National Aeronautics and Space Administration

NASA

EXPLORE EARTH

Earth Science Community Briefing

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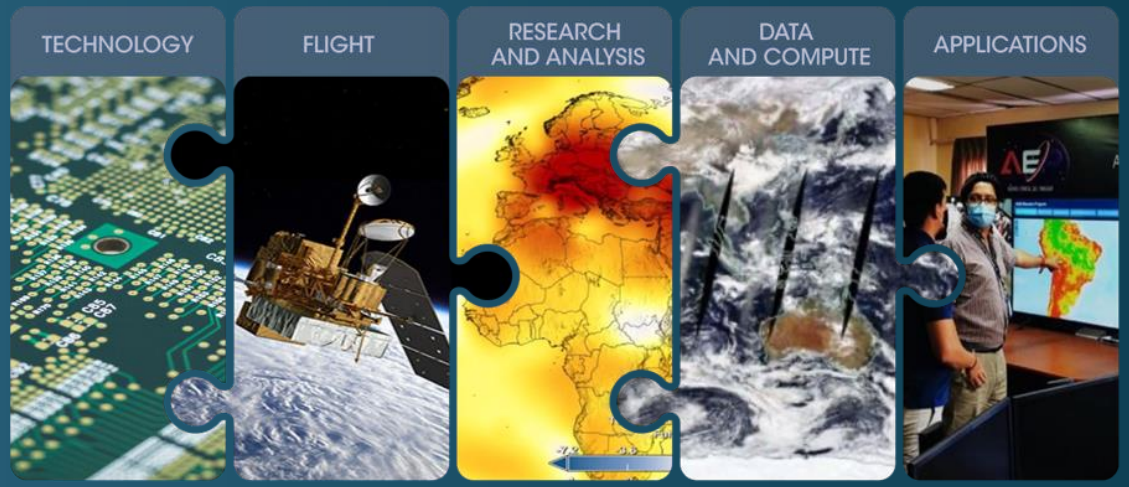
Director, Earth Science Division
Science Mission Directorate, NASA

April 21, 2022

Questions Process

- During Q&A, please type your question directly into the Q&A panel
- Alternatively, you may email questions to Kate Becker at kate.s.becker@nasa.gov

Overview and Agenda

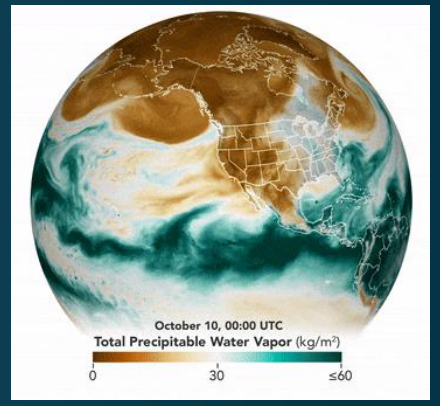


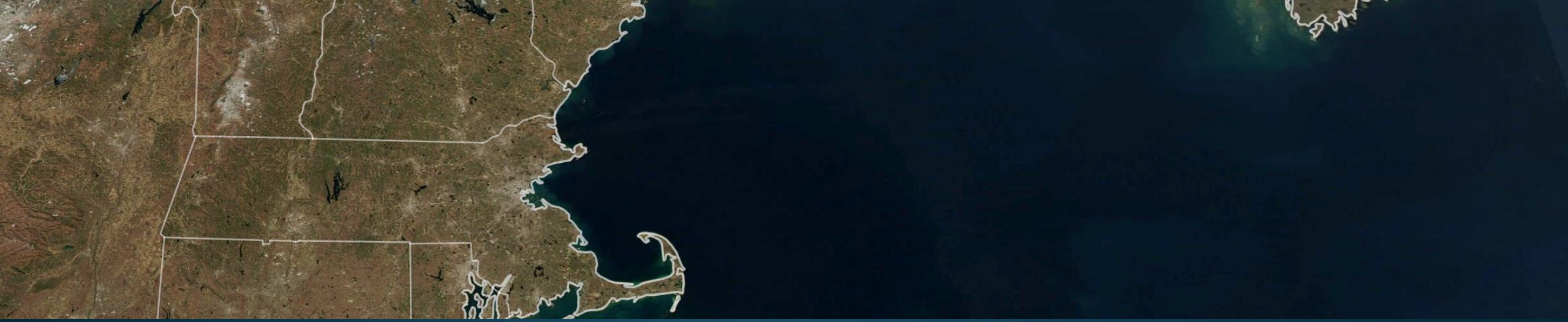
Advancing Earth System Science

End-to-end capability, from launch to science to applications, delivering actionable science to decisionmakers at every level

Agenda

- People
- Budget Outlook
- Delivering on Our Commitments
- Robust Research and Applications Opportunities
- Developing Next-Gen Capabilities
- Building Bridges through Open-Source Science





PEOPLE

New People in ESD

Katie Baynes

Shanna McClain

Christine M. Bognar

Haemee Kang

Christopher Lewis

Will McCarty

Erica Alston

Laura Rogers

Christina Moats-Xavier

Agency Honor Awards

Distinguished Service Medal
Jack Kaye
Dave Jarrett (retired)

Outstanding Leadership Medal
Sandra Cauffman (moved to APD)

Exceptional Service Medal
Bruce Tagg
Lucia Tsaoussi

Exceptional Public Service Medal
Sarah Brennan

Exceptional Administrative Achievement Medal
Kathy Carroll

Early Career Achievement Medal
Helena Chapman

Group Achievement Award

Estimating the Circulation and Climate of the Ocean (ECCO) and Physical Oceanography Distributed Active Archive Center (PO.DAAC)

RRNES (Rapid Responses and Novel Research in Earth Science) Review and Management Team

