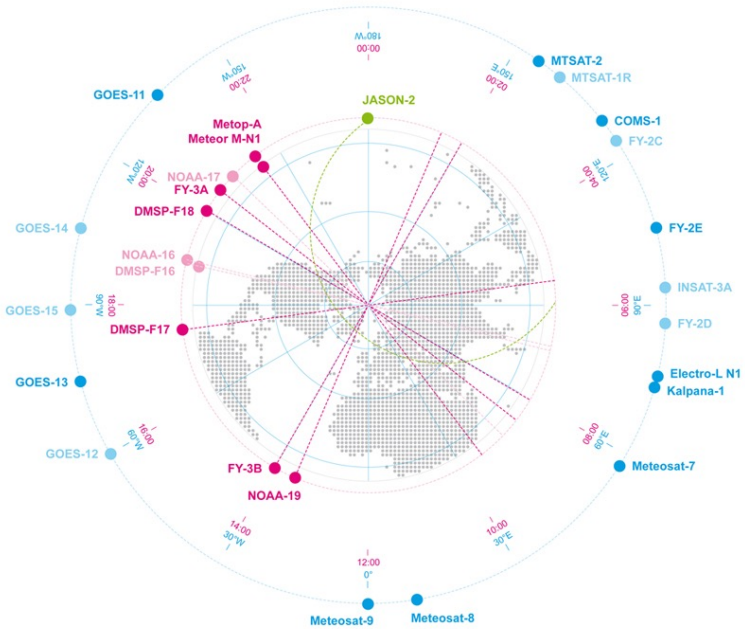


NASA Report on Current & Future Satellite Systems

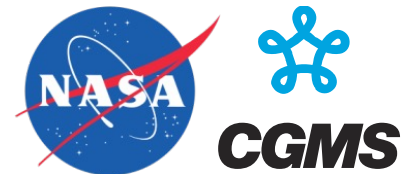


Presented to CGMS-51 Plenary Session, Agency Interventions/Reports,
Agenda Item 2

Presenter: Jack Kaye, NASA Headquarters

Report prepared based on inputs from
numerous colleagues at
NASA HQ, NASA Centers,
and the broader research community

**Coordination Group for
Meteorological Satellites**



Outline

- Status of NASA's Earth-observing spaceborne fleet
- Launch highlights:
 - Earth Surface Mineral Dust Source Investigation (EMIT)
 - Surface Water and Ocean Topography (SWOT)
 - Tropospheric Emissions: Monitoring of Pollution (TEMPO)
 - Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats (TROPICS)
- Mission updates:
 - Signals Of Opportunity P-band Investigation (SNOOPI)
 - Hyperspectral Thermal Imager (HyTI)
 - Investigation of Convective Updrafts (INCUS)
 - Polarized Submillimeter Ice-cloud Radiometer (PolSIR)
- Status of NASA response to 2017 Earth Science Decadal Survey
- Other Updates of interest for CGMS
 - Senior Review
 - Earth Information Center (EIC)
 - Greenhouse gas monitoring & information center
 - Commercial Smallsat Data Acquisition (CSDA) program
 - Open-source science
 - Earth Science to Action Strategy

