Earth Science Division Community Forum

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Science Mission Directorate, NASA

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Enter your questions into the Q&A section

This webinar will be recorded
Accelerating Discovery and Understanding of Earth Science

- Budget Priorities & Challenges
- Mission Milestones
- Element Highlights
- Bridging to the Earth System Observatory
- Delivering Actionable Science
BUDGET PRIORITIES & CHALLENGES
Stewarding Public Investment into Earth Science
FY24 NASA ESD Budget Priorities

• Promote U.S. leadership in Earth system science
• Advance Open-Source Science
• Build an innovative and balanced program driven by the highest national priorities
• Implement the 2017 Decadal Survey Flight recommendations
• Address Sustained Climate Observations
• Fund the Program of Record, including known challenges
• Invest in Earth Science Infrastructure
• Balance commercial sector engagement
## FY24 NASA ESD Budget Request by Program

- FY23 appropriation of $2.2B (increase of $134M) was the largest in ESD history
- President’s FY24 Budget Request seeks $278M increase in Earth to fund Landsat Next and ESO

<table>
<thead>
<tr>
<th>(§K)</th>
<th>FY22</th>
<th>FY23</th>
<th>FY24</th>
<th>FY25</th>
<th>FY26</th>
<th>FY27</th>
<th>FY28</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Earth Science</td>
<td>2,061,200</td>
<td>2,195,000</td>
<td>2,472,794</td>
<td>2,597,458</td>
<td>2,729,988</td>
<td>2,791,241</td>
<td>2,849,031</td>
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<td>Earth Systematic Missions</td>
<td>706,422</td>
<td>914,956</td>
<td>1,027,093</td>
<td>1,073,555</td>
<td>1,162,677</td>
<td>1,130,288</td>
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<td>Earth System Explorers</td>
<td>2,020</td>
<td>2,459</td>
<td>27,789</td>
<td>20,679</td>
<td>43,112</td>
<td>108,970</td>
<td>166,380</td>
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<tr>
<td>Earth Science Data Systems</td>
<td>339,357</td>
<td>366,087</td>
<td>411,681</td>
<td>398,919</td>
<td>408,140</td>
<td>423,762</td>
<td>439,583</td>
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<td>Earth Science Technology</td>
<td>86,131</td>
<td>102,181</td>
<td>105,349</td>
<td>113,460</td>
<td>117,111</td>
<td>118,420</td>
<td>120,787</td>
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<td>Applied Sciences</td>
<td>73,540</td>
<td>75,205</td>
<td>87,330</td>
<td>102,299</td>
<td>106,179</td>
<td>109,341</td>
<td>111,526</td>
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<td>Earth Science Research</td>
<td>541,044</td>
<td>501,996</td>
<td>577,923</td>
<td>589,981</td>
<td>602,235</td>
<td>618,000</td>
<td>629,517</td>
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</table>

- FY23 budget reflects latest approved Operating Plan

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6
NASA Earth Science Program Balance

- Flight: 52%
- Research: 24%
- Data Systems: 16%
- Technology: 5%
- Applied Sciences: 4%

FY22: 47%
FY23: 28%
FY24: 24%
FY25: 17%
FY26: 5%
FY27: 5%
FY28: 4%
ESD President’s Budget and Appropriations History

FY22 Appropriations impact ~$189M

FY23 Appropriations impact ~$216M
## Accumulating Budget Challenges

<table>
<thead>
<tr>
<th>Factor</th>
<th>Impact (approx.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth assumptions</td>
<td>$1.74B</td>
</tr>
<tr>
<td>Landsat Next accounting</td>
<td>$450M</td>
</tr>
<tr>
<td>COVID-19</td>
<td>$300M</td>
</tr>
<tr>
<td>Tech challenges</td>
<td>$250M</td>
</tr>
<tr>
<td>Record inflation</td>
<td>$500M</td>
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<tr>
<td><strong>Total impact</strong></td>
<td><strong>$3.2B</strong></td>
</tr>
</tbody>
</table>

Melting on Humboldt Glacier NASA Earth Observatory images by Wanmei Liang, using Landsat data from the U.S. Geological Survey.
MILESTONES
Advancing Earth Science Program of Record
FY23-24 Milestones

