Environmental Sciences

University of Colorado Boulder

February 3, 2026



What We Were Asked to Do

OVERARCHING TASKS

- Assess **progress from 2007**
- Develop a prioritized list of top-level **science and application objectives** for 2017-2027
- Identify gaps and opportunities in the **programs of record** at NASA, NOAA, and USGS
- Recommend approaches to facilitate the development of a robust, resilient, and appropriately balanced **U.S. program of Earth observations** from space

GENERAL & AGENCY-SPECIFIC TASKS

- **Cross-Agency**
 - Enabling activities
 - Partnerships & synergies
- **NASA**
 - Program balance and scope
 - Ventures flight element
 - Decision principles and measurement continuity
- **NOAA and USGS**
 - Non-traditional observation sources
 - On-ramp of scientific advances
 - Research-to-operations
 - Technology replacement/infusion

Panels

Global Hydrological Cycles and Water Resources

The movement, distribution, and availability of water and how these are changing over time

Weather and Air Quality: Minutes to Subseasonal

Wisconsin and Nancy Baker, NRL

Atmospheric Dynamics, Thermodynamics, Chemistry, and their interactions at land and ocean interfaces

Marine and Terrestrial Ecosystems and Natural Resource Management

Biogeochemical Cycles, Ecosystem Functioning, Biodiversity, and factors that influence health and ecosystem services

Climate Variability and Change: Seasonal to Centennial

Forcings and Feedbacks of the Ocean, Atmosphere, Land, and Cryosphere within the Coupled Climate System

Earth Surface and Interior: Dynamics and Hazards

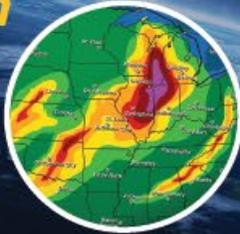
Core, mantle, lithosphere, and surface processes, system interactions, and the hazards they generate

THE IMPORTANCE OF EARTH INFORMATION

Earth-observing satellites provide critical information about our planet. This information supports a broad range of societal needs and enables the scientific discovery required to meet those needs, making us all healthier, safer, and more efficient.

HELPING PLAN OUR DAY

300 billion
weather forecasts
used by Americans
every year



100+ million
American adults use
internet-based
mapping services



Americans rely on sophisticated Earth information throughout their everyday lives, from weather forecasts to navigation applications in their cars. Satellites are the original sources of much of the data.

PROTECTING OUR HEALTH

6.5 million
premature deaths from
air pollution around the
world every year



Earth-observing satellites track the concentration of harmful pollutants across the country, providing air quality data for rural areas without ground-based monitoring systems and measuring the effects of air quality regulations.

50% of the world's population
is at risk from malaria.

Satellite observations of temperature, vegetation, and rainfall help predict the spread of mosquito-borne illnesses like malaria, Zika, and West Nile Virus.



KEEPING US SECURE

The estimated value of NASA and NOAA information services to the U.S. Navy's operational effectiveness is **\$2 billion** per year.

The U.S. Navy and other U.S. defense agencies partner with NASA and NOAA to use satellite data, to access operational services, and to leverage their scientific progress.

MITIGATING NATURAL DISASTERS

Extreme weather and fires have cost the federal government more than **\$350 billion** over the past decade.

Satellite measurements play a critical role in tracking the paths of hurricanes and wildfires so that we can warn populations at risk, assess the damages, and avoid future costs.



ENSURING RESOURCE AVAILABILITY

Advanced technology, including many types of Earth information, will unlock up to **\$1.6 trillion** in economic savings for energy generation and use by 2035.

Satellite observations can also help ensure water availability, which is particularly important to the 20% of the world now living in areas of water scarcity.



A Paradigm and a Challenge

Earth Science and Applications Paradigm for the Coming Decade

Earth science and derived Earth information have become an integral component of our daily lives, our business successes, and society's capacity to thrive. Extending this societal progress requires that we focus on understanding and reliably predicting the many ways our planet is changing.

