Advancing Scientific Understanding of Earth

Earth System Science Research

Barry Lefer, Associate Director

Overall Research Strategy

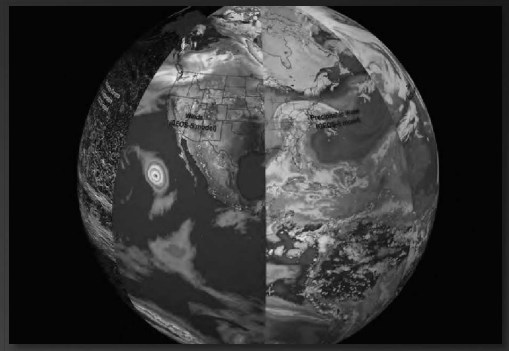
By focusing on things that only NASA can do, the Earth Science Research element is driving the nation's premier knowledge incubator for understanding Earth's complex and interconnected atmosphere, biosphere, cryosphere, hydrosphere, and geosphere system.

- **ONLY NASA can…**
  - Provide end-to-end Earth system science research using NASA space-based observations + ground validation + modeling
  - Establish integrated mission science teams, providing early access to data for high-impact research
  - Support decadal-survey-driven science while also feeding discoveries back into mission planning and design
  - Provide reliable, consistent, calibrated, and trusted data for many essential Earth observations

The Nation gets…

- Scientific discovery that expands human knowledge
- Training for the next generation of engineers, scientists, and technologists through grants and real-world mission work
- Knowledge that leads to improved early warning systems, disaster preparation, and economic advantage
- Increased discovery and mapping of critical minerals
- NASA-developed technologies that underpin everyday applications (i.e., GPS)

Earth Science Research Program Overview



Earth System Science Research

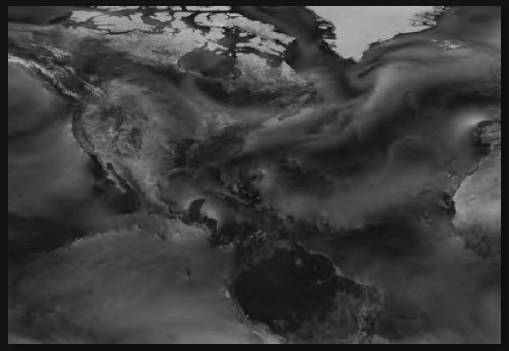
- Competed discipline and interdisciplinary research
- Early career research
- Field campaign support

Airborne Science

- High altitude (ER-2, WB-57)
- Large airborne laboratory (B777)
- Remote sensing jets (G-V, UAVSAR, airSAR-ng)

Space Geodesy

- Very Long Baseline Interferometry (VLBI)
- Satellite Laser Ranging (SLR)
- Global Navigation Satellite System (GNSS)



Integrated Earth System Modeling

- Virtual Modeling Institute (was Model-E, GEOS, ECCO, ISSM, LIS, others)
- Scientific Computing

ESD Research Strategy

- Simplify Research organization structure (transition to Spheres)
- Use directed funds to maintain critical capabilities at NASA Centers
- Release selected solicitations in ROSES as budget allows and streamline the ROSES process