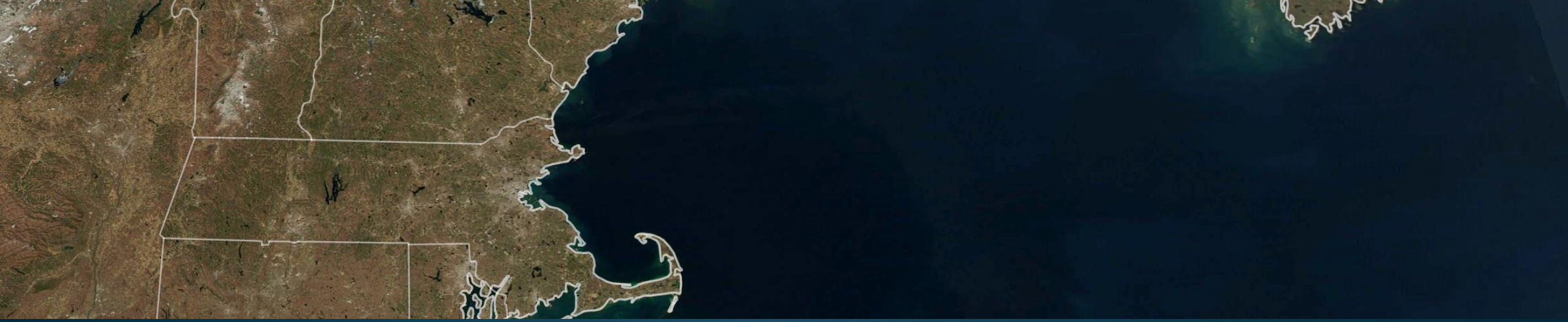
Exports Project Office

Impact Satellite Needs Working Group Team

NASA International Space Apps Challenge Global Organization

Surface Water and Ocean Topography (SWOT) Team

The Globe Program



BUDGET OUTLOOK

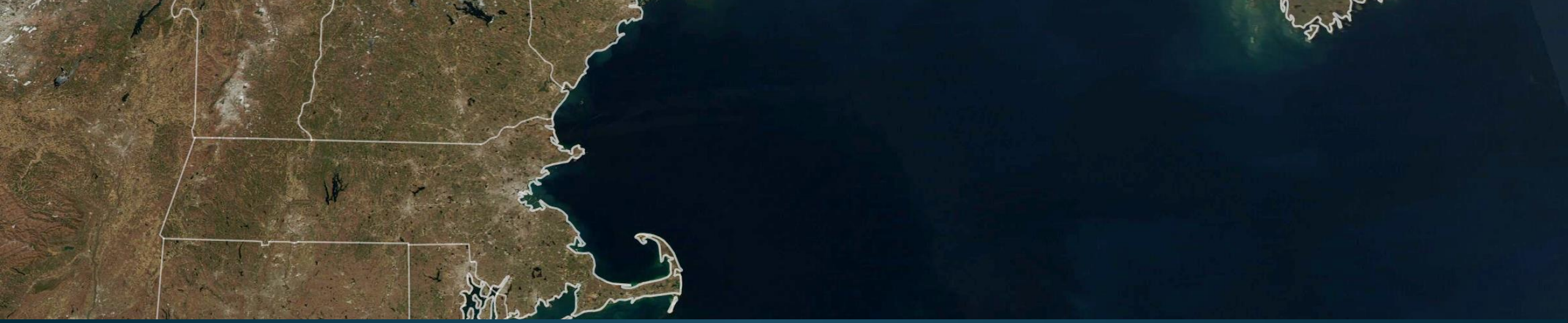
FY23 Earth Science Budget Features

What's Changed

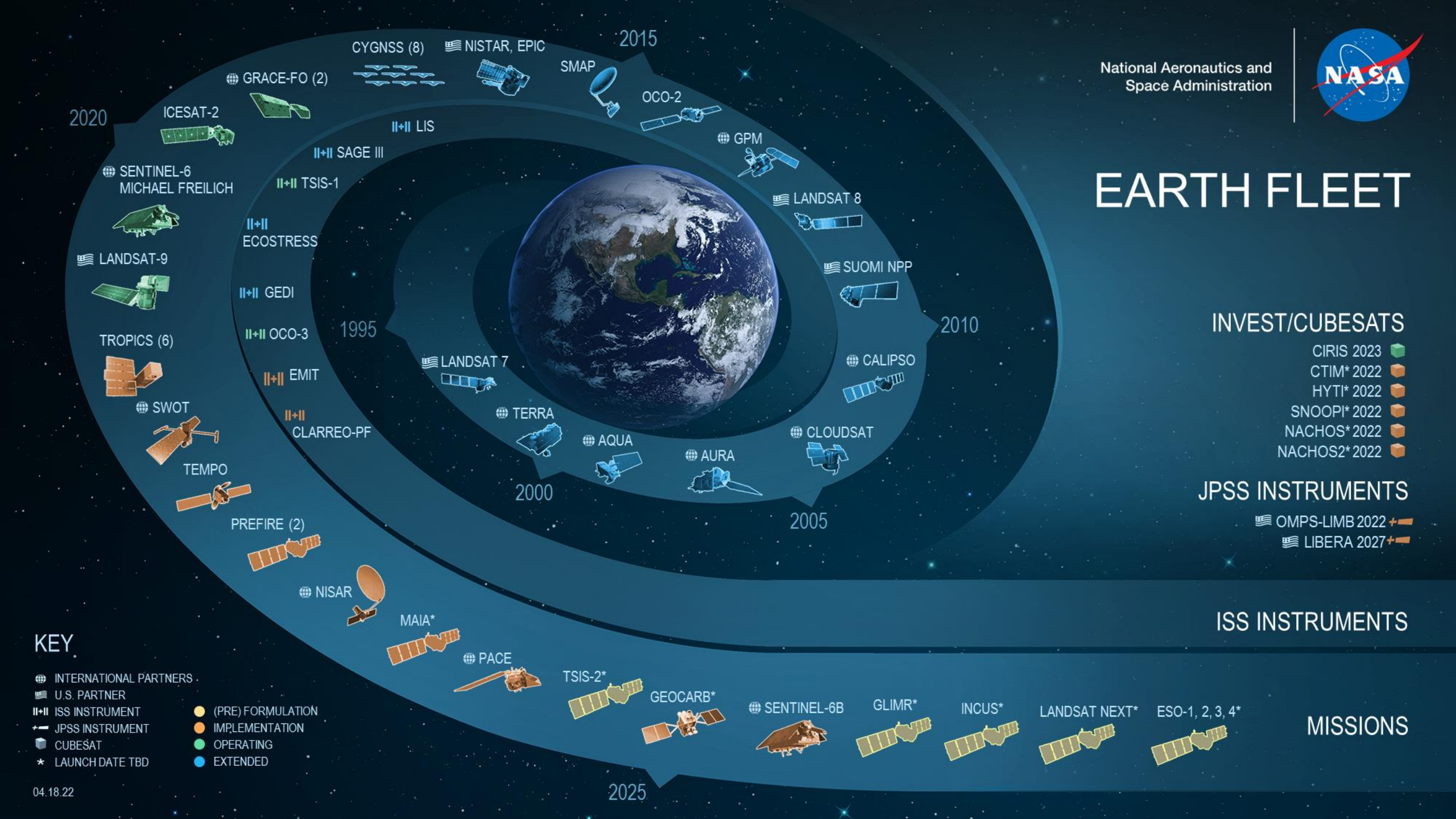
- Accelerates wildfire management support through technology development, modeling, observations, analysis tools, and applications
- Invests in Sustained Climate Observations Future Missions with partners
- Plans for an Earth Information Center with an initial focus on prototyping a greenhouse gas monitoring and information system in coordination with other agencies and partners
- Funds high priority satellite data products in response to the third U.S. Group on Earth Observation interagency assessment of civil agencies' satellite needs
- Supports selected EVM-3/INCUS mission
- Increases GeoCarb and MAIA budgets for access-to-space
- Delays future Venture solicitations by 1 year; new commercial engagement strategy in work

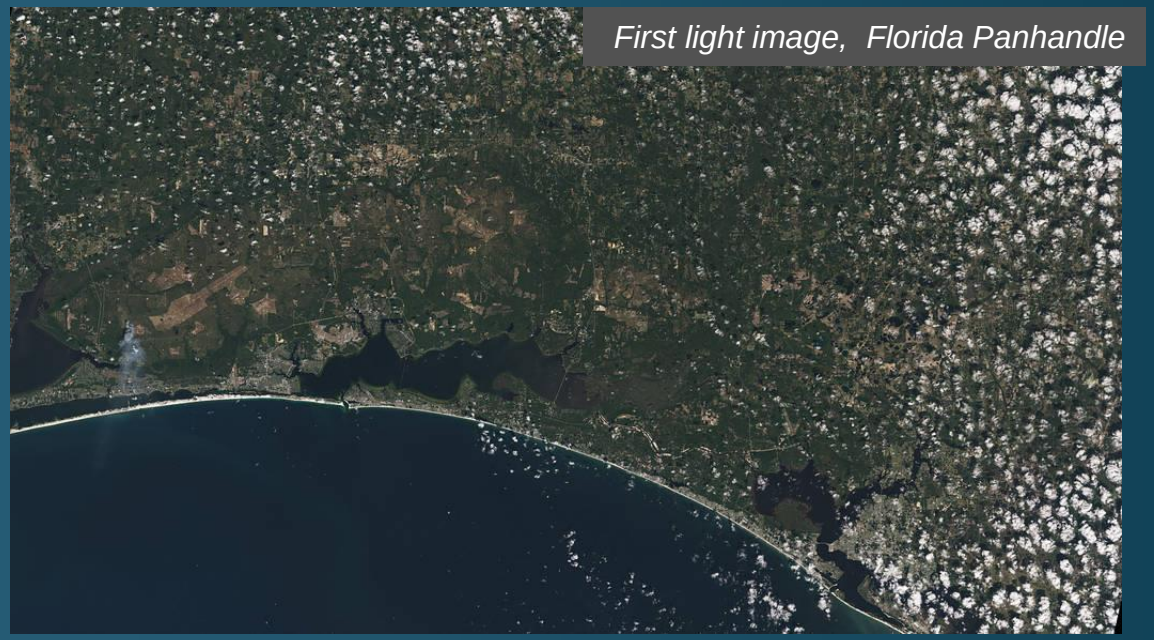
What's the Same

- Implements formulation of Earth System Observatory, including investments in research, data systems and open source science
- Executes first phase of Earth System Explorers
- Continues increases in Commercial SmallSat Data Acquisition
- Supports balanced Research, Technology, and Applied Sciences programs