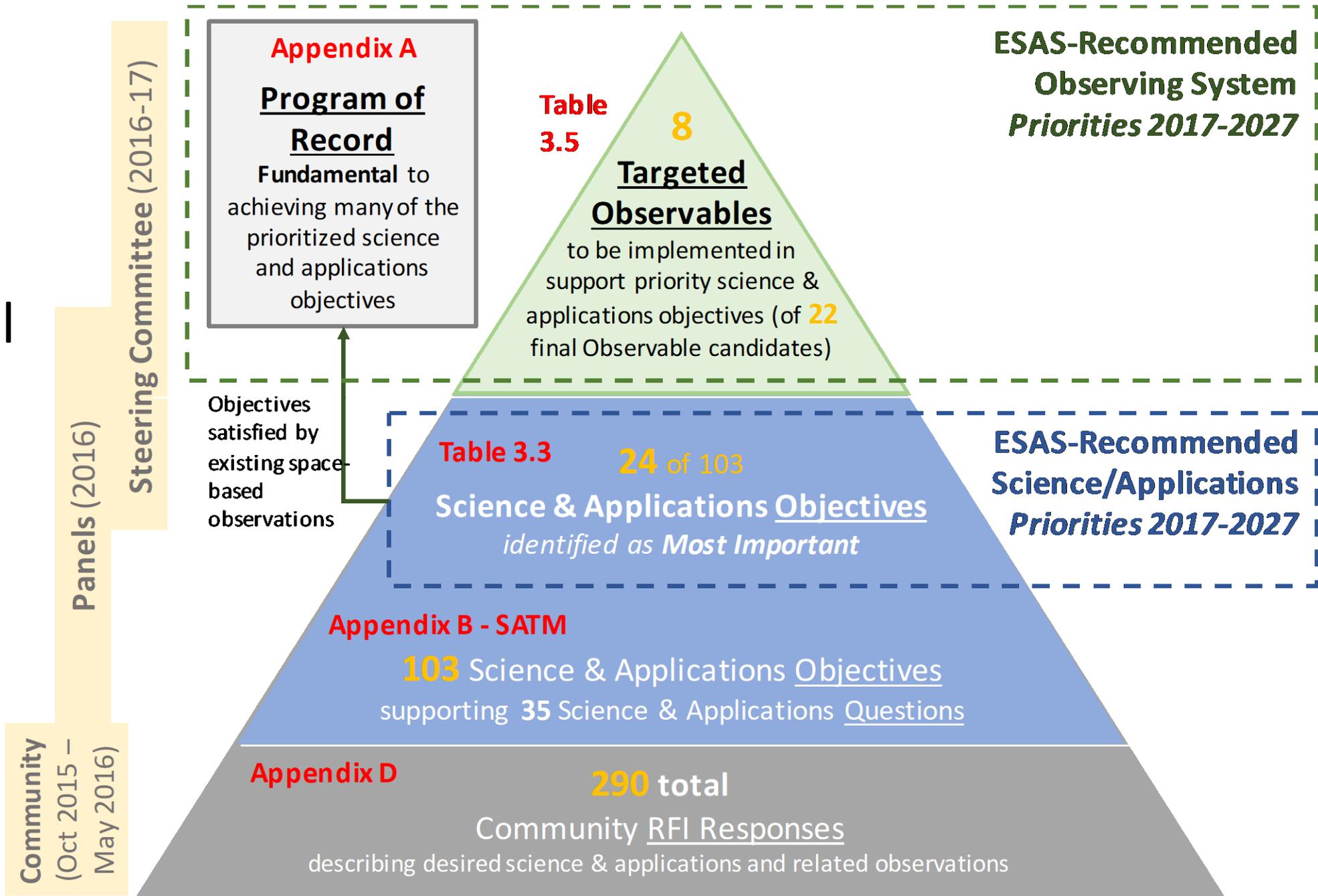
Decadal Community Challenge

Pursue increasingly ambitious objectives and innovative solutions that enhance and accelerate the science/applications value of space-based Earth observation and analysis to the nation and to the world in a way that delivers great value, even when resources are constrained, and ensures that further investment will pay substantial dividends.

Path from Science & Applications to Observational Priorities

Blue: Science & Applications

Green: Observables



Recommended NASA Flight Program Elements

Program of Record.

The series of existing or previously planned observations, which **should be completed as planned**. Execution of the ESAS 2017 recommendation requires that the total cost to NASA of the Program of Record *flight missions from FY18-FY27 be capped at \$3.6B.*

- **Designated.** A new program element for ESAS-designated cost-capped medium- and large-size missions to address ***observables essential to the overall program*** and that are outside the scope of other opportunities in many cases. Can be competed, at NASA discretion.
- **Earth System Explorer.** A new program element involving competitive opportunities for medium-size instruments and missions serving specified ESAS-priority observations. ***Promotes competition among priorities.***
- **Incubation.** A new program element, focused on investment for priority observation opportunities needing advancement prior to cost-effective implementation, including an Innovation Fund to respond to emerging needs. ***Investment in innovation for the future.***
- **Venture.** Earth Venture program element, as recommended in ESAS 2007 with the addition of a new Venture-Continuity component to provide ***opportunity for low-cost sustained observations.***

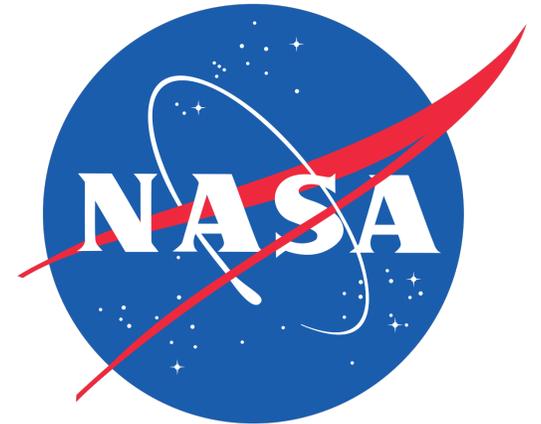
Summary of Top Science & Applications Priorities*