Coordination Group for Meteorological Satellites - CGMS

National Aeronautics and
Space Administration



EARTH FLEET

INVEST/CUBESATS

NACHOS 2022
CTIM 2022
NACHOS-2 2022
MURI-FD 2023
SNOOP* 2024
HYTI* 2024
ARGOS* 2024

JPSS INSTRUMENTS

OMPS-LIMB 2022
LIBERA 2027
OMPS-LIMB 2027
OMPS-LIMB 2032

ISS INSTRUMENTS

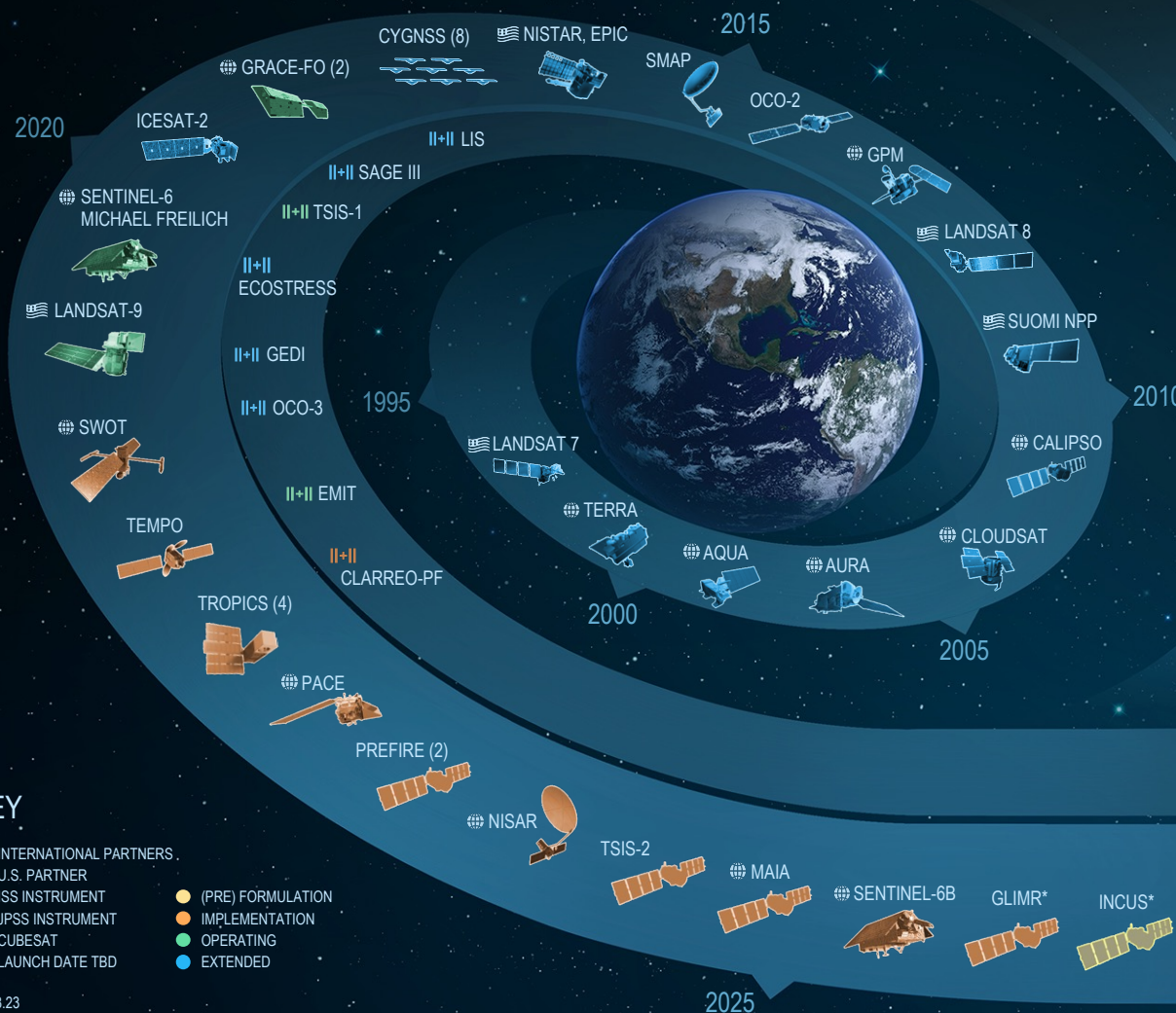
MISSIONS

KEY

INTERNATIONAL PARTNERS
U.S. PARTNER
ISS INSTRUMENT
JPSS INSTRUMENT
CUBESAT
LAUNCH DATE TBD

(PRE) FORMULATION
IMPLEMENTATION
OPERATING
EXTENDED

05.18.23



Coordination Group for
Meteorological Satellites



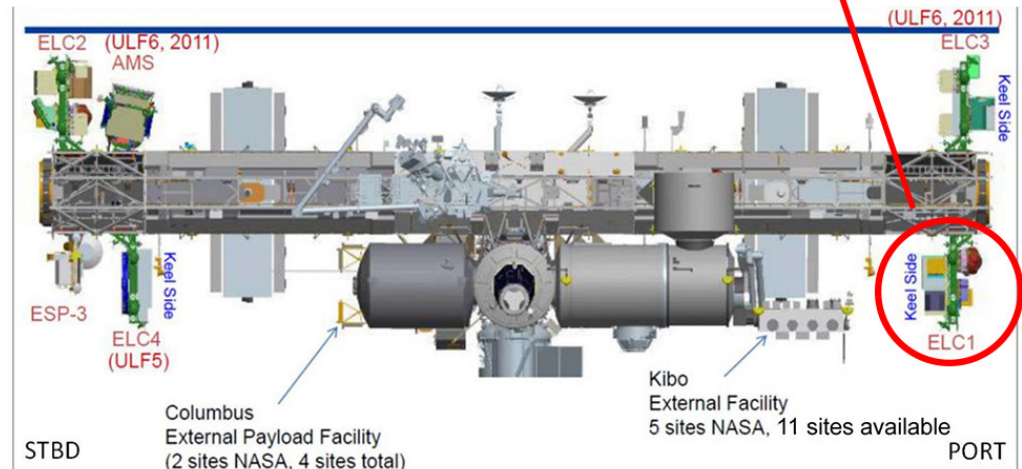
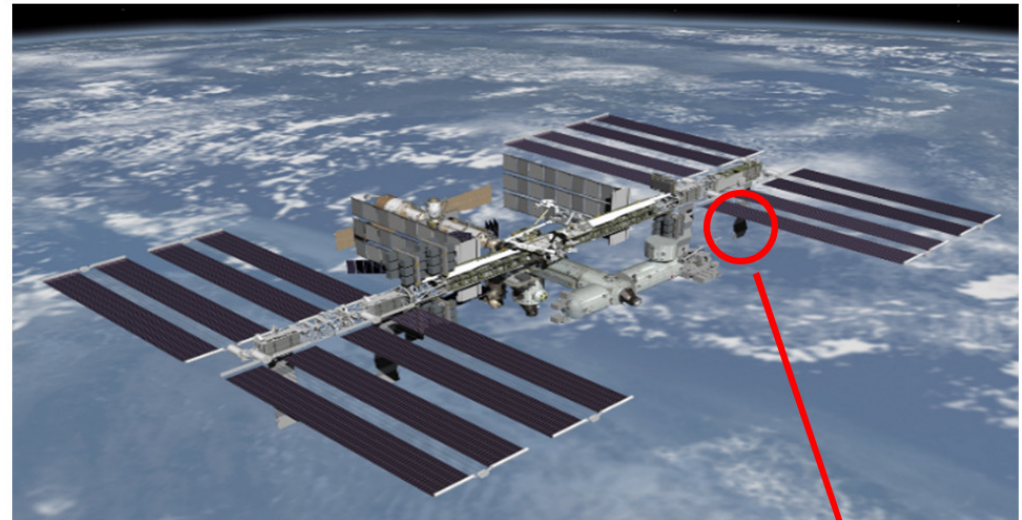
Earth Surface Mineral Dust Source Investigation (EMIT) (1)

EMIT is an Imaging spectrometer operating in the Visible to Shortwave Infrared (VSWIR) range (380 – 2500 nm) sampling at 7.4 nm.

Mission Objectives

EMIT is aimed at comprehensively measuring the mineral composition of Earth's dust source regions.

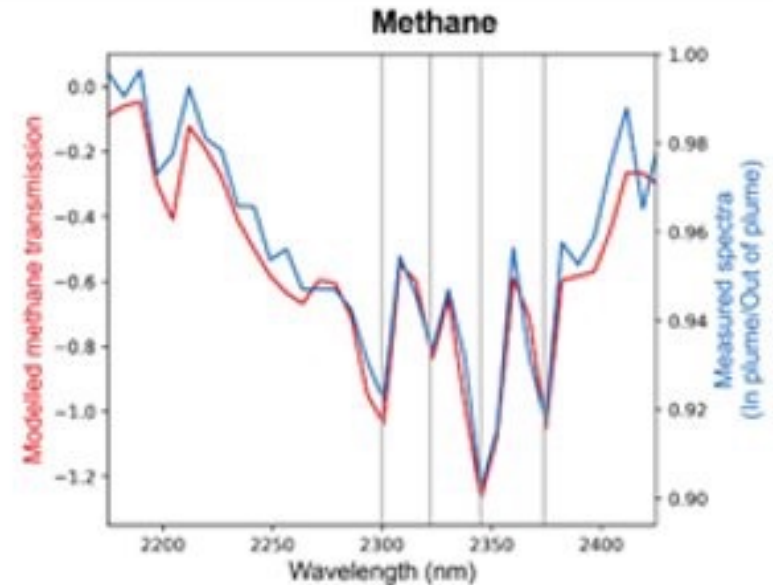
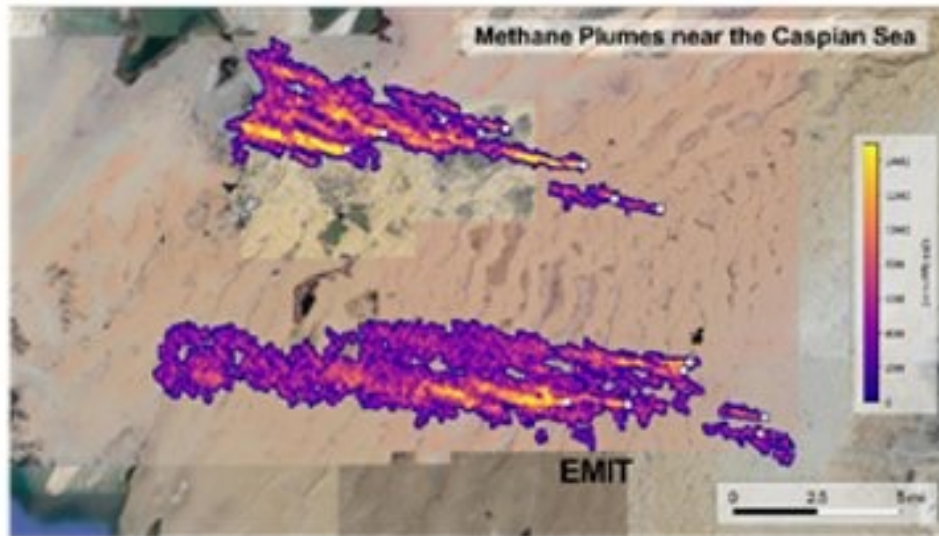
Improve understanding of how dust they heat or cool our planet but predict how future climate scenarios might change the amount and type of mineral dust emitted into the Earth's atmosphere.



Launched on a SpaceX resupply mission to the ISS on 14 July 2022, EMIT was mounted to ExPRESS Logistics Carrier 1.

Earth Surface Mineral Dust Source Investigation (EMIT) (2)

EMIT Science team has identified more than 50 CH₄ super-emitters in Central Asia, the Middle East, and the Southwestern United States.

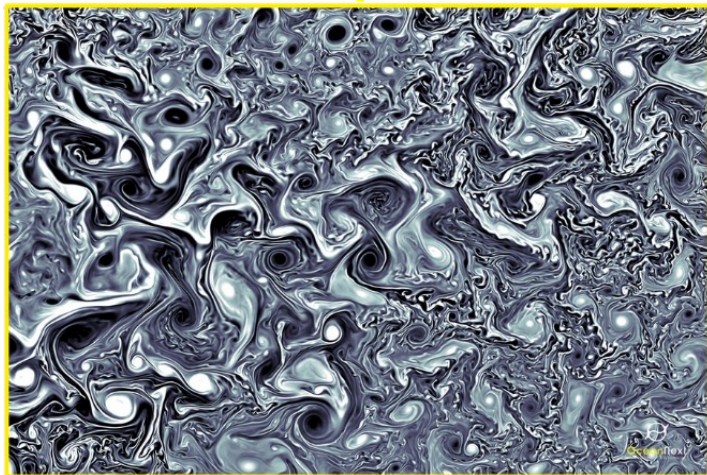
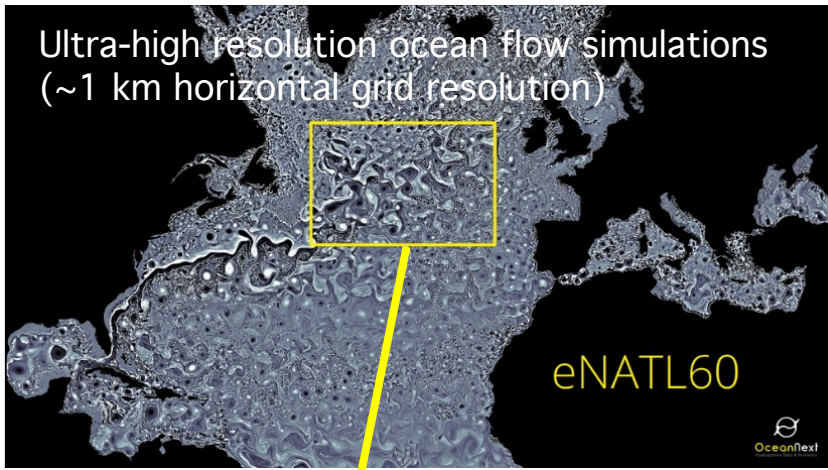


Methane plume identified near Caspian Sea using data from EMIT instrument onboard the ISS. In and out of plume ratios illustrate the spectral fingerprints for methane and agree well with modeled transmission.