DELIVERING ON OUR COMMITMENTS: Advancing Earth Science Program of Record

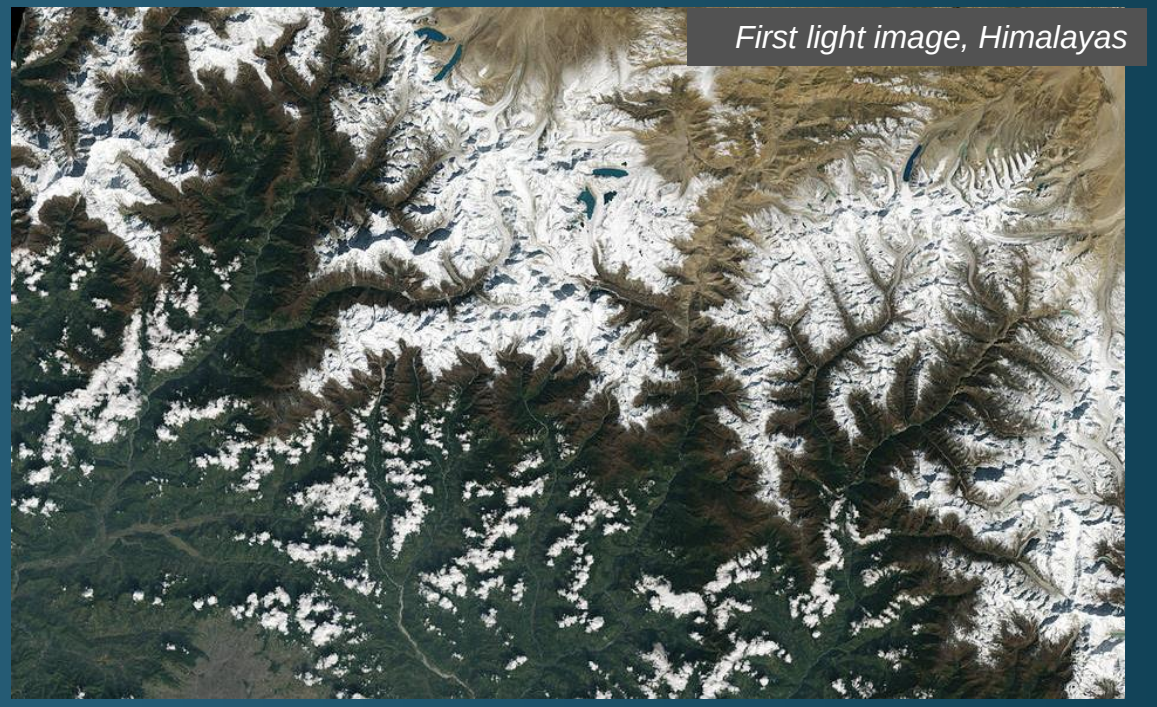

National Aeronautics and Space Administration
NASA
EARTH FLEET
2015
2020
1995
2010
2000
2005
CYGNSS (8)
NISTAR, EPIC
SMAP
OCO-2
GRACE-FO (2)
ICESAT-2
LIS
SAGE III
GPM
SENTINEL-6 MICHAEL FREILICH
TSIS-1
LANDSAT 8
ECOSTRESS
LANDSAT-9
SUOMI NPP
GEDI
TROPICS (6)
OCO-3
CALIPSO
LANDSAT 7
EMIT
SWOT
TERRA
CLOUDSAT
CLARREO-PF
AQUA
AURA
TEMPO
PREFIRE (2)
NISAR
MAIA*
PACE
TSIS-2*
GEOCARB*
SENTINEL-6B
GLIMR*
INCUS*
LANDSAT NEXT*
ESO-1, 2, 3, 4*
INVEST/CUBESATS
CIRIS 2023
CTIM* 2022
HYTI* 2022
SNOOPI* 2022
NACHOS* 2022
NACHOS2* 2022
JPSS INSTRUMENTS
OMPS-LIMB 2022
LIBERA 2027
ISS INSTRUMENTS
MISSIONS
KEY
INTERNATIONAL PARTNERS
U.S. PARTNER
ISS INSTRUMENT
JPSS INSTRUMENT
CUBESAT
LAUNCH DATE TBD
(PRE) FORMULATION
IMPLEMENTATION
OPERATING
EXTENDED
04.18.22



First light image, Florida Panhandle

Landsat 9 Data Released

- Data released to public in mid-February
- Instrument handover to USGS completed in February; spacecraft handover expected in late May



First light image, Himalayas

First light image, Detroit and Lake Erie

Other Recent Launches

STP-H8

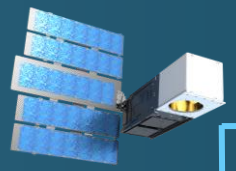
- Launched Dec. 21, 2021 with the Compact Ocean Wind Vector Radiometer (COWVR) and Temporal Experiment for Storms and Tropical Systems (TEMPEST)
- Will evaluate these small instruments' data quality for assimilation into DoD weather models

NACHOS-1 (Credit: Los Alamos National Laboratory)

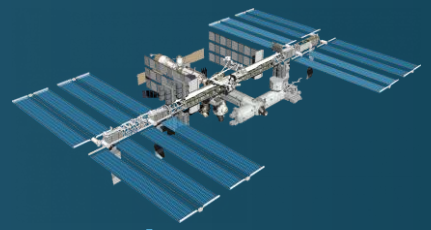
NACHOS-1

- Launched Feb. 19, 2022; deployment from ISS expected no earlier than June 2022
- 3U-sized, ultra-compact, high-resolution hyperspectral imager for measuring atmospheric trace gases (NO_2, SO_2, O_3, CH_2O, and more)

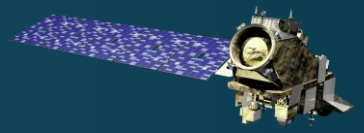
Earth Science Launch Timeline



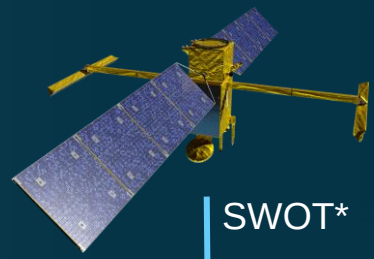
TROPICS
1, 2, 3



EMIT (ISS)



OMPS-Limb
(JPSS-2/NOAA)

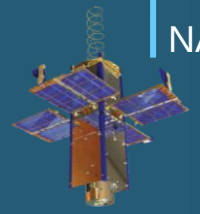


SWOT*

TEMPO**

2022

February | **April** | **May** | **June** | **Late Summer** | **September** | **October** | **November** | **December**

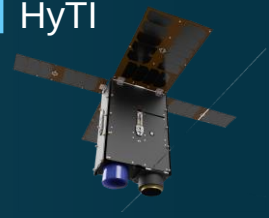


NACHOS-1

SNOOPI

CTIM-FD

NACHOS-2



HyTI

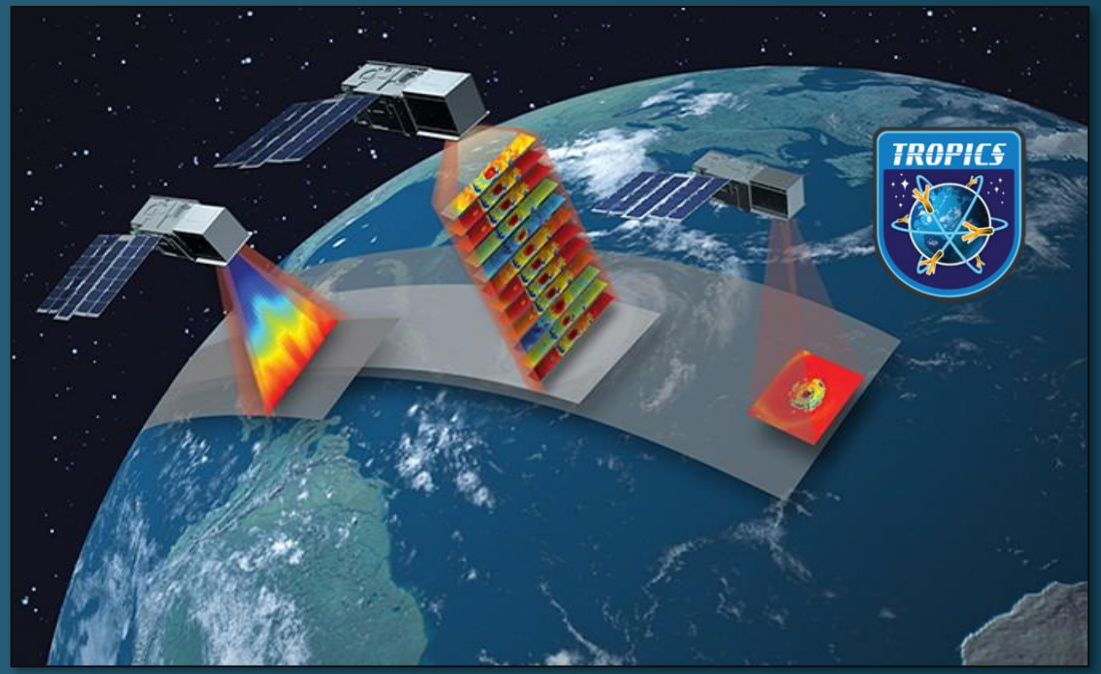
**Agency Commitment June 2023*
***Agency Commitment March 2023*

03.17.22

Upcoming Launches

TROPICS Constellation

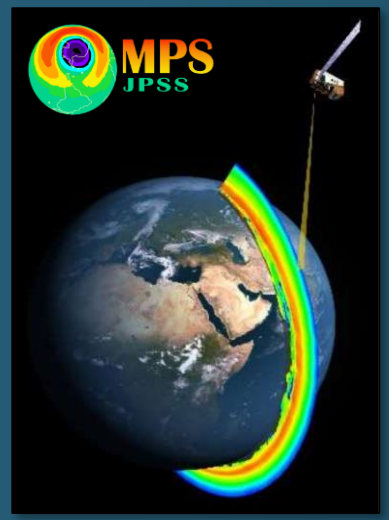
Each launch will carry two CubeSats to three orbital planes (6 total) to study tropical cyclones



EMIT on the ISS

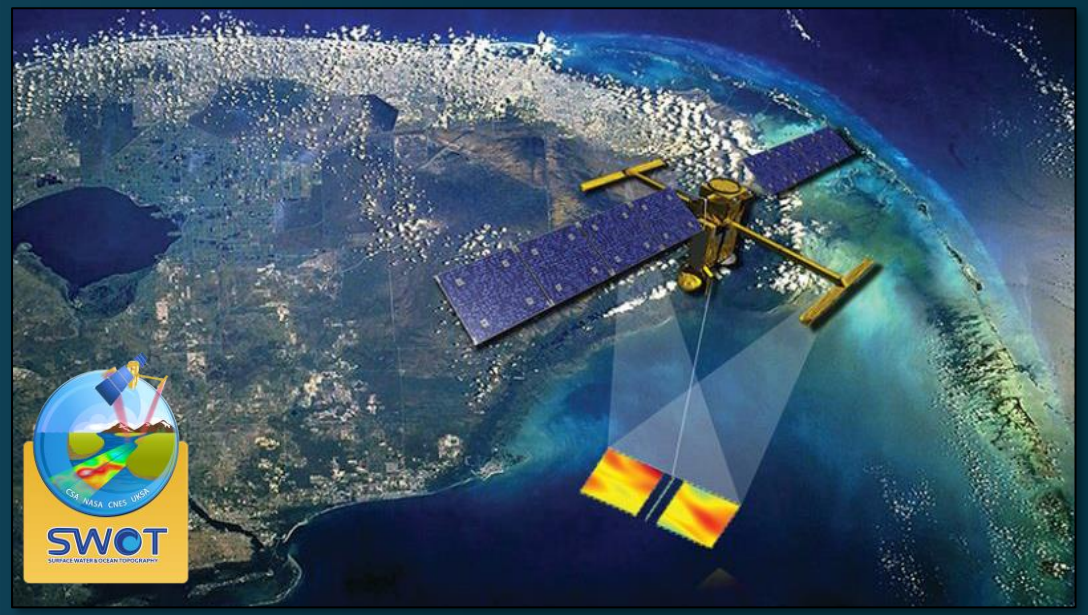
Will use NASA-invented technology to measure the composition of Earth's arid land dust source regions