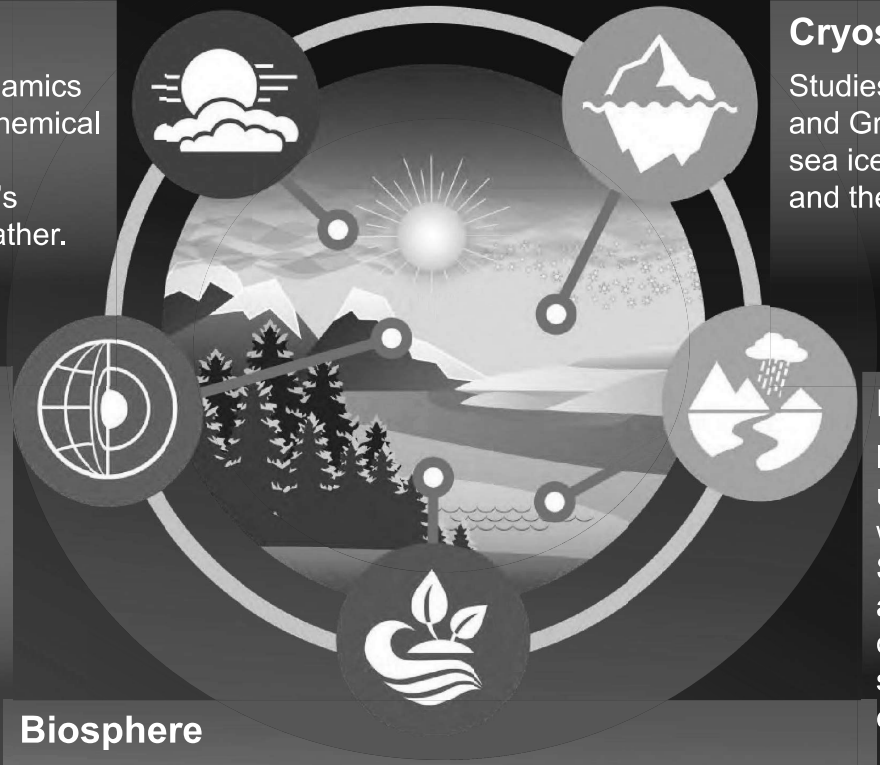
ESD Research advances Earth system science by enabling the use of satellite, airborne, and ground-based observations, along with modeling approaches, to improve understanding of Earth processes.

Atmosphere

Studies the dynamics and thermodynamics of the atmosphere, its physical and chemical composition, and the interdependent impacts that these have on the Earth's radiative balance, air quality, and weather.

Cryosphere

Studies polar ice, including the Antarctic and Greenland ice sheets, polar glaciers, sea ice in the Arctic and Southern Oceans, and the cryosphere's link to Earth system



Geosphere

Studies processes and changes in the Earth's core, mantle, and crust along with surface topography and geology, and the hazards they generate, along with studying geodesy and geodynamics.

Hydrosphere

Improves the observation, understanding, and prediction of water and energy in the Earth System across land, ocean, and the atmosphere through the integration of measurements from satellites, surface networks, and airborne campaigns.

Biosphere

Studies the interactions between/within terrestrial and aquatic ecosystems, along with changes in their biogeochemistry and biodiversity, to further understand the Earth system in which both human-induced and natural changes influence productivity and the availability of natural resources.

Transition from Focus Areas to Spheres

Former Program Area	Sphere or Enabling Capability (EC)
Atmospheric Composition Modeling and Analysis Program	Atmosphere
Atmospheric Dynamics	Atmosphere
Radiation Sciences	Atmosphere
Tropospheric Composition	Atmosphere
Upper Atmosphere Research	Atmosphere
Biological Diversity Research	Biosphere
Land-Cover and Land-Use Change	Biosphere
Ocean Biology and Biogeochemistry	Biosphere
Terrestrial Ecology	Biosphere
Cryospheric Sciences	Cryosphere
Earth Surface and Interior	Geosphere
Physical Oceanography	Hydrosphere
Precipitation Science	Hydrosphere
Terrestrial Hydrology	Hydrosphere
Water and Energy Cycle	Hydrosphere
Interdisciplinary Science	Embedded in all Spheres
Airborne Science Program	EC: Airborne Science Program
Early Career Research	EC: Early Career Research
GLOBE	EC: Ground Networks, Calibration Labs, and Crowdsourcing
Modeling, Analysis, and Prediction	EC: Integrated Earth System Modeling
Scientific Computing	EC: Integrated Earth System Modeling

Enabling Capabilities

Foundational cross-cutting activities, opportunities, technologies, systems, or processes that benefit all Earth Science Division elements and research Spheres.