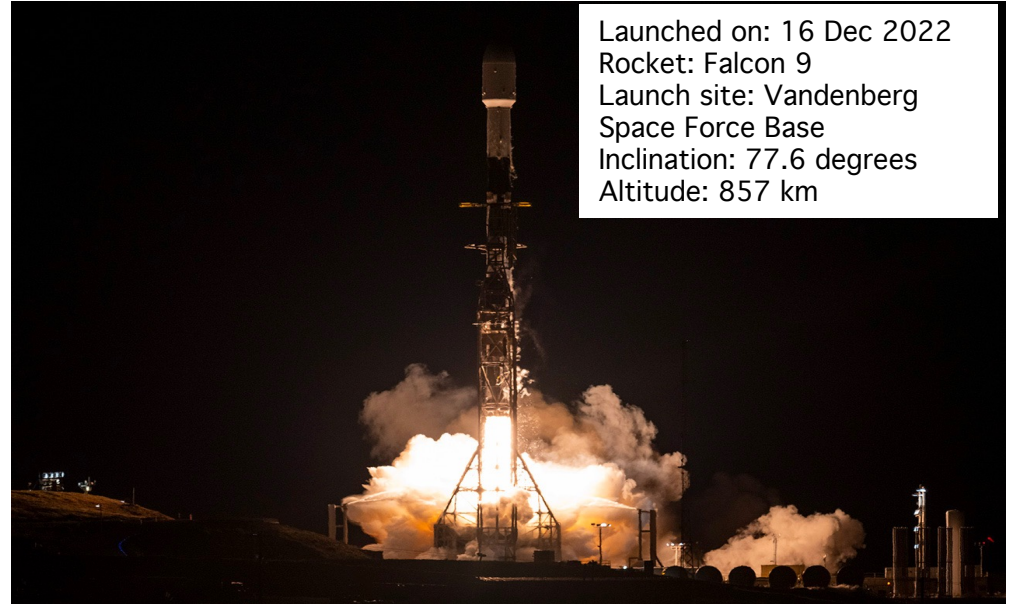
Surface Water and Ocean Topography (SWOT) (1)

The **SWOT** satellite carries a Ka-and radar interferometer (KaRIn), a Jason-class altimeter, a DORIS Antenna, a microwave radiometer, a X-band antenna, Laser Reflector Assembly, and a GPS Receiver. It has contribution from NASA, France's Centre National D'Études Spatiales (CNES), and the Canadian Space Agency.

Ultra-high resolution ocean flow simulations
(~1 km horizontal grid resolution)



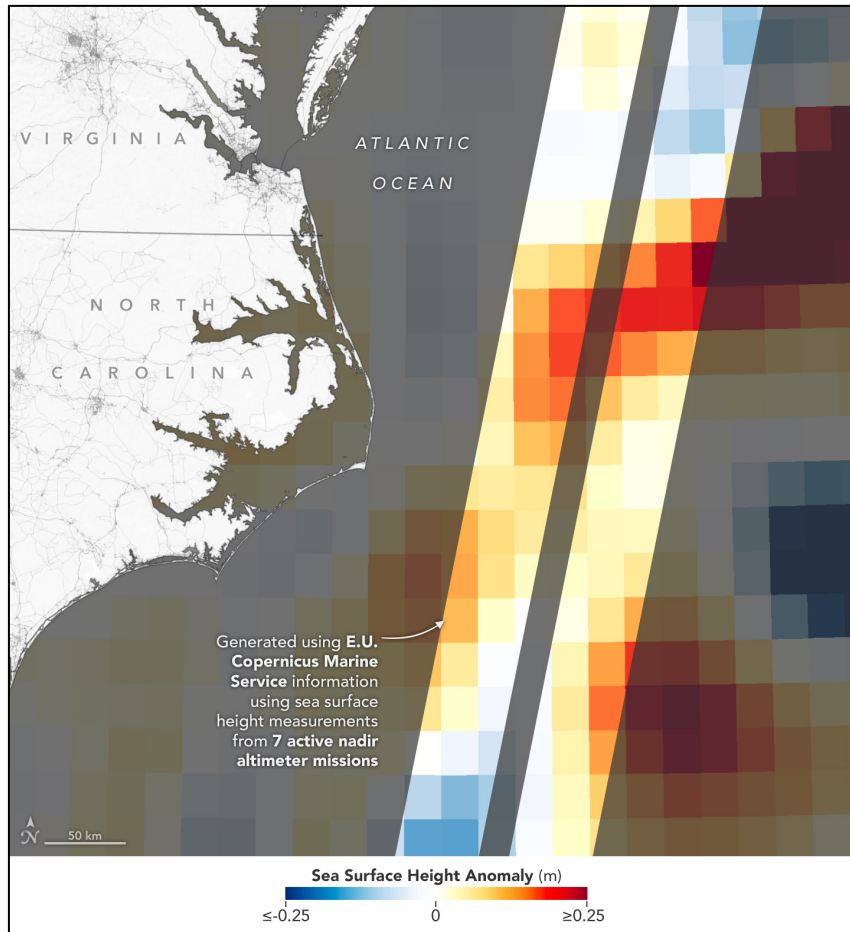
Launched on: 16 Dec 2022
Rocket: Falcon 9
Launch site: Vandenberg
Space Force Base
Inclination: 77.6 degrees
Altitude: 857 km



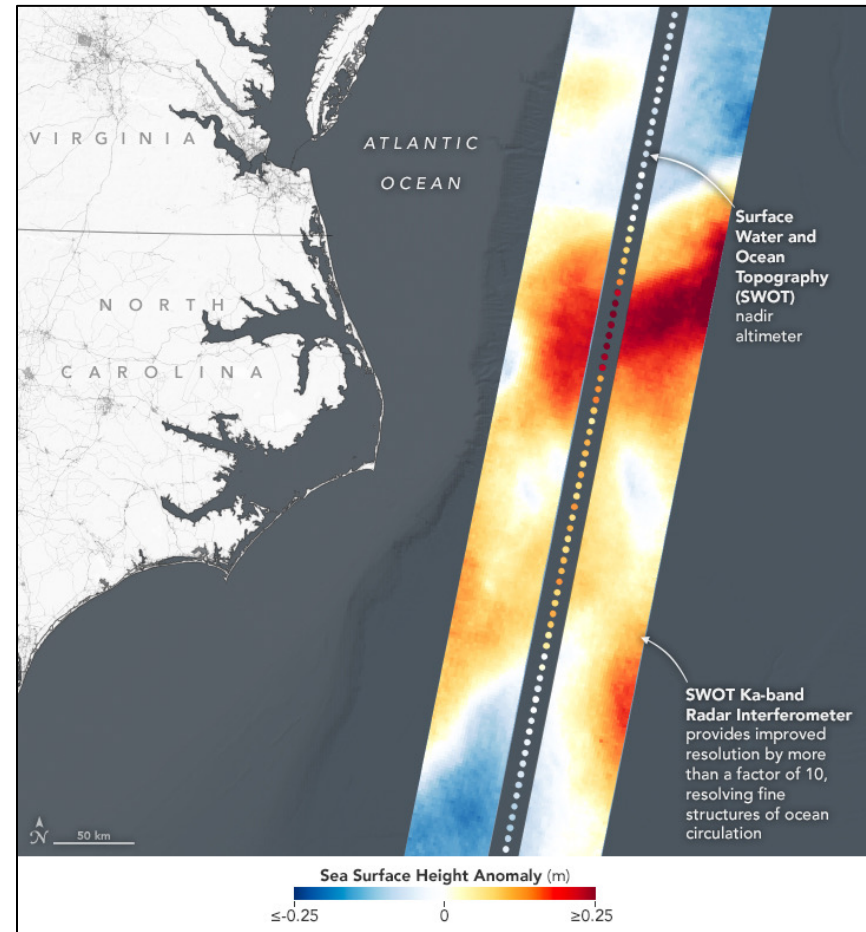
Small-scale currents and eddies affect global climate through modulation of sea surface temperature and heat flux, as well as the oceanic uptake of carbon dioxide from the atmosphere.