Upcoming Launches



OMPS-Limb on JPSS-2

Will provide high resolution ozone and aerosol profiles and contribute to understanding ozone trends



SWOT

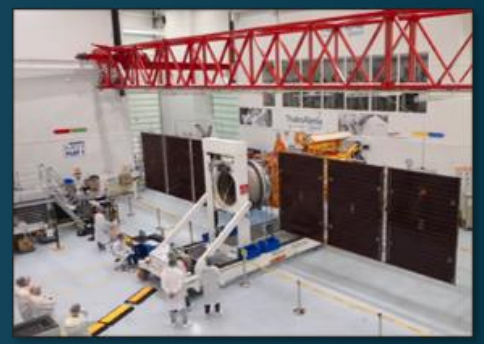
Will observe Earth's surface water, fine details of the ocean's surface topography, and changes in water bodies

TEMPO

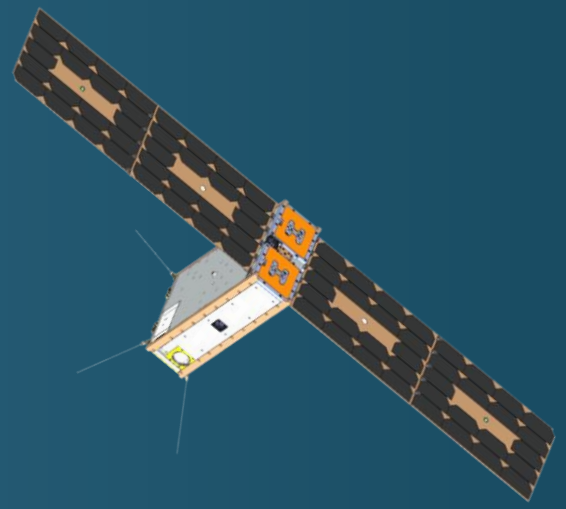
First space-based instrument to monitor air pollutants hourly across the North American continent during daytime

SWOT Observatory: Integration and Testing

- NASA ESD visited the SWOT I&T team at the Thales facility in February
- Radiated Electromagnetic Interference/Electromagnetic Compatibility test completed April 14
- Thermal vacuum testing beginning in June



Upcoming ESTO Launches

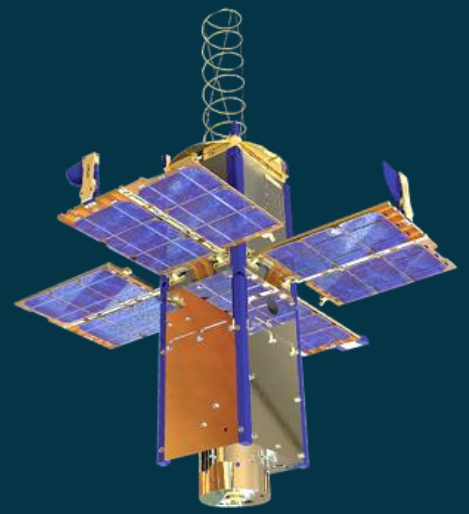


CTIM-FD: Compact Total Irradiance Monitor – Flight Demonstration

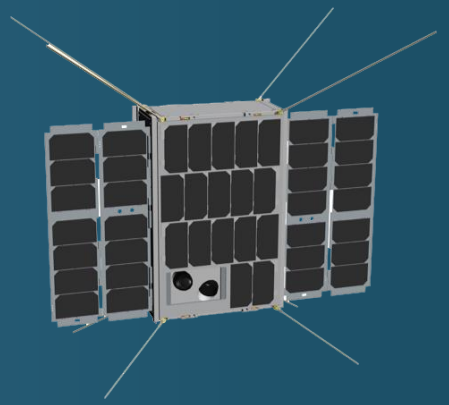
- Will demonstrate technology to enable the measurement of total solar irradiance from a CubeSat

NACHOS 2: NanoSat Atmospheric Chemistry Hyperspectral Observation System

- 3U-sized, ultra-compact, high-resolution hyperspectral imager for measuring atmospheric trace gases (NO_2, SO_2, O_3, CH_2O and more)



Upcoming ESTO Launches

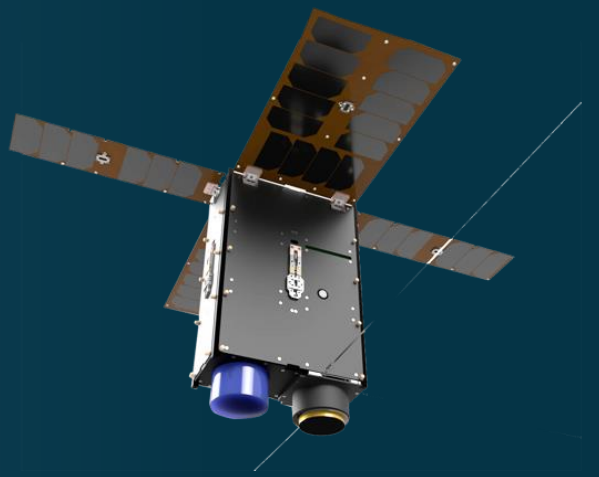


SNOOPI: Signals Of Opportunity P-band Investigation

- Will demonstrate technology to measure root zone soil moisture and snow water equivalent from a CubeSat

HyTI: Hyperspectral Thermal Imager

- Thermal infrared imager on a CubeSat with high-spatial, spectral, and temporal resolution, using onboard data processing



SNOOPI and HyTI have synergy of measuring closely coupled soil moisture and evapotranspiration

Earth Science Flight Opportunities

Open solicitation/In review | Completed solicitation

Mission	Mission Type	Release	Selection	Major Milestone
EVS-1 (EV-1) (AirMoss, ATTREX, CARVE, DISCOVER-AQ, HS3)	5 Suborbital Airborne Campaigns	2009	2010	Completed KDP-F
EVM-1 (CYGNSS)	Class D SmallSat Constellation	2011	2012	Launched Dec. 2016
EVI-1 (TEMPO)	Class C Geostationary Hosted Instrument	2012	2012	Delivered to storage Dec. 2018
EVI-2 (ECOSTRESS & GEDI)	Class C & Class D ISS-hosted Instruments	2013	2014	Launched June & Dec. 2018
EVS-2 (ACT-America, ATOM, NAAMES, ORACLES, OMG, CORAL)	6 Suborbital Airborne Campaigns	2013	2014	Completed KDP-F
EVI-3 (MAIA & TROPICS)	Class C LEO Hosted Instrument & Class D CubeSat Constellation	2015	2016	MAIA Delivery 2022; TROPICS Launch 2022
EVM-2 (GeoCarb)	Class D Geostationary Hosted Instrument	2015	2016	Launch TBD
EVI-4 (EMIT & PREFIRE)	Class C ISS-hosted Instrument & Class D Twin CubeSats	2016	2018	EMIT Launch 2022; PREFIRE Delivery 2023
EVS-3 (ACTIVATE, DCOTSS, IMPACTS, Delta-X, SMODE)	5 Suborbital Airborne Campaigns	2017	2018	4 in deployment. Delta-X is in post-deployment phase.
EVI-5 (GLIMR)	Class C Geostationary Hosted Instrument	2018	2019	Delivery NLT 2024
EVC-1 (Libera**)**	Class C JPSS-Hosted Radiation Budget Instrument	2018	2020	Delivery NLT 2025
EVM-3 (INCUS)	Full Orbital	2020	2021	Launch ~2026
EVI-6	Instrument Only	2022	2023	Delivery NLT 2027
ESE	Explorer Mission	2022	2024	Launch ~2029 & ~2031
EVC-2	Continuity Measurements	2023	2024	Delivery NLT 2028
EVS-4	Suborbital Airborne Campaigns	2023	2024	N/A
ESE	Explorer Mission	2024	2026	Launch TBD
EVI-7	Instrument Only	2024	2025	Delivery NLT 2030
EVM-4	Full Orbital	2024	2025	Launch ~2030
EVC-3	Continuity Measurements	2026	2027	Delivery NLT 2031
EVS-5	Suborbital Airborne Campaigns	2027	2028	N/A

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 Mission-3: INCUS

Addressing why convective storms, heavy precipitation, and clouds occur exactly when and where they do

Three SmallSats

- JPL Ka-band radar with 5 beams (RainCube heritage)
- JPL cross-track scanning microwave radiometer (TEMPEST-D heritage)
- Tendeg deployable 1.6m Ka-band antenna
- Blue Canyon Technologies X-SAT Venus commercial bus

PI: Susan van den Heever, Colorado State University

JPL Colorado State University BLUE CANYON TECHNOLOGIES TENDEG Space Antennas And Deployables

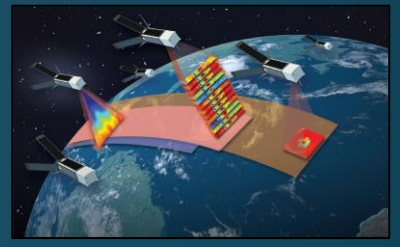
EVI-6 Announcement of Opportunity (AO)

Final AO released April 19!