- **2023**
  - January: Inaugural Earth System Explorer (ESE) AO Released
  - April: Polarized Submillimeter Ice-cloud Radiometer (PolSIR) selected as Earth Venture Instrument-6 (EVI-6)
  - July: Earth Information Center Opening
  - **2023 Year of Open Science**

- **2024**
  - January: Make Earth System Explorers (ESE) Step-1 selections in Q3 FY24
  - October: Launch new SERVIR Hub in Central America
  - Release prototype version of Greenhouse Gas Information and Monitoring Center with interagency partners in November 2023
  - Initiate Decadal Survey Midterm Assessment

- 2023-24
  - Earth Information Center Opening
  - Polarized Submillimeter Ice-cloud Radiometer (PolSIR) selected as Earth Venture Instrument-6 (EVI-6)
<table>
<thead>
<tr>
<th>Mission</th>
<th>Mission Type</th>
<th>Release</th>
<th>Selection</th>
<th>Major Milestone</th>
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</thead>
<tbody>
<tr>
<td>EVS-1 (EV-1)</td>
<td>5 Suborbital Airborne Campaigns</td>
<td>2009</td>
<td>2010</td>
<td>Completed KDP-F</td>
</tr>
<tr>
<td>EVI-1 (TEMPO)</td>
<td>Class C Geostationary Hosted Instrument</td>
<td>2012</td>
<td>2012</td>
<td>Launched Apr 2023</td>
</tr>
<tr>
<td>EVI-2 (ECOSTRESS &amp; GEDI)</td>
<td>Class C &amp; Class D ISS-hosted Instruments</td>
<td>2013</td>
<td>2014</td>
<td>Launched Jun &amp; Dec 2018</td>
</tr>
<tr>
<td>EVS-2 (ACT-America, ATOM, NAAMES, ORACLES, OMG, CORAL)</td>
<td>6 Suborbital Airborne Campaigns</td>
<td>2013</td>
<td>2014</td>
<td>Completed KDP-F</td>
</tr>
<tr>
<td>EVI-3 (MAIA &amp; TROPICS)</td>
<td>Class C LEO Hosted Instrument &amp; Class D CubeSat Constellation</td>
<td>2015</td>
<td>2016</td>
<td>MAIA Delivery 2022; TROPICS Launch launched May 2023</td>
</tr>
<tr>
<td>EVM-2 (GeoCarb)</td>
<td>Class D Geostationary Hosted Instrument</td>
<td>2015</td>
<td>2016</td>
<td>Cancelled</td>
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<tr>
<td>EVI-4 (EMIT &amp; PREFIRE)</td>
<td>Class C ISS-hosted Instrument &amp; Class D Twin CubeSats</td>
<td>2016</td>
<td>2018</td>
<td>EMIT launched to ISS Jul 2022; PREFIRE delivery NLT 2023</td>
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<tr>
<td>EVS-3 (ACTIVATE, DCOTSS, IMPACTS, Delta-X, SMODE)</td>
<td>5 Suborbital Airborne Campaigns</td>
<td>2017</td>
<td>2018</td>
<td>All in post-deployment phase</td>
</tr>
<tr>
<td>EVI-5 (GLIMR)</td>
<td>Class C Geostationary Hosted Instrument</td>
<td>2018</td>
<td>2019</td>
<td>Delivery NLT 2024</td>
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<tr>
<td>EVC-1 (Libera)</td>
<td>Class C JPSS-Hosted Radiation Budget Instrument</td>
<td>2018</td>
<td>2020</td>
<td>Delivery NLT 2025</td>
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<tr>
<td>EVM-3 (INCUS)</td>
<td>Full Orbital</td>
<td>2020</td>
<td>2021</td>
<td>Launch ~2026</td>
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<tr>
<td>EVI-6 (PolSIR)</td>
<td>Instruments and SmallSats</td>
<td>2022</td>
<td>2023</td>
<td>Delivery NLT 2027</td>
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<tr>
<td>ESE</td>
<td>Explorer Mission</td>
<td>2023</td>
<td>2025</td>
<td>Launch ~2031 &amp; ~2033</td>
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<tr>
<td>EVS-4</td>
<td>Suborbital Airborne Campaigns</td>
<td>2023</td>
<td>2024</td>
<td>N/A</td>
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<tr>
<td>EVC-2</td>
<td>Continuity Measurements</td>
<td>2024</td>
<td>2025</td>
<td>Delivery NLT 2029</td>
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<tr>
<td>EVI-7</td>
<td>Instrument Only</td>
<td>2025</td>
<td>2026</td>
<td>Delivery NLT 2030</td>
</tr>
<tr>
<td>EVM-4</td>
<td>Full Orbital</td>
<td>2025</td>
<td>2026</td>
<td>Launch ~2031</td>
</tr>
<tr>
<td>ESE</td>
<td>Explorer Mission</td>
<td>2025</td>
<td>2027</td>
<td>Launch ~2034 &amp; 2036</td>
</tr>
<tr>
<td>EVC-3</td>
<td>Continuity Measurements</td>
<td>2027</td>
<td>2028</td>
<td>Delivery NLT 2032</td>
</tr>
<tr>
<td>EVS-5</td>
<td>Suborbital Airborne Campaigns</td>
<td>2027</td>
<td>2028</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Open solicitation/In review**