Understanding of the roles played by fine-scale ocean turbulence (and tidal motions) in influencing the large-scale ocean circulation, and thereby, the climate system

Surface Water and Ocean Topography (SWOT) (2)



Comparison image: The spatial resolution of SWOT ocean measurements is 10 times greater than the composite of sea surface height data gathered over the same area by seven other satellites: Sentinel-6 Michael Freilich, Jason-3, Sentinel-3A and 3B, Cryosat-2, Altika, and Hai Yang 2B.



SWOT first light image: On Jan. 21, 2023, SWOT measured sea surface height in the Gulf Stream off the coastal North Carolina and Virginia. The two KaRIn antennas acquired data that was mapped as two wide, colored strips spanning a total of 75 miles (120 kilometers) across.

Tropospheric Emissions: Monitoring of Pollution (1)

TEMPO is a grating spectrometer, sensitive to visible and ultraviolet wavelengths of light. It is attached to the Earth-facing side of a commercial telecommunications satellite that is stationed in a geostationary orbit. It will collect high-resolution measurements of ozone, nitrogen dioxide and other pollutants, data which will revolutionize air quality forecasts. It is integrated onto a Maxar 1300 Series Spacecraft bus and hosted on an Intelsat Commercial Satcom mission (IS40e) stationed at 91 deg W.

- Instrument was successfully powered (07 June) and currently in extended degassing period.
- First light scheduled for late-July 2023.
- Public release of standard products in October 2023.
 - Species: NO₂, O₃, HCHO, SO₂, Aerosol products
 - Spatial resolution: 2.1 km N/S × 4.7 km E/W = 9.8 km² (native) at center of FOR

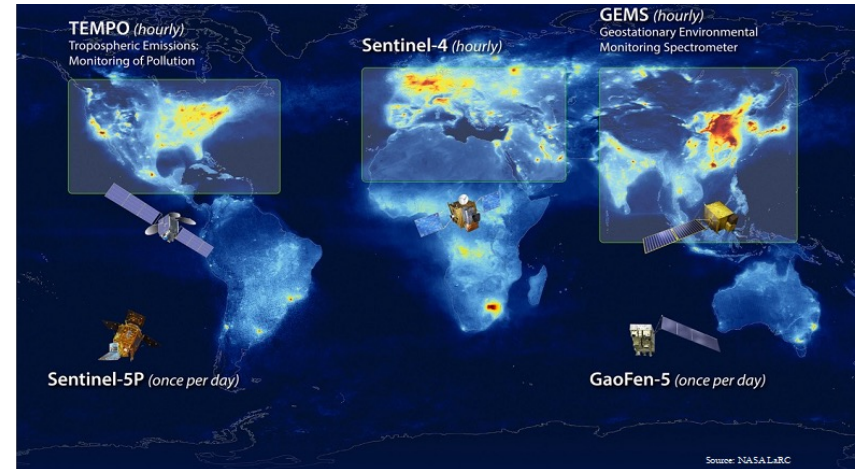


Launched 07 April 2023, 12:30 Eastern on Space X Falcon 9

Tropospheric Emissions: Monitoring of Pollution (2)

Significance

- It is NASA's first mission that will measure air pollution over North America, from Mexico City to the Canadian oil sands, and from the Atlantic to the Pacific at hourly temporal and high spatial resolution.
- It is the part of a global constellation of satellites that includes The European Sentinel-4 mission that will measure pollution over Europe, and Korean Geostationary Environmental Monitoring Spectrometer (GEMS), both are currently in orbit.
- It initiates from the geostationary orbit those that were acquired from the polar orbits by the Ozone Monitoring Instrument (OMI), SCIAMACHY, and Global Ozone Monitoring Experiment (GOME).



Synergistic TEMPO Air Quality Science (STAQS)

STAQS campaign (Summer 2023) seeks to integrate TEMPO satellite observations with traditional air quality monitoring to improve understanding of air quality science and increase societal benefit.

STAQS will be conducted in summer 2023, targeting three primary cities: Los Angeles, New York City, and Chicago; and secondary domains: Toronto, Baltimore, and Washington, DC. with ground and airborne based measurements.

The campaign is being coordinated with other air quality campaigns.

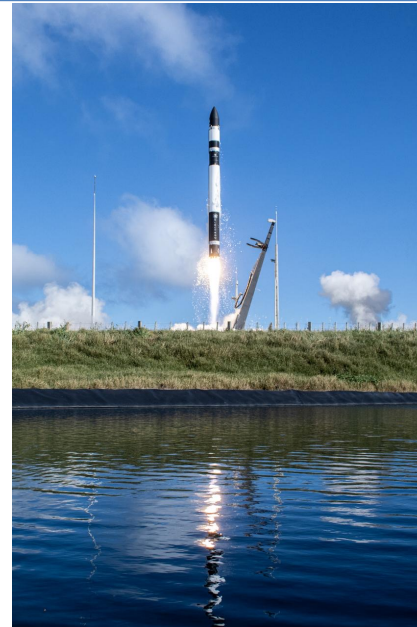
Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats (TROPICS) (1)

TROPICS is a constellation four dual-spinning 3U CubeSats equipped with a 12-channel passive microwave spectrometer providing imagery near 90 and 205 GHz, temperature sounding near 118 GHz, and moisture sounding near 183 GHz. Each Cubesat comprises a 2U Blue Canyon Technologies spacecraft bus with an altitude determination and control system, avionics, power, and communications, a 1U spinning radiometer payload.

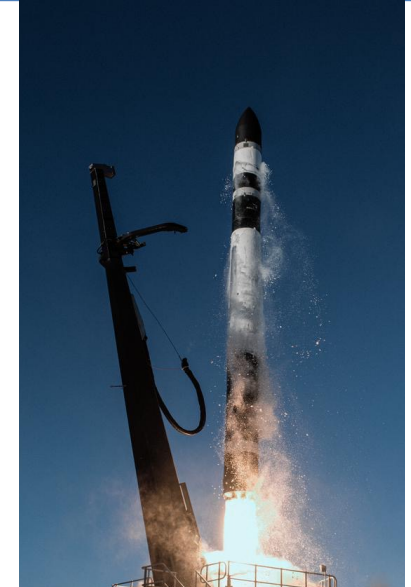
Significance

- First high-revisit, nearly-global microwave observations of precipitation, temperature, and humidity
- Complements GPM, CYGNSS, and NOAA GOES/JPSS missions with high-refresh, near-all-weather measurements of precipitation and thermodynamic structure
- Increases understanding of critical processes driving significant and rapid changes in storm structure and intensity