- PI-Managed Mission Cost Cap of $37M (FY24)
- NASA will determine platform and launch vehicle
- Solicits Class D instruments and SmallSats
- Selection anticipated in early 2023

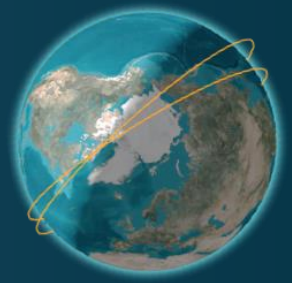
EVI-1
TEMPO

EVI-2
GEDI &
ECOSTRESS



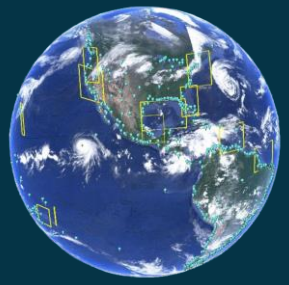
EVI-3
TROPICS

EVI-3
MAIA



EVI-4
PREFIRE

EVI-4
EMIT



EVI-5
GLIMR

EVI-6
TBD

ROBUST RESEARCH AND APPLICATIONS OPPORTUNITIES: ROSES-22 and More

Earth Science ROSES-22 Elements

Solicitation Element	Program	Proposal Due Date
A.2 Land Cover/Land Use Change	R&A	07/14/2022 (Step-2)
A.4 Scoping Studies for the Next Terrestrial Ecology Field Campaign	R&A	11/18/2022
A.6 Carbon Monitoring System: Continuing Prototype Product Development	R&A	09/30/2022
A.8 Physical Oceanography	R&A	05/25/2022
A.13 Ocean Vector Winds Science Team	R&A	10/06/2022
A.18 Aura Science Team and Atmospheric Composition Modeling and Analysis Program	R&A	08/19/2022
A.19 Airborne and Satellite Investigation of Asian Air Quality	R&A	10/04/2022
A.20 Terrestrial Hydrology	R&A	09/15/2022
A.22 Weather and Atmospheric Dynamics	R&A	TBD
A.23 Earth Surface and Interior	R&A	06/15/2022
A.24 Rapid Response and Novel Research in Earth Science	ESD	No Due Date
A.25 Airborne Instrument Technology Transition	R&A	TBD
A.26 Earth Science U.S. Participating Investigator	R&A	07/19/2022
A.27 Making Earth System Data Records for Use in Research Environments	R&A	06/02/2022
A.28 Interdisciplinary Research in Earth Science	R&A	11/16/2022
A.29 Earth Science Research from Operational Geostationary Satellite Systems	R&A	TBD
A.30 Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) Mission Validation	R&A	TBD
A.32 Studies with ICESat-2	R&A	10/12/2022
A.33 ECOSTRESS Science and Applications Team	R&A/APS	06/01/2022
A.36 Earth Science Applications: Agriculture	APS	06/17/2022
A.40 Earth Science Applications: Ecological Forecasting	APS	TBD
A.43 Commercial Smallsat Data Acquisition New Vendor Onramp Evaluation	ESDS	TBD
A.44 Commercial Smallsat Data Scientific Analysis	ESDS	TBD
A.46 Advanced Component Technology	ESTO	TBD
A.48 Sustainable Land Imaging – Technology	ESTO	TBD
A.51 Applications-Oriented Augmentations for Research and Analysis	APS/R&A	No Due Date
A.52 Earth System Science for Building Coastal Resilience	R&A	05/17/2022
A.53 Technology Development for Support of Wildfire Science and Disaster Mitigation	ESTO/R&A/APS	TBD

Earth Science Applications Guidebook

April 13: NASA Earth launches Earth Science Applications Guidebook

A new web-based resource synthesizing best practices in developing *decision-support applications* of Earth science information

Audiences:
Emerging applications specialists, Basic research scientists considering applications work, PIs new to societal applications and/or NASA.

View:
AppliedSciences.NASA.gov/Guidebook

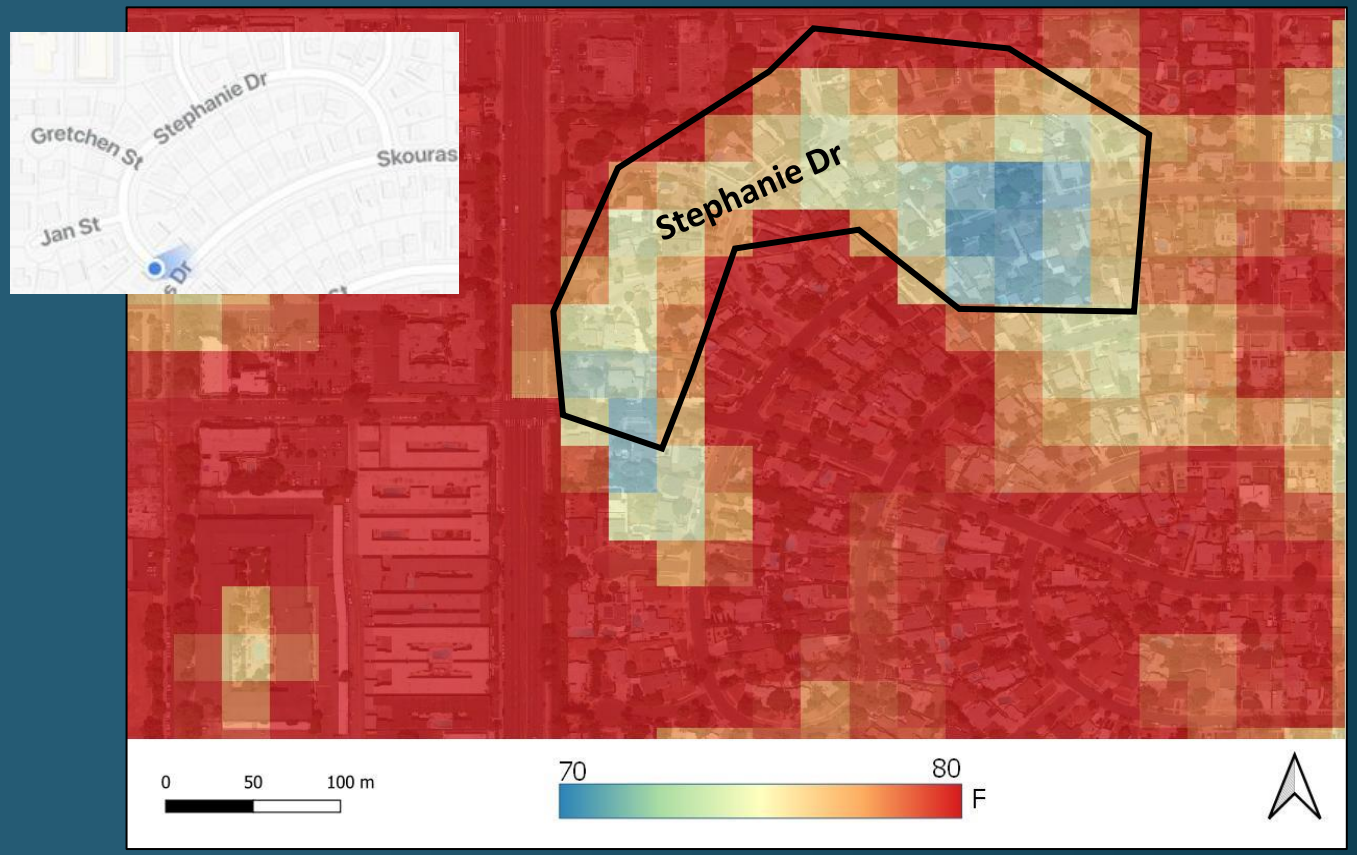
Key features	
Multiple entry pathways	Multimedia features
Easy user interface	Plain language content
Downloadable content	Practical tips & insights

View Guidebook

Societal Applications: Uses of Earth science information to support organizations' planning, decision making, and actions