* Complete set of Questions and Objectives in Table 3.3

Science & Applications Topic	Science & Applications Questions addressed by MOST IMPORTANT Objectives
Coupling of the Water and Energy Cycles	<p>(H-1) How is the water cycle changing? Are changes in evapotranspiration and precipitation accelerating, with greater rates of evapotranspiration and thereby precipitation, and how are these changes expressed in the space-time distribution of rainfall, snowfall, evapotranspiration, and the frequency and magnitude of extremes such as droughts and floods?</p> <p>(H-2) How do anthropogenic changes in climate, land use, water use, and water storage interact and modify the water and energy cycles locally, regionally and globally and what are the short- and long-term consequences?</p>
Ecosystem Change	<p>(E-1) What are the structure, function, and biodiversity of Earth's ecosystems, and how and why are they changing in time and space?</p> <p>(E-2) What are the fluxes (of carbon, water, nutrients, and energy) <i>between</i> ecosystems and the atmosphere, the ocean and the solid Earth, and how and why are they changing?</p> <p>(E-3) What are the fluxes (of carbon, water, nutrients, and energy) <i>within</i> ecosystems, and how and why are they changing?</p>
Extending & Improving Weather and Air Quality Forecasts	<p>(W-1) What planetary boundary layer (PBL) processes are integral to the air-surface (land, ocean and sea ice) exchanges of energy, momentum and mass, and how do these impact weather forecasts and air quality simulations?</p> <p>(W-2) How can environmental predictions of weather and air quality be extended to seamlessly forecast Earth System conditions at lead times of 1 week to 2 months?</p> <p>(W-4) Why do convective storms, heavy precipitation, and clouds occur exactly when and where they do?</p> <p>(W-5) What processes determine the spatio-temporal structure of important air pollutants and their concomitant adverse impact on human health, agriculture, and ecosystems?</p>
Reducing Climate Uncertainty & Informing Societal Response	<p>(C-2) How can we reduce the uncertainty in the amount of future warming of the Earth as a function of fossil fuel emissions, improve our ability to predict local and regional climate response to natural and anthropogenic forcings, and reduce the uncertainty in global climate sensitivity that drives uncertainty in future economic impacts and mitigation/adaptation strategies?</p>
Sea Level Rise	<p>(C-1) How much will sea level rise, globally and regionally, over the next decade and beyond, and what will be the role of ice sheets and ocean heat storage?</p> <p>(S-3) How will local sea level change along coastlines around the world in the next decade to century?</p>
Surface Dynamics, Geological Hazards	<p>(S-1) How can large-scale geological hazards be accurately forecasted and eventually predicted in a socially relevant timeframe?</p>

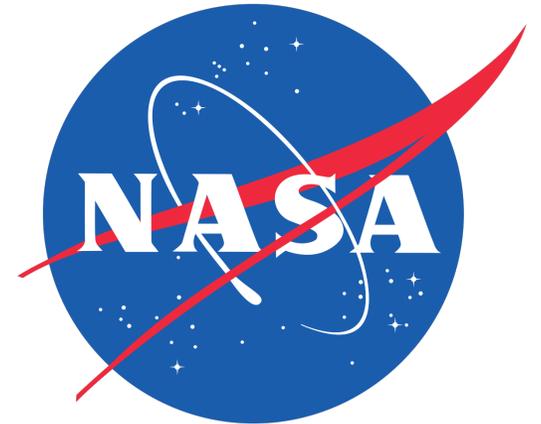
NASA Portfolio Balance

- Earth Science research and analysis: *maintain* at approximately 24% of the ESD budget (22-26%)
 - Includes 18% for openly competed research and analysis
 - Includes approximately 3% each for computing and administration
- Flight program (including Venture): *maintain* at 50-60% of the ESD budget
- Mission operations: *maintain* at 8-12% of the ESD budget
- Technology program: *increase* from current 3% to about 5% of the ESD budget
- Applications program: *maintain* at 2-3% of the ESD budget



Programmatics - NASA

- Rec 4.6** Apply **decision rules** (included) to maintain programmatic balance (programmatic balance was a high priority)
- Rec 4.7** Small scope changes to **applications & technology programs**
- Rec 4.8** Reevaluate **Ventures structure** at mid-term
- Rec 3.3** **Avoiding cost growth** is critical to program's success (capability and reliability are where the flexibility must be found)



This is *too important* to
not do the best we
possibly can.



Our best *requires* all
perspectives!