- Airborne Science Program
- Early Career Research
- Ground Networks & Calibration Labs
- Integrated Modeling Virtual Institute

Integrated Earth System Modeling Strategy

- **Streamline NASA's modeling and scientific computing capabilities**
  - Coordinated leadership and alignment with one strategy involving the best experts nationwide
  - Workflows: Consolidate systems, code, software engineering, physical locations
- **Prioritized investments:** Aligned and coordinated research effort that advance priority model components using advanced technologies (e.g. HPC, AI and foundation modeling) and industry best practices
- **Flexibility and scalability** of models linked to the scientific computing systems that support them

National leadership in modeling and model-based analysis of the Earth system to advance state-of-the-art prediction and risk assessment to support economic growth, national priorities and national security

NASA HQ Earth Science Division

Earth System Science Research Program (ESSRP)

Associate Director for Research (Acting) | Barry Lefer
Deputy Associate Director for Research (Acting) | Michelle Hawkins

SCIENCE SPHERES

Atmosphere

Ken Jucks
Upper Atmosphere Research

Emma Knowland
Tropospheric Composition

Will McCarty^
Atmospheric Dynamics

Ed Nowottnick*
Radiation Science

Justin Stachnik*^
Atmospheric Dynamics

John Sullivan*^
Atmospheric Composition

Biosphere

Kelsey Bisson*
Ocean Biology & Biogeochemistry

Laura Lorenzoni
Ocean Biology & Biogeochemistry

Ryan Pavlick^
Terrestrial Ecology

Woody Turner
Biological Diversity

Krishna Vadrevu*
Land-Cover and Land-Use Change

Amanda Whitehurst
Terrestrial Ecology

Cryosphere & Geosphere

Thorsten Markus
Cryospheric Science

Kevin Reath*
Earth Surface & Interior

Hydrosphere

Craig Ferguson^
Terrestrial Hydrology

Jessica Hausman*
Ocean Physics

Will McCarty^
Precipitation Science

Justin Stachnik*^
Precipitation Science

Nadya Vinogradova Shiffer
Ocean Physics

Enabling Capabilities

Gerald Bawden
Special Projects

Amy Chen
Ground Networks, Calibration Labs, and Crowdsourcing

David Considine
Integrated Earth System Modeling

Craig Ferguson^
Scientific Computing

Cynthia Hall*
Early Career Research

Argie Kavvada
Integrated Earth System Modeling

Yaítza Luna-Cruz
Early Career Research

Ryan Pavlick^
Airborne Science Program

Derek Rutovic
Airborne Science Program

John Sullivan*^
Ground Networks, Calibration Labs, and Crowdsourcing

Lucia Tsaoussi
Space Geodesy

* | Detailee, Contractor, or IPA
^ | Dual Role

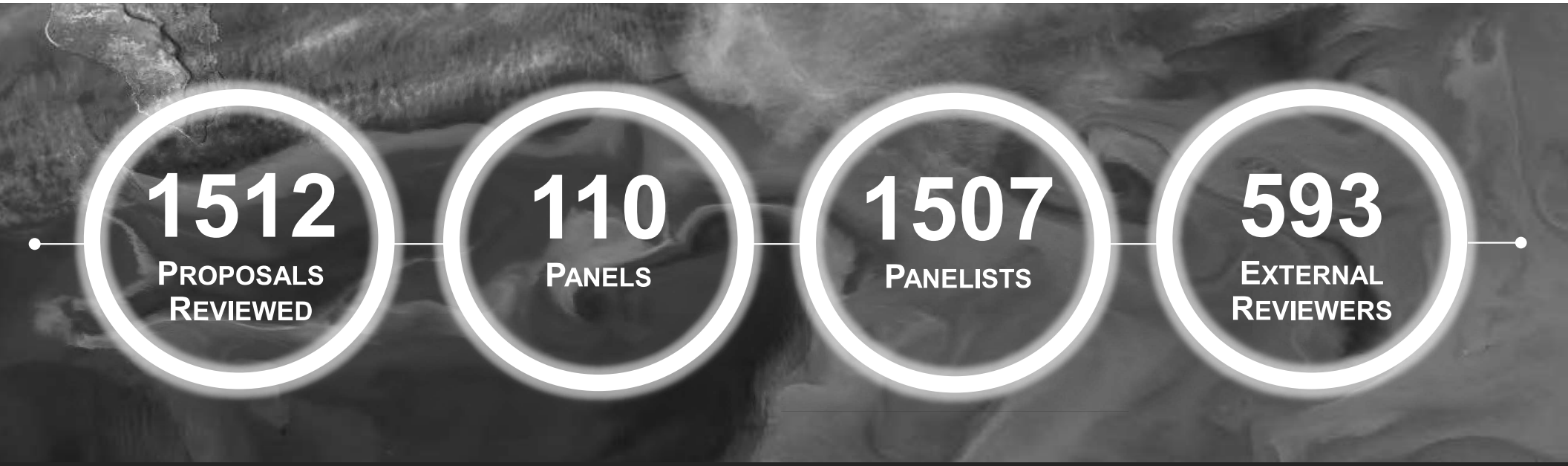
Streamlining ideas for Research Opportunities in Space and Earth Sciences (ROSES) 2026