ECOSTRESS for Urban Heat Mitigation

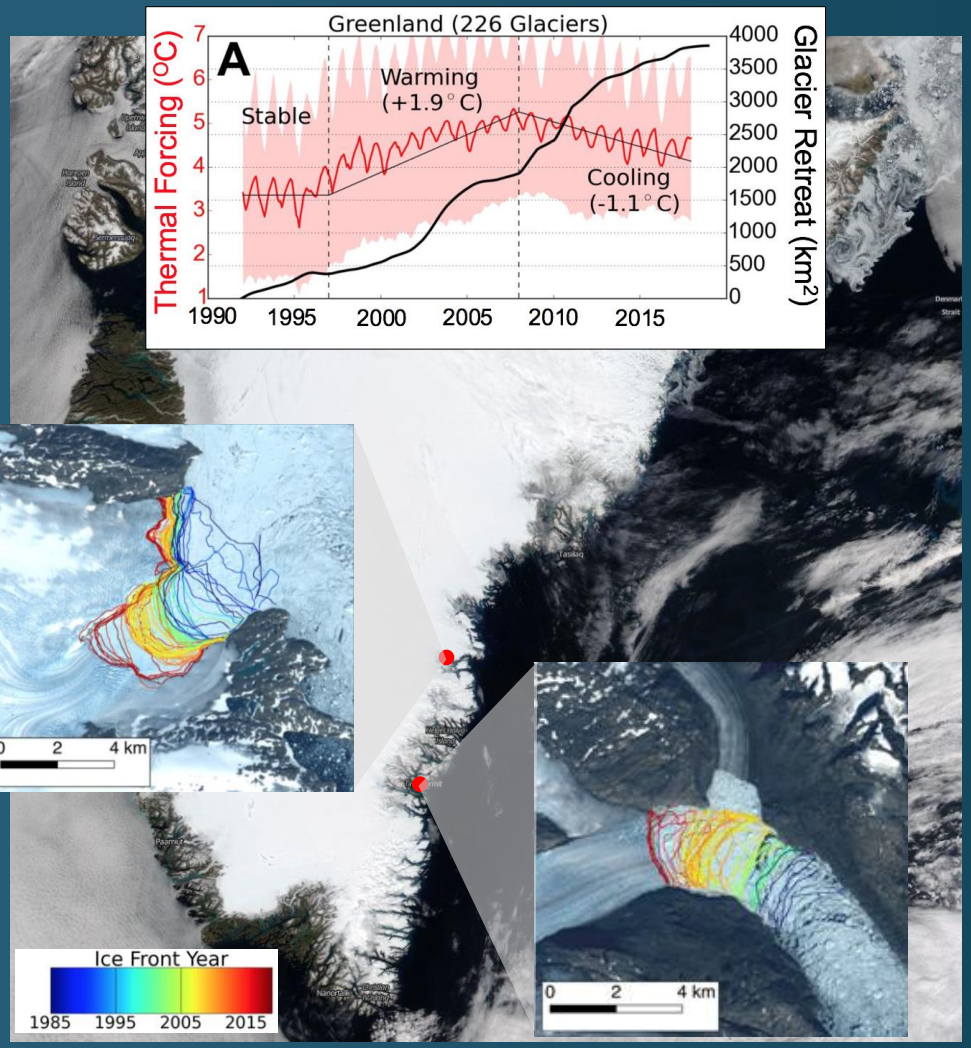
An arc of cooler temperatures observed by ECOSTRESS around Stephanie Drive in Los Angeles validates cooling impact of pavement coatings



- Based on ECOSTRESS validation, city of Los Angeles secured $8 million in funding to expand pilot pavement coating program
- Urban heat mitigation will be applied in neighborhoods with the highest heat risk
- Strong partnerships between scientists and local policy makers were critical to the success of this work

"I call this the $8 million image."
– *Greg Spotts, Chief Sustainability Officer and Executive Officer, LAStreets*

Ocean Warming Drives Greenland Glacier Retreat



- Multi-year measurements from the Oceans Melting Greenland (OMG) campaign
- Role of ocean warming in ice sheet dynamics below the surface
  - Warming indicated by average ocean temperature below 200 m
- Ice sheet loss linked from “undercutting”
  - Warm, salty water at bottom of fjord melts the base of a glacier, causing ice above to break apart
  - Changes loss estimates by at least a factor of 2
  - Most significant in deep fjords
- “Memory” in the system
  - Ocean warming paused in 2008–2017, the net ice discharge from Greenland glaciers kept increasing, ice fronts kept retreating, and rate of undercutting remained higher than in the previous decade
- OMG ended on Dec. 31, 2021, after five years of airborne and ship-based observations and science

Wood, M., et al. (2021). Ocean forcing drives glacier retreat in Greenland. *Science Advances*, *7*(1), https://doi.org/10.1126/sciadv.aba7282

2020-2021 Student Airborne Research Program

SARP is an eight-week summer internship program for rising senior undergraduate students to acquire hands-on research experience in all aspects of a scientific campaign.

SARP 2020 and 2021 students with instrument teams during science flights aboard the NASA DC-8.

Science Objectives:

- LA air quality
- Central Valley agricultural emissions
- Satellite cal/val
- Halogen chemistry
- NO_x emissions
- Overfly Long Beach harbor

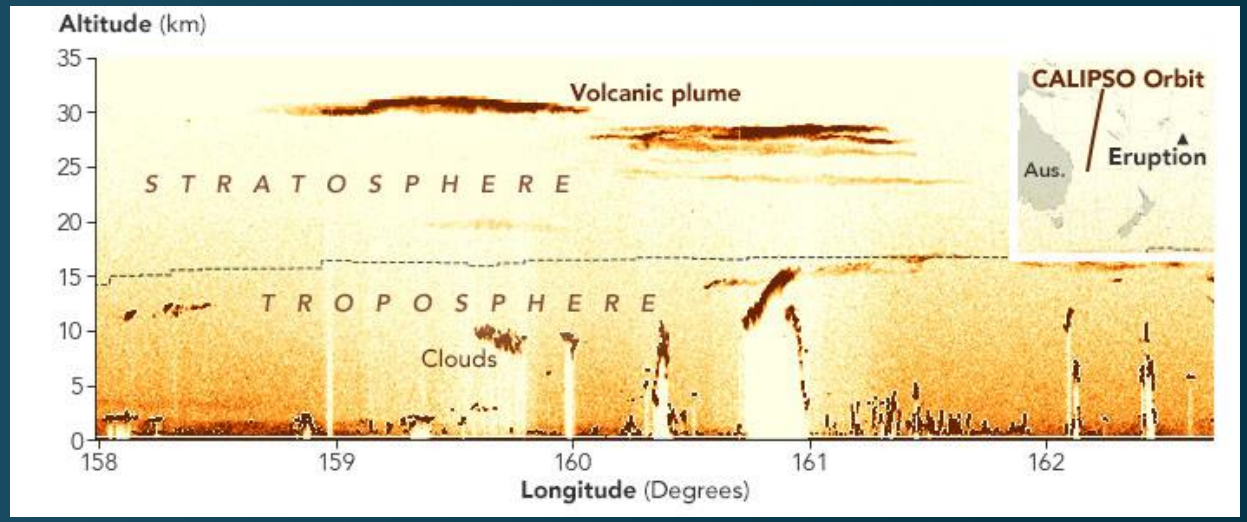
Participation:

- 56 students from 30 states
- 7 research mentors
- 5 faculty mentors
- 4 flight days, 6 flights

Disasters Activation : Hunga Tonga-Hunga Ha’pai Volcanic Eruption

Unprecedented eruption of sub-marine volcano on January 13-14, 2022

Tsunami impacts felt across Pacific Islands and as far as Pacific Coast of Continental US



Stratospheric plume

Credits: NASA Earth Observatory/CALIPSO team

Tsunami impacts in Tonga on Damage Proxy Map

Credits: NASA JPL

New Agriculture Activities

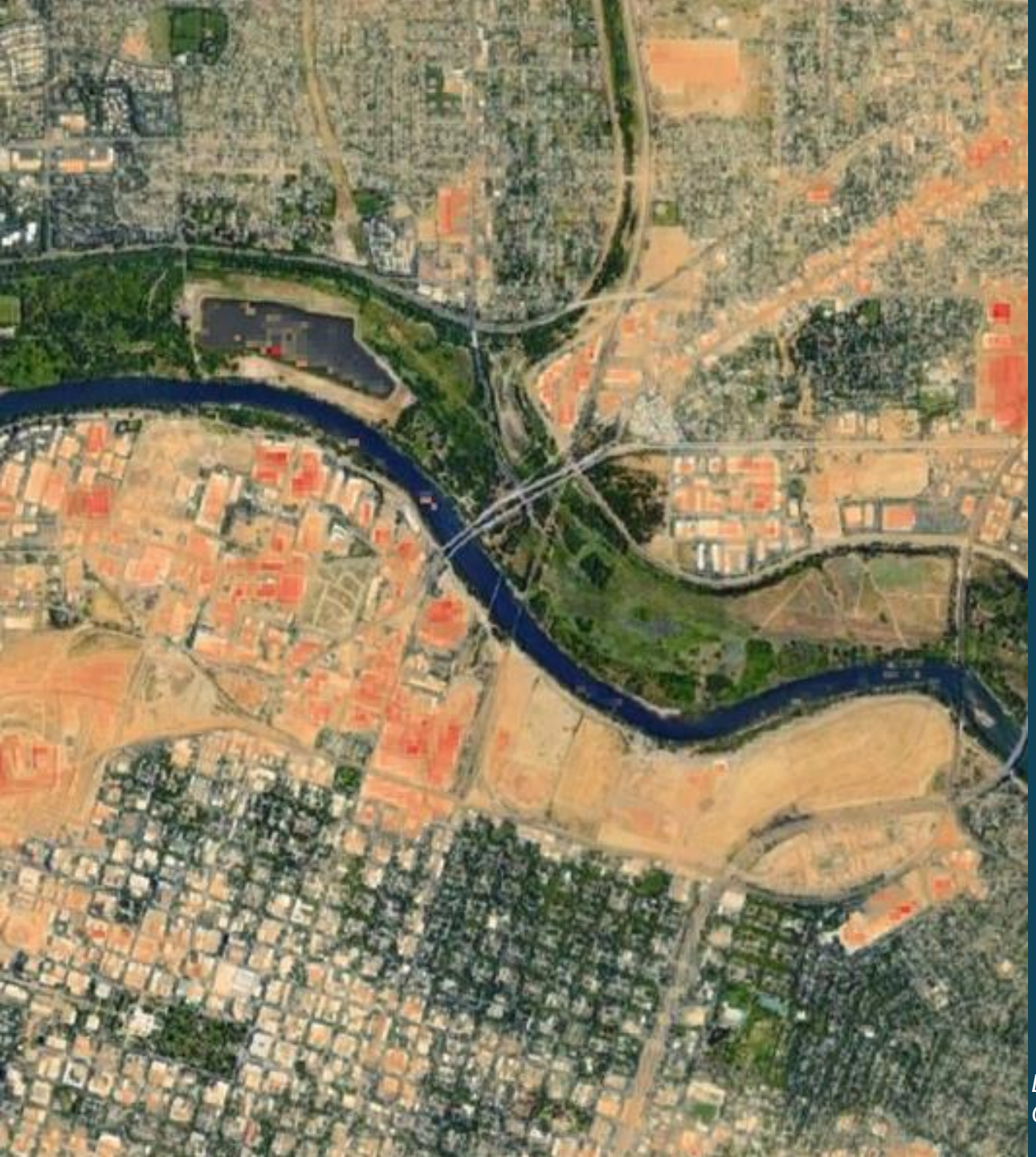
Solicitation for domestic Agriculture consortium released February 14, 2022

- Notices of intent are requested by May 5, 2022
- Proposals are due June 17, 2022

ESD presence at 2022 Commodity Classic in March 2022

Virtual Exhibit

NASA Team Onsite



Equity & Environmental Justice

NASA is committed to ensuring that investments made in NASA satellites and science help people across the U.S. make informed decisions about the challenges they face in their communities.