**Coordination Group for
Meteorological Satellites**

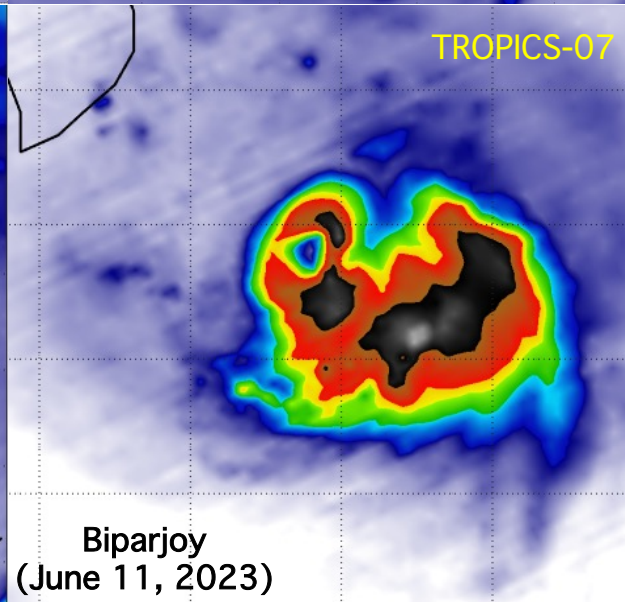
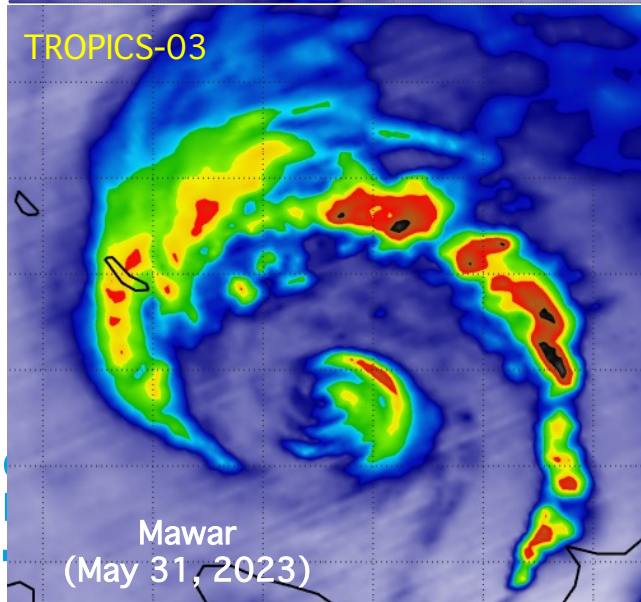
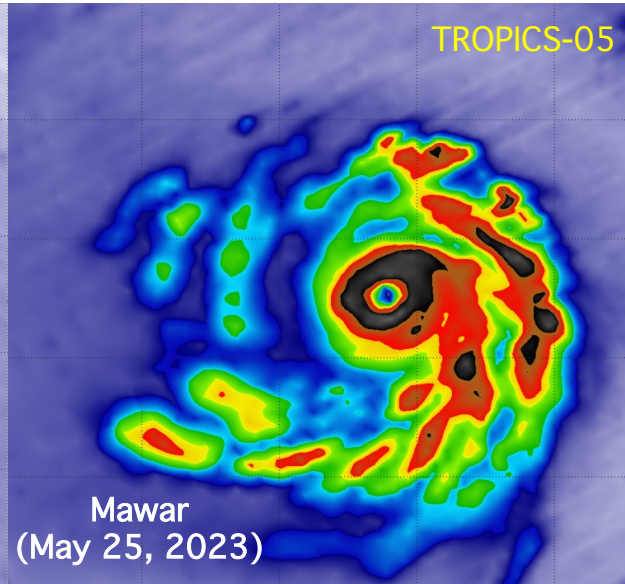
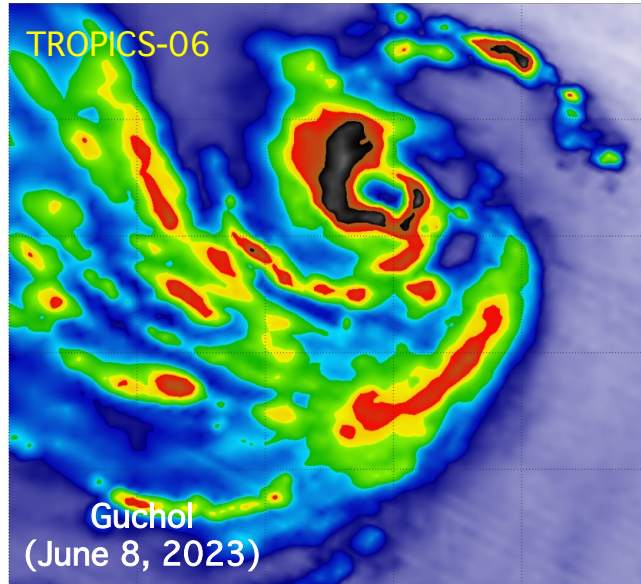


Rocket Lab Electron rocket lifts off Launch Complex 1, in Māhia, New Zealand, at 9a.m. EDT on Sunday, May 7

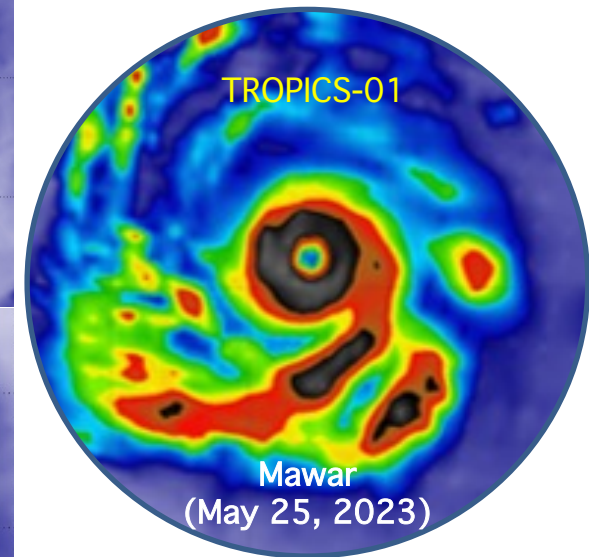


Rocket Lab Electron rocket lifts off Launch Complex 1, in Māhia, New Zealand, at 11:46 p.m. EDT on Thursday, May 25

Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats (TROPICS) (2)

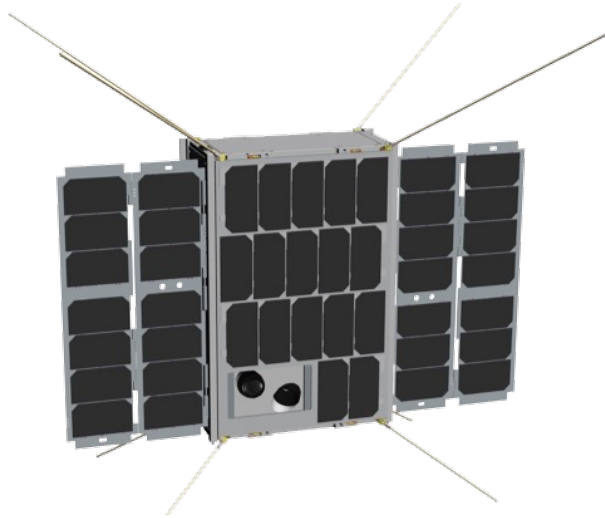


205 GHz band from the
five TROPICS satellites
(MIT Lincoln Labs)



Mission Updates

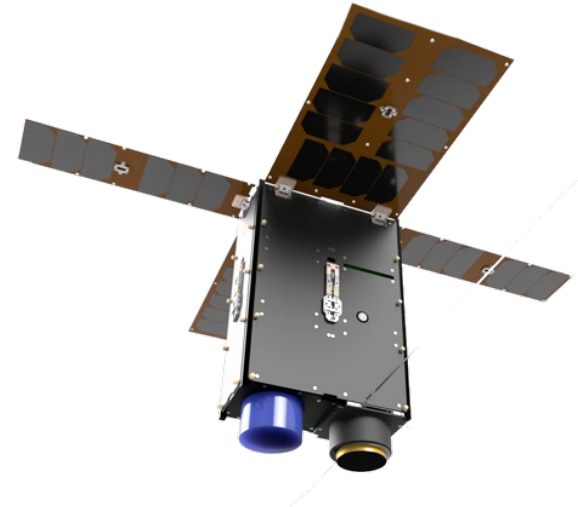
2023-2024 TECHNOLOGY DEMONSTRATION



Signals Of Opportunity P-band Investigation (SNOOPI)

A 6U CubeSat reflectometer capable of using P-band signals of opportunity from geostationary satellites for retrievals of root zone soil moisture (RZSM) and snow water equivalent (SWE).