Changes to annual ROSES proposals formats could reduce submission burden and reviewer workload while increasing productivity and efficiency.

These potential changes could include:

1. ESD Research releasing an element for each Sphere instead of each program
2. Implementing a 2-step process or mandatory NOI
3. Reducing proposal submission pages
4. Sphere-focused calls with related sub-elements
5. Proposing to a fixed $ amount with budget submitted and finalized after selection

Implementing some/all of these measures will reduce review time (submittal to selection decision) from >6 months to <3 months.



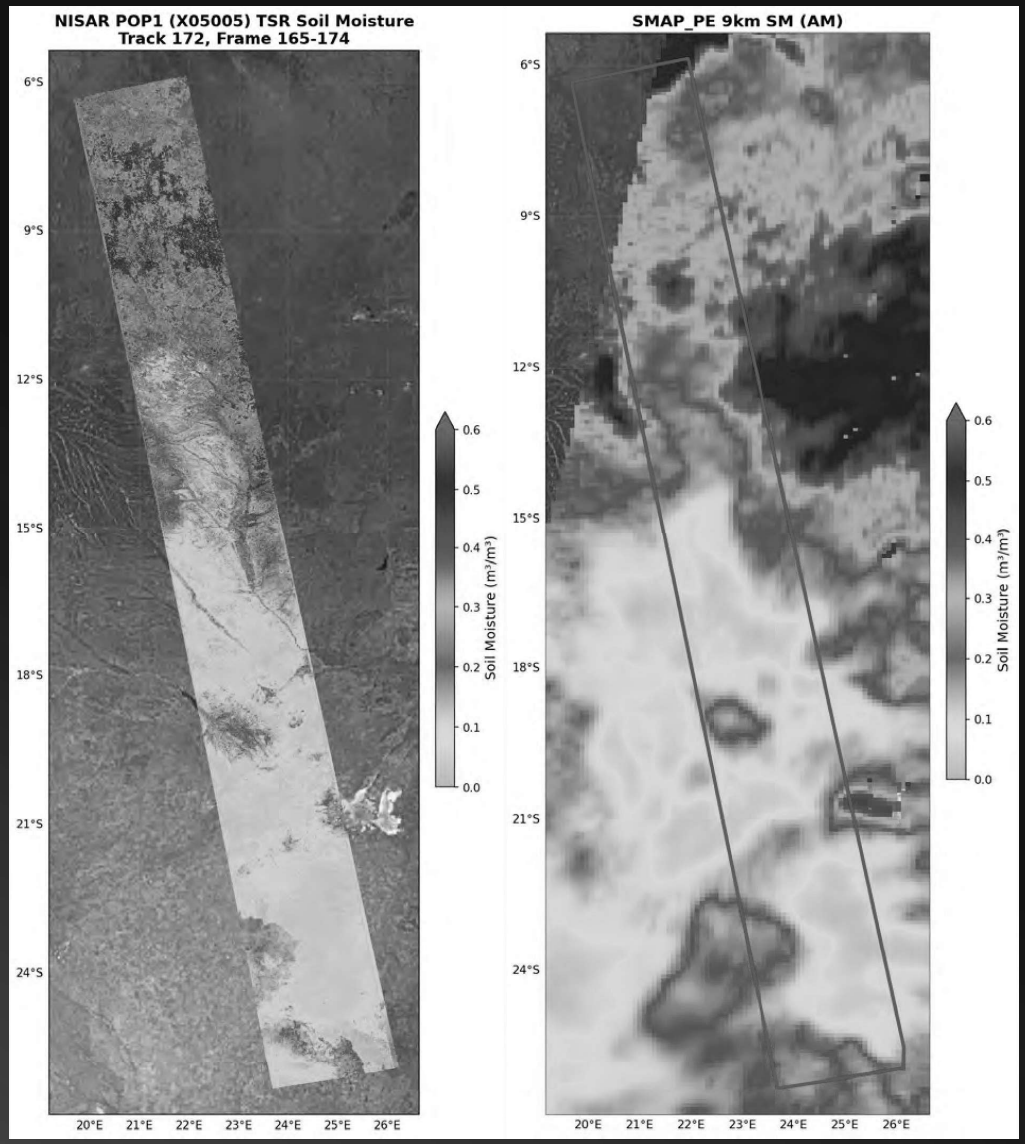
ESD Research by the Numbers:
Calendar Year 2025