**Completed solicitation**

**EVS**
Sustained sub-orbital investigations (~4 years)

**EVM**
Complete, self-contained, small missions (~4 years)

**EVI**
Full function, facility-class instruments Missions of Opportunity (MoO) (~3 years)

**EVC**
Complete missions or hosted instruments targeting “continuity” measurements (~3 years)

**ESE** *(NEW)*
Medium-size instruments and missions (~2 years)
Earth Venture Instrument-6: PolSIR
(Polarized Submillimeter Ice-cloud Radiometer)

Will observe ice clouds’ daily cycle of ice content at high altitudes throughout tropical and sub-tropical regions to improve climate models and forecasts

- Two identical CubeSats flying in orbits separated by three to nine hours
- GSFC will provide project management
- Two spacecraft to be built by Blue Canyon Technologies
- Space operations will be conducted by the Space Science and Engineering Center, University of Wisconsin - Madison

PI: Ralf Bennartz, Vanderbilt University
Deputy PI: Dong Wu, Goddard Space Flight Center
TEMPO (EVI-1) First Light

Launched April 7, 2023 on a Maxar communications satellite

First light images released Aug 24, 2023

Tropospheric Emissions: Monitoring of Pollution (TEMPO) is monitoring air pollutants hourly across the North American continent during daytime
TROPICS (EVI-3) First Light

Constellation of four satellites successfully deployed on two separate Rocket Lab launches on May 8, 2023 and May 26, 2023

First light images were released July 19, 2023

TROPICS is helping weather researchers learn more about the environmental factors contributing to hurricane structure and intensity
PACE Advances Ocean Science

- Monitors fisheries
- Respond to toxic algae blooms
- Key ocean and atmosphere data for forecasting air quality and weather that will improve our understanding of Earth’s Climate
- Anticipated launch early 2024
Will measure some of the planet's most complex processes such as ice-sheet collapse and natural hazards such as earthquakes, volcanoes, and landslides. NISAR can assist planners and decision makers with managing both hazards and natural resources in the future.
Earth Science Research and Technology Highlights
The Ice Sheet Mass Balance Inter-comparison Exercise (IMBIE) found:

- Ice sheets have lost 7,560 billion tons of ice from 1992 to 2020
- Ice sheet mass loss now accounts for a quarter of all sea-level rise - a fivefold increase since the 1990s.
Figure shows total additionally preserved Above Ground Carbon (AGC) aggregated by continent and biome. PAs effectively preserve additional AGC across continents and biomes, with forest biomes dominating the global signal, particularly in South America. The additional preserved AGC (Gt) in WWF biome classes (total Gt +/− SEM area). Full set of analyzed GEDI data are represented in figure (n = 412,100,767).
ROSES ESD Updates and Highlights

• Proposals received for 12 ROSES-23 elements
  • Between April and September 2023, 11 element selections completed from ROSES-22 and -23.
  • 5 remaining elements in ROSES-23 with due dates between now and December

• In ROSES-23:
  • 5 elements used Dual Anonymous Peer Review
  • 1 element called for Inclusion Plan – A.24 Earth Surface and Interior