- Equity and Environmental Justice community listening workshop held in October
- Environmental Justice-related solicitations released in December and February
- Upcoming data workshop and ongoing trainings for new users of NASA data

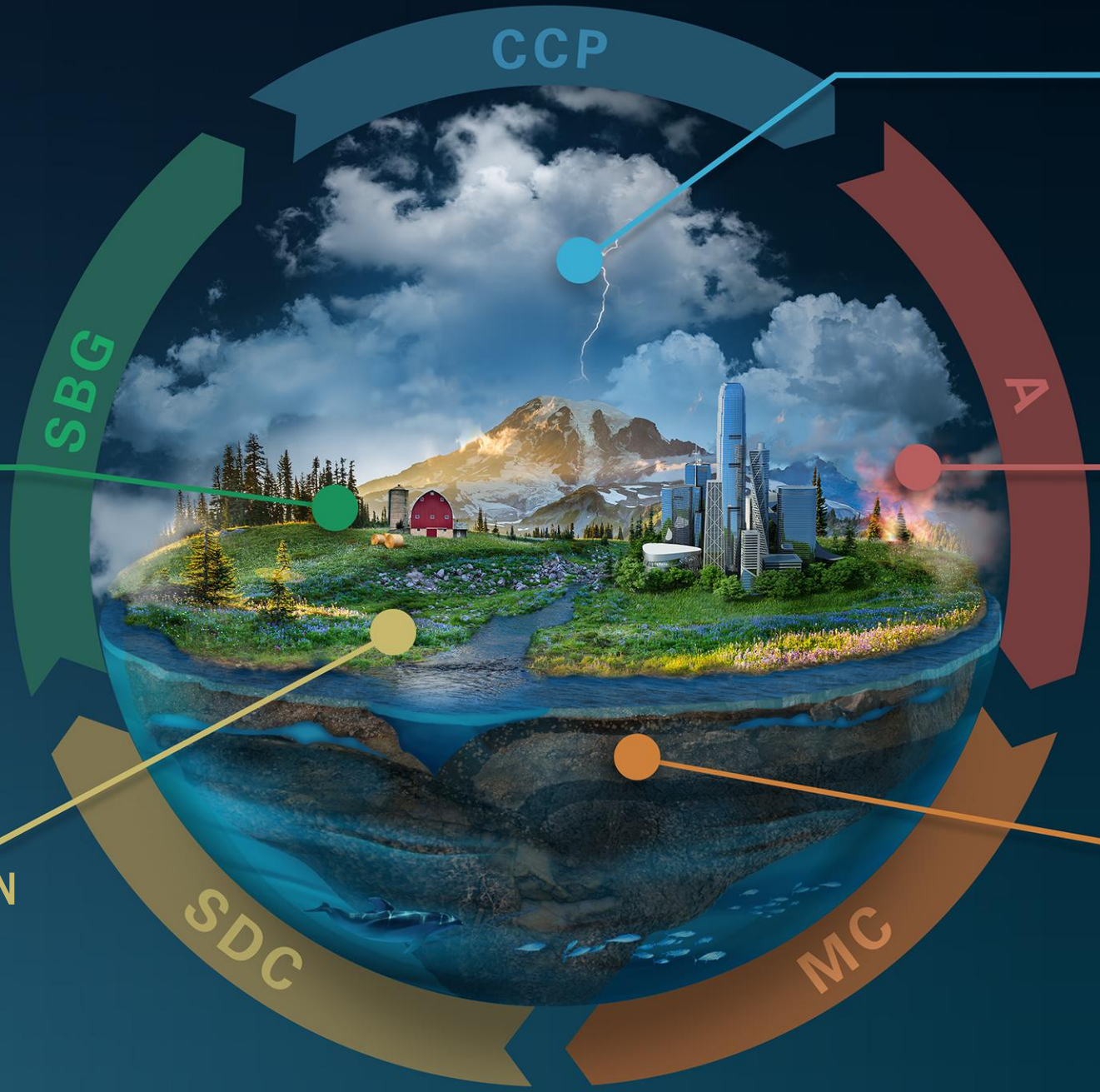
https://science.nasa.gov/earth-science/equity-and-environmental-justice

Landsat 8-derived mean land surface temperature in central Sacramento, California for prioritized urban cooling interventions.

DEVELOPING NEXT-GEN CAPABILITIES: Earth System Observatory & Tech Investments

EARTH SYSTEM OBSERVATORY

INTERCONNECTED CORE MISSIONS



CLOUDS, CONVECTION AND PRECIPITATION

Water and Energy in the Atmosphere

AEROSOLS

Particles in the Atmosphere

MASS CHANGE

Large-scale Mass Redistribution

SURFACE DEFORMATION AND CHANGE

Earth Surface Dynamics

SURFACE BIOLOGY AND GEOLOGY

Earth Surface & Ecosystems

EARTH SYSTEM OBSERVATORY

INNOVATION & COMPETITION
EARTH EXPLORER MISSIONS

Greenhouse Gases

Ozone and Trace Gases

Atmospheric Winds

Ice Elevation

Snow Depth and Water Content

3D Ecosystem Structure

Ocean Surface Winds and Currents

ESO Updates

ACCP, MC and SBG continue in Pre-Phase A

- Conducting instrument RFIs (Requests for Information) and Mission Design Labs
- Meeting with international partners
- Preparing for ESO Pre-ASMs (Acquisition Strategy Meetings) in May 2022

Mission Concept Reviews

- MC and ACCP expected in May 2022
- SBG likely in June 2022

NEW: Earth System Explorers (ESE)

- PI-Managed Mission Cost (PIMMC) cap of $310M (FY24 $)
- NASA will provide launch vehicle services
- Two-step selection process currently planned

Step 1 Selection

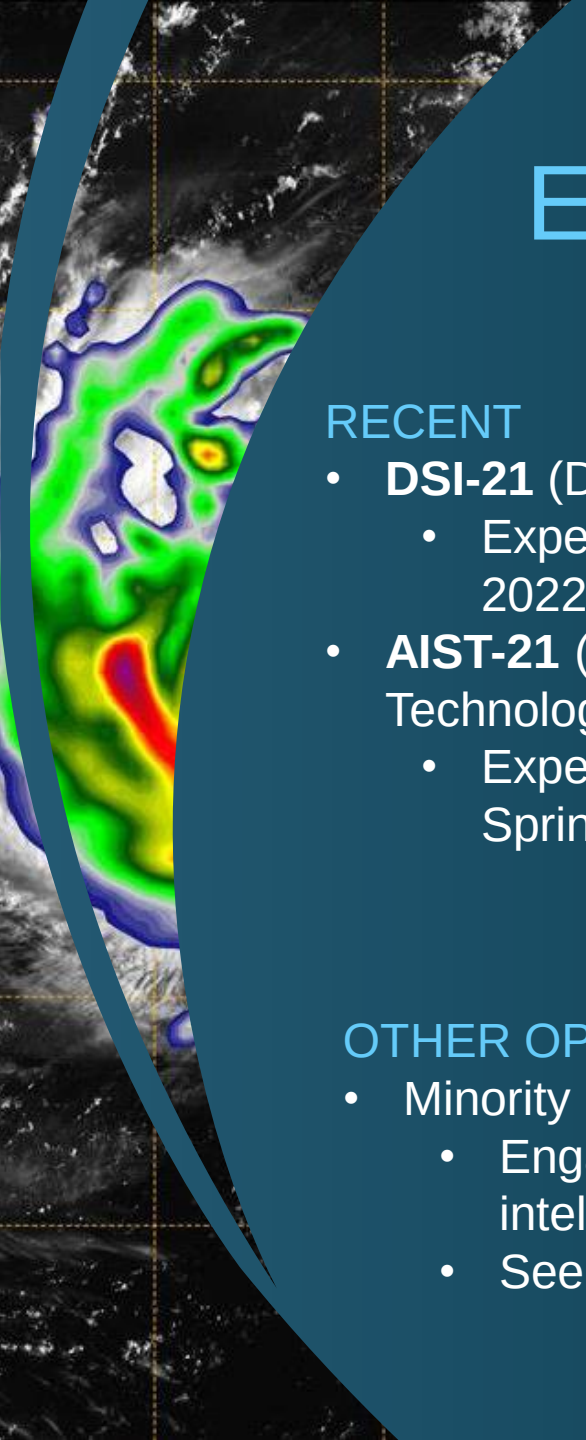
- Up to 4 Proposals
- 9-month Phase A concept studies