Thank You!

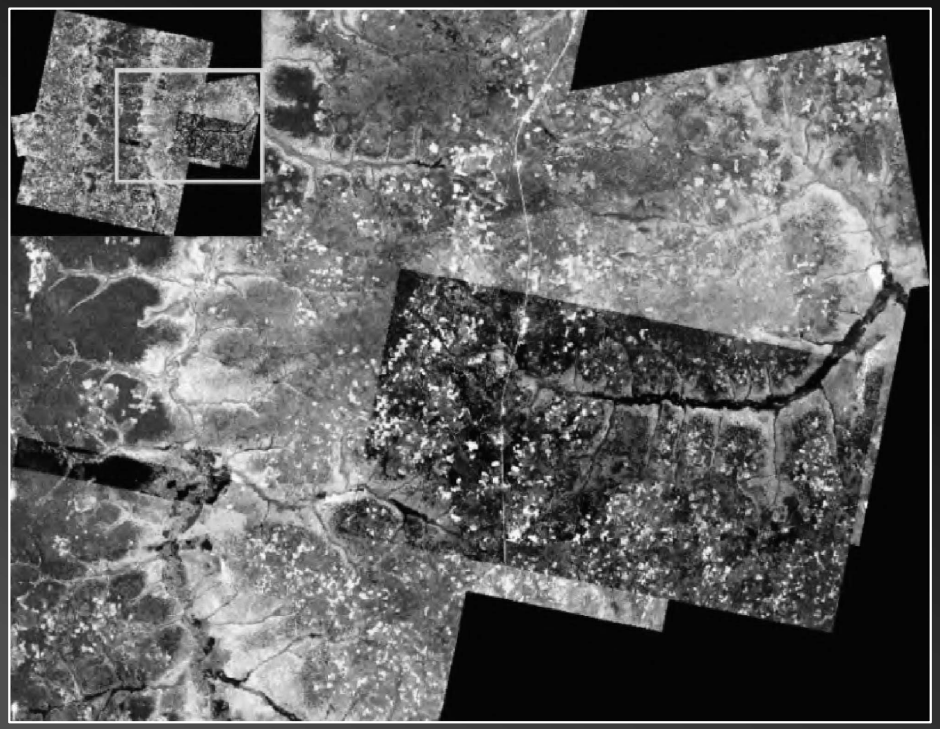
Highlights: Estimates of Soil Moisture from NISAR