• 28 ROSES-22 A.28 Interdisciplinary Research in Earth Science (IDS) selections recently announced:
  • 23 funded by IDS + augmentations by FireSense (1); EarthAction-Fire (1); and Environmental/Climate Justice (3)

Word cloud representing A.28 IDS proposal topics.
BioSCape: Exploring Biodiversity's Role in Ecosystem Function and Services

Flights in South Africa Oct-Nov 2023

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LVIS</td>
<td>Land, Vegetation, and Ice Sensor (Laser altimeter: 1064nm) 3D Vegetation Structure</td>
</tr>
<tr>
<td>HyTES</td>
<td>Hyperspectral Thermal Emission Spectrometer (TIR: 7.5-12µm) Land and Water Surface Temperatures, Plant ET</td>
</tr>
<tr>
<td>PRISM</td>
<td>Portable Remote Imaging Spectrometer (UV-VNIR: 350-1050nm) Composition of Aquatic Constituents, H2O Quality</td>
</tr>
<tr>
<td>AVIRIS-NG</td>
<td>Airborne Visible-Infrared Imaging Spectrometer-Next Gen (VSWIR: 380-2510nm) Ecosystem Vegetation Composition, H2O Quality, Geology</td>
</tr>
</tbody>
</table>

www.bioscape.io
Preliminary NO$_2$ slant columns from August 23, 2023 collected from GCAS (airborne TEMPO proxy) on the LaRC GIII in LA.

Additional parameters:
- HCHO
- aerosols
- ozone
- methane
- mixed layer height

SARP Alumni involved in AEROMMA/STAQS with some of the 2023 SARPians

Collaboration list: https://csl.noaa.gov/projects/ages/
For the first time there were TWO locations: SARP West, the ongoing one in Palmdale/UC Irvine; and “SARP East” based in Virginia with LaRC, GSFC, WFF and partners collaboration.

**SARP West: June 18- Aug 11**
- 15th year
- 24 students, 4 Faculty and 5 mentors

**SARP East: June 5-July 28**
- Inaugural year
- 22 students, 5 Faculty and 5 mentors

SARP West sampling around Central CA Valley dairy and at AFRC with DC-8.

SARP East class conducting field research, studying in classroom, & preparing for deployment.
Earth Systems Digital Twins (ESDTs) are an emerging capability for understanding, forecasting, and conjecturing the complex interconnections among Earth systems, including anthropomorphic forcings and impacts to humanity.

Recent and ongoing activities:

• 16 current ESDT technology development projects funded under the AIST program.
• Workshops and other community meetings to explore science use cases, enabling technologies, frameworks, prototyping, interoperability, and federation:
  • Standards for Interoperable Digital Twins Workshop: Sep 18, 2023
• Collaboration with ESA, Destination Earth, CNES, and others

Visit the dedicated ESDT webpage here: https://esto.nasa.gov/earth-system-digital-twin/
BRIDGING TO THE NEXT-GENERATION
Developments in the Earth System Observatory
Landsat Next

Landsat Next mission is a constellation of three identical satellites, approximately equally distributed in orbit
• ≤ 9 day global land revisit frequency
• 26 spectral bands (21 VSWIR; 5 TIR)
• Target Launch Readiness Date: November 2030

Status and next steps:
• Held KDP-A Program Management Council on Nov. 2
• Landsat Instrument Suite proposals currently under evaluation with award planned in spring of 2024.

Landsat Next will provide more than twice as many spectral bands, with resolution improved by a factor of 2, and with the repeat coverage of Landsats 8 and 9, combined
ESO Core Missions

- Successfully completed Mission Concept Reviews summer 2022
- Missions passed KDP-A and now in Formulation
- ESO Independent Review Board, July-October
  - IRB report and NASA response posted at nasa.gov/reports
- AOS-Storm and AOS-Sky have Phase A trade studies under way.
- SDC will remain in extended study phase to take advantage of NISAR mission lessons learned

AOS-Storm
AOS-Sky
MCR: May 2022
KPD-A: Jan 2023

SBG
MCR: June 2022
KDP-A: Nov 2022

GRACE-C
MCR: Jun 2022
KDP-B: Sept 2023

SDC
Remaining in Extended Study Phase
Final Announcement of Opportunity (AO) released on May 2, 2023