Step 2 Selection

- Up to 2 Missions
- Staggered phasing and funding

ESE Community Announcement Issued Oct. 6, with Draft AO targeted for Spring 2022

Earth Science Technology Opportunities



RECENT

- **DSI-21** (Decadal Survey Incubation) closed
  - Expect awards to be announced in Spring 2022
- **AIST-21** (Advanced Information Systems Technologies) closed
  - Expect awards to be announced in Spring 2022

ROSES-22 upcoming solicitations

- **ACT-22** (Advanced Component Technologies)
- **SLIT-22** (Sustainable Land Imaging Technology)

NEW

- Technology Development For Support of Wildfire Science and Disaster Mitigation

OTHER OPPORTUNITIES (not in ROSES)

- Minority Serving Institutions – Space Accelerator: Applications closed March 30
  - Engage under-represented academic institutions in the areas of machine learning, artificial intelligence, and system-level autonomy
  - See: https://www.nasa-space-accelerator.com/

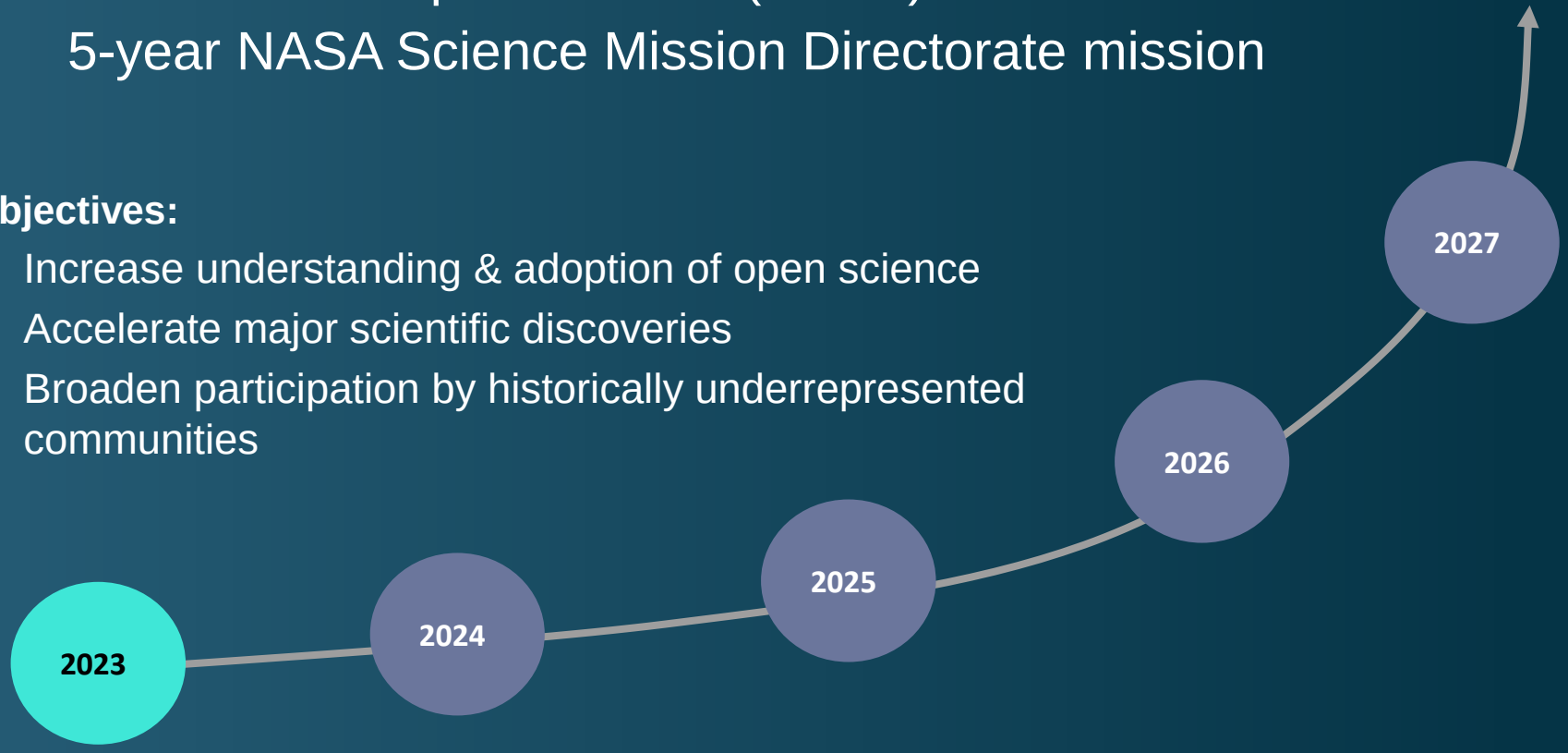
BUILDING BRIDGES:
Open-Source Science Initiative

Leading the Path to Open-Source Science

Transform to Open Science (TOPS) is a $40 million*
5-year NASA Science Mission Directorate mission

Objectives:

- Increase understanding & adoption of open science
- Accelerate major scientific discoveries
- Broaden participation by historically underrepresented communities



Year of Open Science

Goals for 2027:

20K earn Open Science Badge

5+ major discoveries

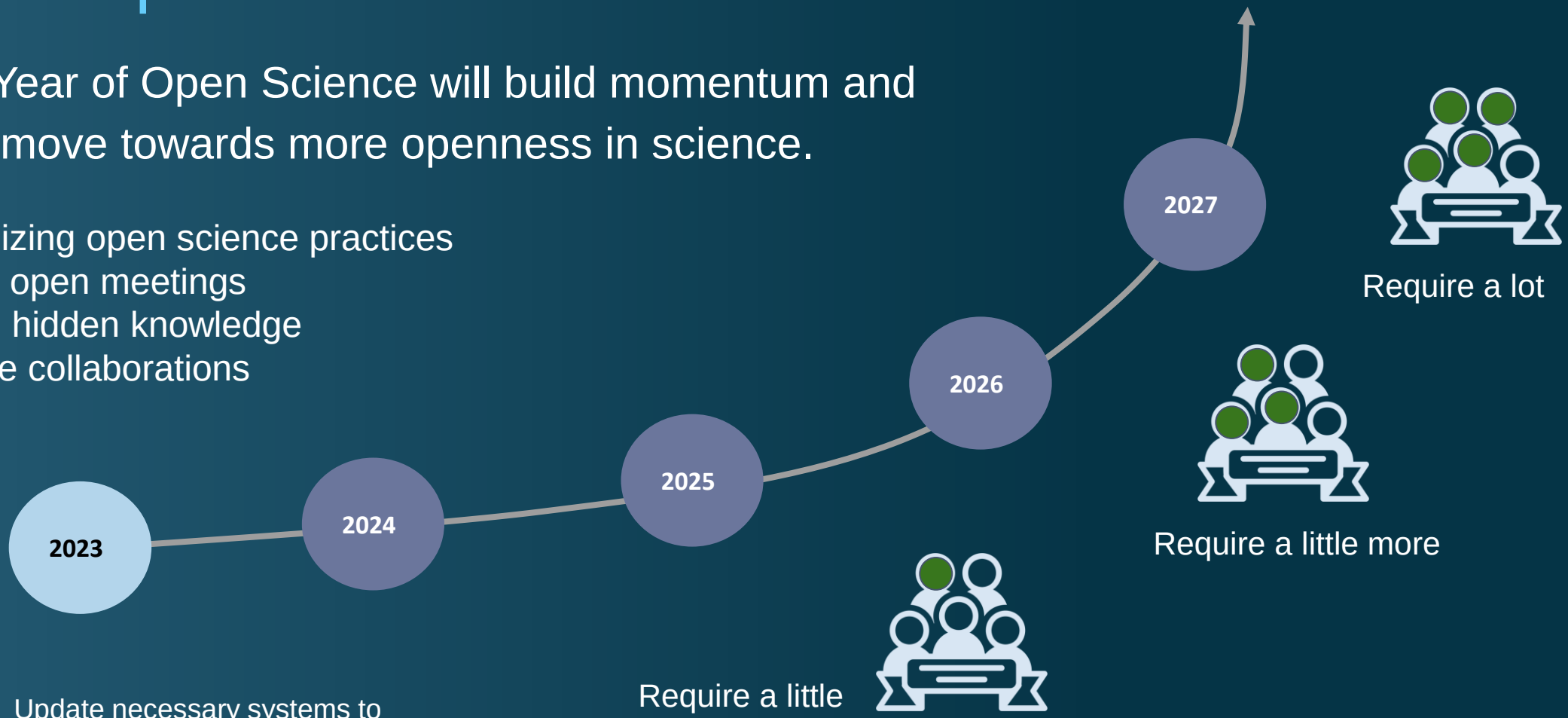
Increase participation of underrepresented groups by 2x

*pending appropriations

Moving Towards Openness: Year of Open Science and the Future

The 2023 Year of Open Science will build momentum and support to move towards more openness in science.

- Recognizing open science practices
- Holding open meetings
- Sharing hidden knowledge
- Inclusive collaborations



Upcoming Open Source Science Activities

RFI for SMD Policy Directive-41 amendments (~July 2022)

ESO Open-Source Science Workshop #3 (Late Summer 2022)

For more information on NASA's Earth System Observatory:
https://science.nasa.gov/earth-science/earth-system-observatory

Questions Process

- During Q&A, please type your question directly into the Q&A panel
- Alternatively, you may email questions to Kate Becker at kate.s.becker@nasa.gov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