<https://esto.nasa.gov/invest/snoopi/>

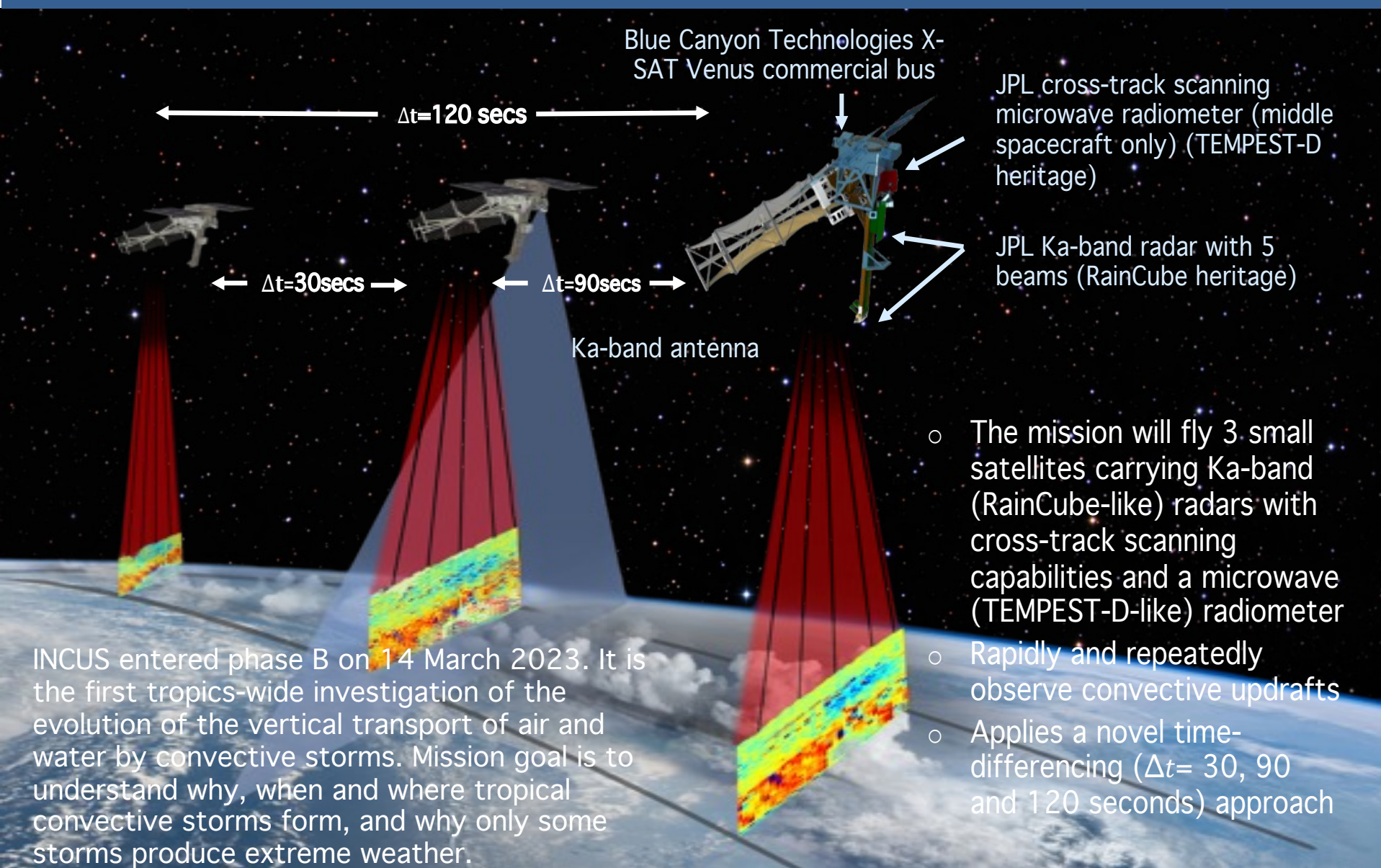


Hyperspectral Thermal Imager (HyTI)

A 6U Thermal Imaging cubesat with 25 channels between 8-10.7 μm , at a ground sampling distance of approximately 60 meters.

<https://esto.nasa.gov/invest/hyti/>

Investigation of Convective Updrafts (INCUS)

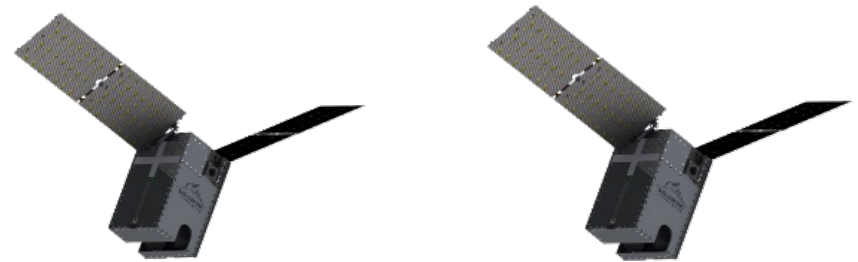


Polarized Submillimeter Ice-cloud Radiometer (PoSIR)

On May 22, 2023, NASA announced the selection of **PoSIR** as the sixth Earth Venture Instrument (EVI-6) investigation aimed at study of ice clouds to determine how and why they change throughout the day, which will provide crucial information about how to accurately simulate these high-altitude clouds in global climate models.

Mission Overview

- The 2-year investigation will comprise of two identical 12 U CubeSats, each with dual-band radiometers: 683-GHz (QV & QH), 325/1.5-GHz (QV), 325/3.5-GHz (QV), 325/9.5-GHz (QV & QH)
- Low earth orbit between 35° and 51° inclination separated by 3-8 hours
- **Cost:** \$37M (FY24) Class-D mission with Launch provided by NASA Launch Services Program outside cost cap
- **Team:** Vanderbilt University, NASA/GSFC, University of Wisconsin, Wisconsin: Blue Canyon Technologies, Virginia Diodes Inc., NOAA, Université Paris-Saclay
- **Expected launch:** Not earlier than 2027



Science Objectives

- Constrain seasonally influenced diurnal cycle of tropical ice water path (IWP) and particle diameter
- Determine the diurnal variability of ice clouds in the convective outflow areas
- Determine the relationship between shortwave and longwave radiative fluxes and the diurnal variability of ice clouds

NASA Response to the 2017 Earth Science Decadal Survey

Earth System Observatory

EARTH SYSTEM OBSERVATORY

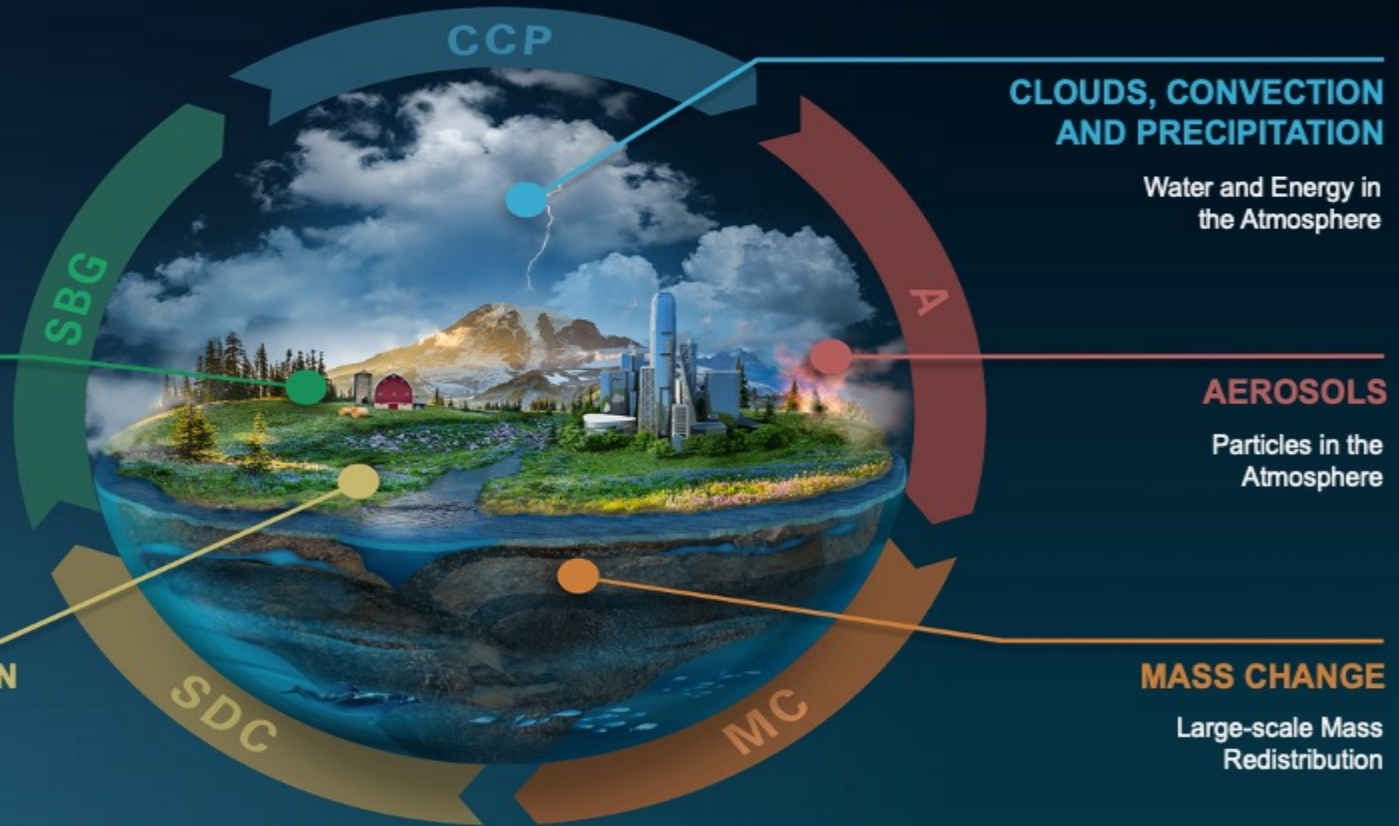
INTERCONNECTED
CORE MISSIONS

SURFACE BIOLOGY AND GEOLOGY

Earth Surface &
Ecosystems

SURFACE DEFORMATION AND CHANGE

Earth Surface Dynamics



NASA Response to the 2017 Earth Science Decadal Survey

Earth System Observatory - Core Missions

- Atmosphere Observing System (AOS-Storm and AOS-Sky), Surface Biology and Geology (SBG) and Mass Change (MC) passed KDP-A and now in Formulation
- SDC will remain in extended study phase to take advantage of NISAR mission lessons learned
- ESO Independent Review Board, July - October 2022
 - IRB report and NASA response posted at:
<https://www.nasa.gov/news/reports/index.html>