AO closed August 2, 2023

Step 1 selection anticipated Q3 FY24

PI-Managed Mission Cost (PIMMC) cap of $310M (FY24 $)

NASA will provide launch vehicle services

Two-step selection process

New Earth System Explorers Program Office established at GSFC; SRR/SDR completed in March 2023 and KDP-I in June 2023
DELIVERING ACTIONABLE SCIENCE
Showing People our Earth as NASA Sees It
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Open Science 101: A community-developed introduction to core open science skills

- Know how to write a NASA open science and data management plan
- Learn about tools and best practices
- Increase the impact & visibility of your science
- Earn your digital NASA open science badge

Enroll now!

Self-Paced Online Course

Online & In-person Workshops

Images by Freepik
Recent Disaster Response Support

**Earthquake in Morocco**
Damage proxy maps delivered by partners at the Earth Observatory Singapore using recent Sentinel-1 SAR overpasses. Stakeholders: Bureau of Humanitarian Affairs at the U.S. State Dept., and ESRI Disasters Response

**Hurricane Idalia**
MODIS acquired this image of Idalia. At this time, Idalia was moving north, and the National Hurricane Center reported wind speeds of about 85 miles per hour. Stakeholders: FEMA, Florida Division of Emergency Management (FDEM)

**Hurricane Hillary**
Provided expedited pre- and post-event Sentinel-2 imagery for FEMA’s situational awareness during this event. Stakeholders: FEMA HQ

**Wildfires in Hawaii**
Damage proxy map depicting buildings likely damaged in Maui, derived from synthetic aperture radar imagery acquired by JAXA ALOS-2 satellites. Stakeholders: Pacific Disaster Center, World Central Kitchen, FEMA Region 9, and Esri Disaster Response
Upcoming FireSense Airborne Campaign

NASA FireSense
partnership US Forest Service (USFS) and
Fish Lake National Forest (FLNF) and
USFS FASMEE
(Fire And Smoke Model Evaluation Experiment)

2023 fall prescribed burn
stand replacing crown fire
restore aspen to improve elk habitat
reduce hazardous fire fuels
measure extreme fire behavior and smoke plumes
improve fire behavior and smoke models

NASA instruments coordinated with ground sampling
airborne sampling with
UAVSAR, AVIRIS, SLAP, MASTER
measurements of pre-fire fuel type and moisture
active fire dynamics (e.g., intensity)
post-fire effects (e.g., burn severity)
Mission: To extend accessible and integrated greenhouse gas (GHG) data and modeling capabilities from US government and non-public sources for scalable impact.

Use Cases

Use Case 1
Improve access and latency to gridding of anthropogenic CH₄ inventory

Use Case 2
Complement anthropogenic GHG emissions with natural GHG emissions and fluxes

Use Case 3
Identify, and quantify estimates from super emitting events, leveraging aircraft and satellite data.

Upcoming Milestones
- Oct. 2, 2023: soft launch of Center, beta portal release
- Nov. 28, 2023: Targeted Stakeholder Workshop (invitation-only, hybrid virtual / in-person in D.C.)
The Earth Information Center (EIC) opened on June 21, 2023, at the Mary W. Jackson NASA Headquarters building in Washington, DC.

NASA created the Earth Information Center with founding partners FEMA, EPA, NOAA, USAID, USDA and USGS. The EIC draws data from research conducted by NASA’s centers and government and industry partners.
Earth Information Center

**Earth Pulse:** Near real time tracking of data transfer between satellites and Earth

**Space for Earth:** An immersive installation where viewers can experience Earth’s interconnected systems and imagine Earth from Space.

**Hyperwall:** A 22-foot LED hyperwall framed by two circular 4K screens, featuring videos, dashboards with real-time data on Earth science, and dazzling imagery of our planet.

**More EICs Coming Soon!**

- **February 2024:** Smithsonian Museum of Natural History EIC opens, featuring a 30’ Hyperwall
- **June 2024:** Kennedy Space Center Visitor Complex EIC exhibit opens at the LC-39 Gantry