Rajat Bindlish, NASA Goddard Space Flight Center

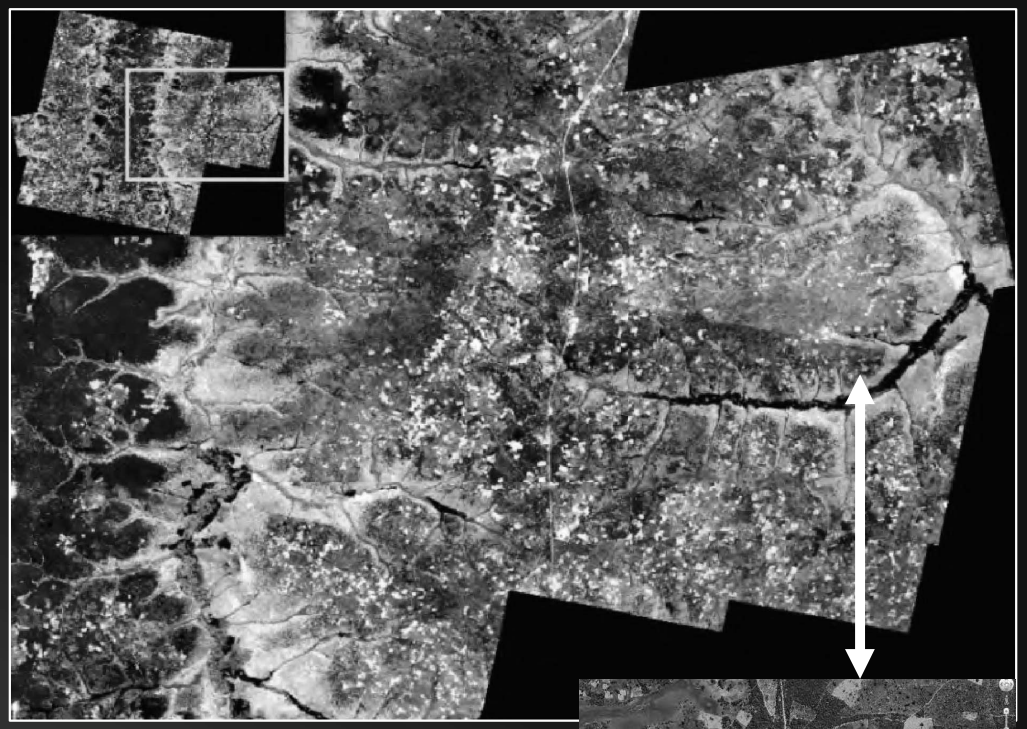
- Soil moisture estimates for November 11, 2025; (left) From NISAR at 200 m resolution; (right) Soil Moisture Active Passive (SMAP) at 9 km resolution.



Highlights: Network-based Radiometric Normalization for Commercial Satellite Time Series



Before normalization



After normalization

Dry agriculture fields

Mosaic of 10 Planet Scope time series images acquired in June 2022, in Bié Province, Angola.

Lin Yan, David Roy, Haiyan Huang, Michigan State University

ESD Airborne Science Goals and Strategy

The Airborne Science project aims to provide unique airborne platforms needed to collect Earth science observations to support:

a) Fundamental Earth System Science research;
b) Development and testing of new sensors/capabilities;
c) Calibration and validation of satellite/ground observations; and
d) Rapid instrument deployment for emergency response (as possible)