AOS

MCR: May 2022
KDP-A: Jan 2023

SBG

MCR: Jun 2022
KDP-A: Nov 2022

MC

MCR: Jun 2022
KDP-A: March 2023

SDC

Remaining in extended
Study Phase

Earth System Explorers (ESE)

- Draft Announcement of Opportunity (AO) released on Dec 6, 2022
- Final AO was released May 2, 2023
- PI-Managed Mission Cost (PIMMC) cap of \$310M (FY24 \$)
- NASA will provide launch vehicle services
- Two-step selection process

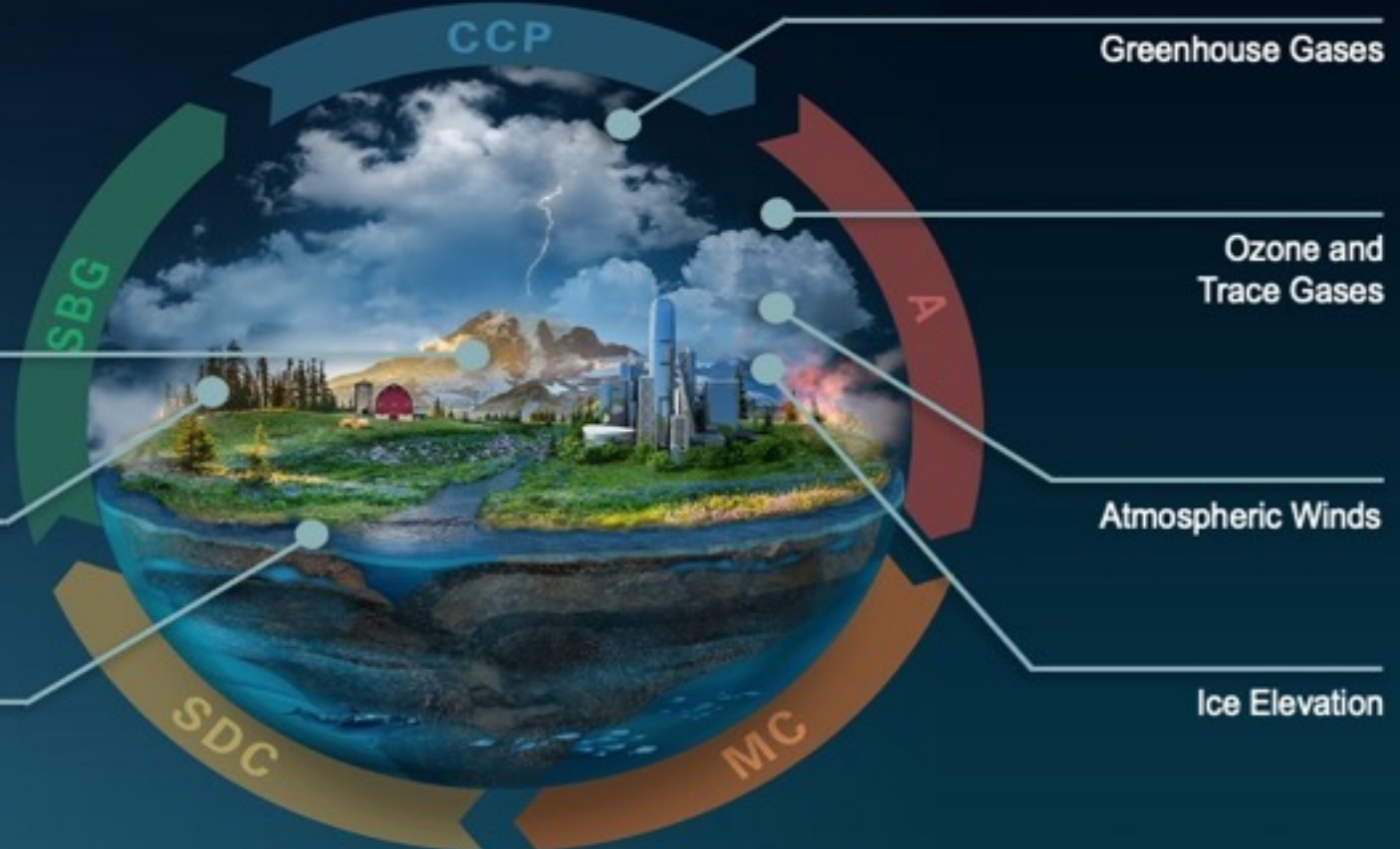
EARTH SYSTEM OBSERVATORY

INNOVATION & COMPETITION
EARTH EXPLORER MISSIONS

Snow Depth and
Water Content

3D Ecosystem
Structure

Ocean Surface
Winds and Currents



NASA Response to the 2017 Earth Science Decadal Survey

Earth System Incubation

- In June 2023, the Planetary Boundary Layer (PBL) and Surface Topography and Vegetation (STV) Incubation Teams met for the first time.
- The teams were established last year to inform program strategy and decisions in pursuit of Decadal Survey Incubation (DSI) program goals, which is to accelerate the readiness of cost-effective flight implementations of PBL and STV targeted observables.
- In April 2022, 35 awards were made under a NASA ROSES solicitation, of which 6 were for Technology tasks; 25 were for Science tasks; 3 were for Observing System Simulation Experiments (OSSE's), and 1 for Incubation Team Co-leadership.
- Information regarding the awarded proposals is available at:
<https://esto.nasa.gov/project-selections-for-dsi-21/>.

Other topics of interest to CGMS members

Senior Review

What is Senior Review?

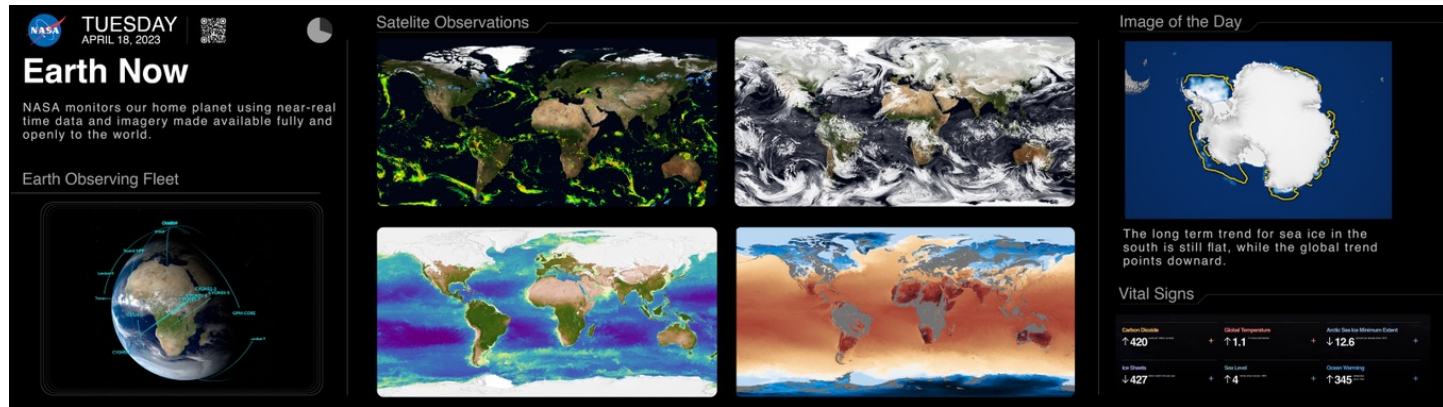
- The process by which Earth Science missions that have completed their prime missions seek to extend their operations.
- At the invitation of ESD, each mission submits a formal proposal that documents the goals of the extension, the health and status of the satellite(s) and instrument(s), and the budget required for an extension.
- ESD establishes several review panels to evaluate the scientific value, technical performance, proposed costs, and broader national interests associated with the proposed extensions.
- The Senior Review is held every three years

Updates

- In December 2022, three Earth Science ISS missions, GEDI, ECOSTRESS, OCO-3, proposed to an out of cycle Senior Review and were granted mission extensions through September 2026, in alignment with the next Senior Review Cycle.
- The 2023 Earth Science Senior Review is currently underway.
 - Twelve missions have been invited to propose for mission extensions: Aqua, Aura, CYGNSS, DSCOVR (EPIC and NISTAR instruments), GPM, GRACE-FO, ICESAT-2, OCO-2, SAGE-III, SMAP, Terra, and TSIS-1.
- After evaluation by the review panels, a final report will be prepared and released by the end of fiscal year 2023.