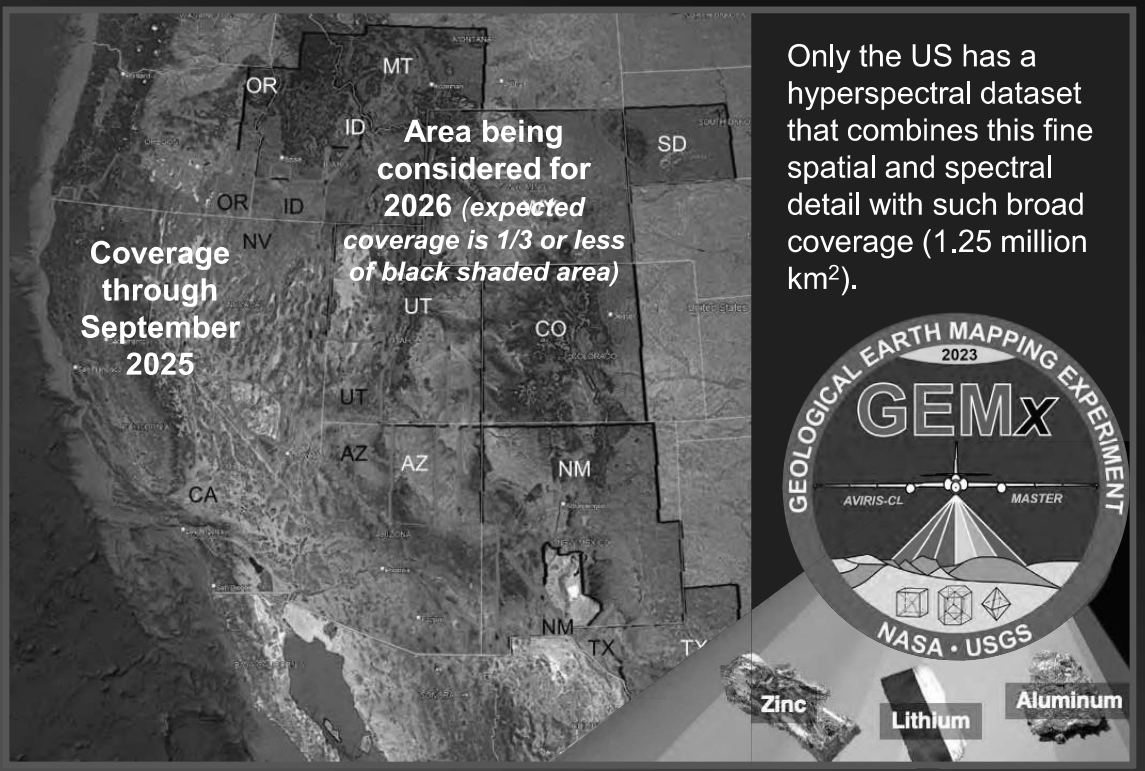

The ESD Airborne Science Program is modernizing and recapitalizing a diverse fleet to support world-class airborne science well into the future
NASA
G-III
G-III
P-3
G-IV
B777
GV
WB-57
ER-2
AIRBORNE SCIENCE PROGRAM
NASA

Airborne Efficiencies/Changes

- Moved the NASA P-3 aircraft to flyable storage so that it can be reactivated when needed again in FY27
- Retire UAVSAR on G-III aircraft and finish transition to AirSAR-nextgen on G-IV aircraft
- Retire G-III remote sensing aircraft and transfer support to GV remote sensing aircraft
- Dedicated GV aircraft for science
- Prepare for loss of ER-2 (full transition to WB-57) when US Air Force decides to retire fleet of U-2 aircraft
- Encouraging ESD community to leverage Commercial Aviation Services (CAS) B200 providers for Earth Science needs

Large Capacity B777	Low Altitude P-3	Synthetic Aperture Radar G-III → G-IV	Flexible Remote Sensing G-III → G-V	High Altitude ER-2/WB-57F
✓ (Mods on going, Ready FY27)	× (flyable storage, reactivate for FY27)	✓ (Transition in progress)	✓ (Just Purchased GV)	✓

Highlights: Airborne Science



GEMx (NASA-USGS joint project) is mapping essential minerals within the U.S., bolstering both security and prosperity while decreasing reliance on foreign sources

- Demonstrated the synergistic use of emerging technologies (i.e. hyperspectral microwave, water vapor differential absorption lidars) to explicitly improve the characterization of the Planetary Boundary Layer (PBL)
- Over the past five years the Arctic Boreal Vulnerability Experiment (ABoVE) used the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) to image approximately 17,000 flight lines in the Alaska and the Arctic, mapping tundra, taiga, peatlands, and wetlands in unprecedented hyperspectral detail

Space Geodesy Strategy

- **Maintain U.S. competitive advantage and core observations in this critical infrastructure that supports our national security**
- **Continue to develop the next generation of geodetic observatories and technologies**
- **Collaborate with US industry on acquisition of lasers, antennas & satellite retro reflector arrays**
- **Collaborate with federal partners i.e. National Geospatial Agency (NGA/DoD) and National Geodetic Survey (NGS/NOAA/DoC), co-chaired working group**
  - Technical working groups explore efficiencies and leveraged funding (NGA interest in Global Differential GPS)
  - Continue work with NSF - evolving collaboration in the Geodetic Facility for the Advancement of Geoscience (GAGE)

Enable the high-accuracy (sub-millimeter) reference frame for applications for autos, aircraft, ships, and satellites that rely on global positioning, navigation and timing.

Highlights: Space Geodesy

- The Satellite Laser Ranging (SLR) observations have enabled the NASA Surface Water and Ocean Topography (SWOT) mission achieve its required radial orbit accuracy of less than 1.6 cm
- SLR observations validated the performance of the GRACE Follow-On (GRACE-FO) mission, this information was critical to provide an essential solution for one of the GRACE-FO accelerometers
- NASA's Space Geodesy project is a foundational technology that drives efficiency, safety, and innovation across a wide range of economic sectors