Earth Information Center

A physical and virtual space to engage and amplify impact – *to show people our Earth as we see it.*



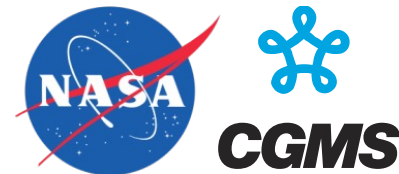
Earth Pulse display showing Near Space Network data collection



Opens to public on
26 June 2023

An immersive installation to allow visitors to go inside the data

**Coordination Group for
Meteorological Satellites**



Greenhouse Gas (GHG) Monitoring & Information Center

Mission: To extend accessible and integrated greenhouse gas (GHG) data and modeling capabilities from U.S. Government and non-public sources for scalable impact

Strategic Goals

1. **Accelerate** GHG monitoring, measurement, reporting and verification decision support, connecting technology, tools, and data.
2. **Foster collaboration** with networks of interagency, intergovernmental and private sector partners to co-develop and increase adoption of impactful applications.
3. **Promote scientific innovation and transparency** by leveraging advanced data systems capabilities and open-source science principles.
4. Develop products needed by users, updated on a regular basis, and enabled by advanced science-based capabilities.
5. **Establish bidirectional knowledge transfer** and engagement with federal, state, local and tribal governments, researchers, and the general public.
6. **Integrate diversity, equity and inclusion** in the Center's research, knowledge transfer, community engagement, management and operations functions.

Use Case 1: Improve access of gridded anthropogenic GHG inventory data to federal, state, local and tribal governments, and the general public.

Use Case 2: Complement EPA's anthropogenic GHG emission data with up-to-date NASA data on natural GHG emissions and fluxes.

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

Commercial Smallsat Data Acquisition (CSDA) program

- In December 2022, NASA Commercial Smallsat Data Acquisition (CSDA) program completed the evaluation of Synthetic Aperture Radar (SAR) data from Airbus U.S. Optical data from Black Sky is currently being evaluated by a team with expertise in optical data. Referred to as On-ramp # 2.
 - NASA ESD augmented funds of 26 existing research projects that can potentially use the data to advance their research and application goals.
 - The summary results of both evaluations will be published in 2023
- On-ramp # 3: CSDA will begin evaluating the quality and usefulness of data from four commercial vendors:
 - Capella Space (<https://www.capellaspace.com/>); ICEYE U.S. (<https://www.iceye.com/en-us/>); GHGSat (<https://www.ghgsat.com/en/>); GeoOptics (<https://geooptics.com/>)
 - Principal Investigators for evaluation were selected under solicitation A.43, ROSES 2022
- A second solicitation - A.44 ROSES 2022 was also released to promote and sustain scientific use of purchased data (Planet Labs, Maxar, Spire, TBE DESIS) by the scientific and applied science communities.
- NASA data buy is unique:
 - End User License Agreements (EULA) currently permit sharing of data with U.S. Government researchers.
 - Global coverage
 - Research Use (i.e., not operational); 30-day latency (default)
 - Large volume (e.g., 12,000+ profiles/day from Spire)

White House declared 2023 as the Year of Open Science



NASA's Transform to Open Science (TOPS) will launch NASA's year of Open Science, and will energize and uplift open science across the scientific community through:



Visibility

Publishing articles, appearing on podcasts, developing targeted communication that expands footprint

Integrating Open Science into themes at large-scale events and conferences



Capacity Sharing

Producing online, free, Open Science curriculum on Open edX

Hosting workshops, events, cohorts, science team meetings, hackathons

Constructing multiple pathways to Open Science Badge



Incentives

Developing Open Science

Badge/Certification
Sponsoring high profile prizes and challenges

Establishing high profile awards in support of open science research



Moving Towards Openness

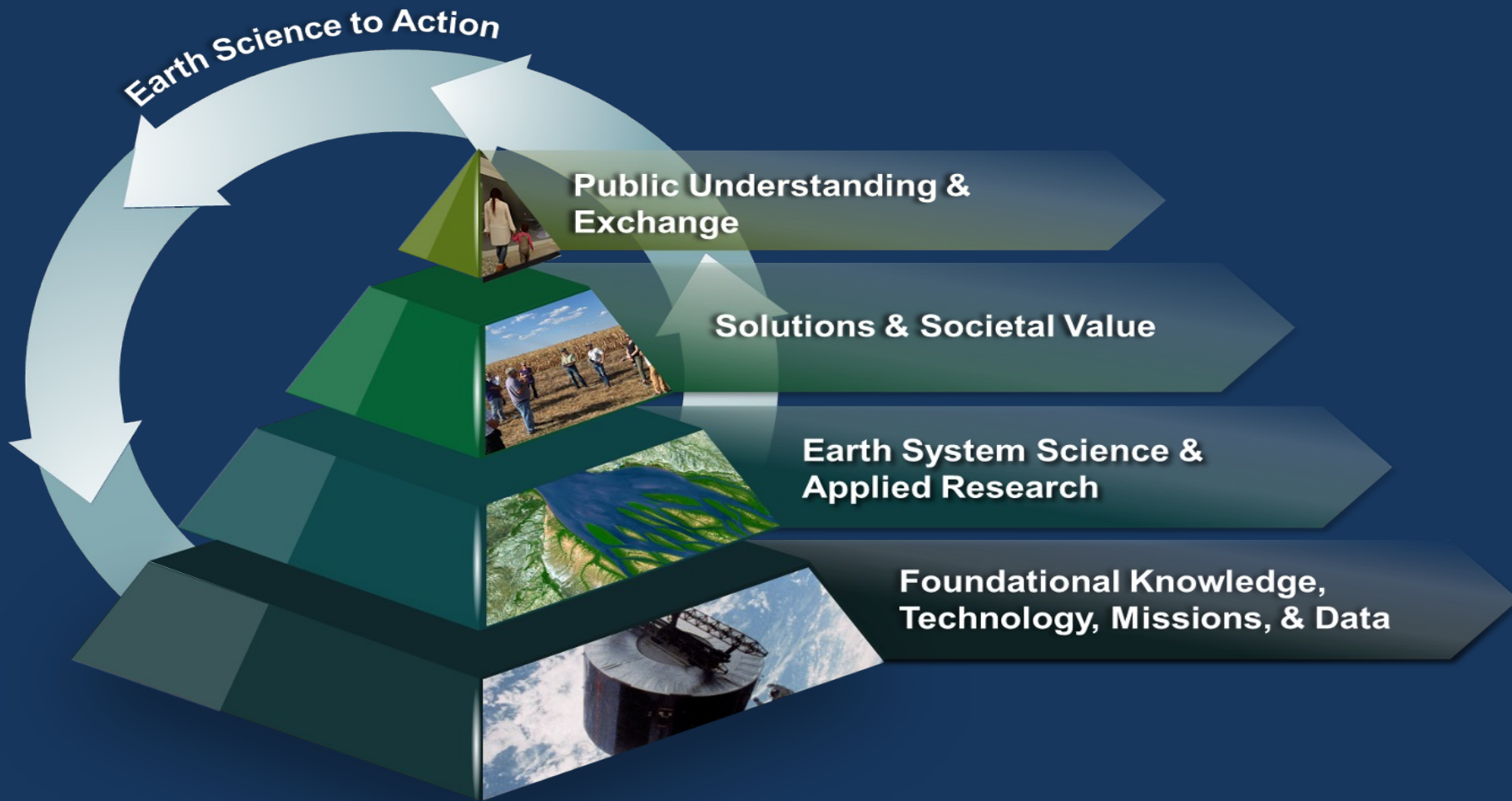
Recognizing open science practices

Holding open meetings

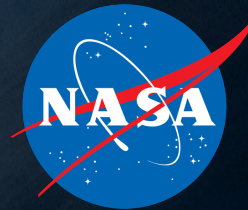
Sharing hidden knowledge

Inclusive collaboration

Earth Science to Action Strategy



Thank you



NASA EARTH
Your Home. Our Mission.

Back up