

NASA Missions Program Overview

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Technology Validation Program Manager
Earth Science Technology Office, NASA

September 6, 2022

September 5-7,2022
Berlin, Germany

Earth Science Strategic Objectives

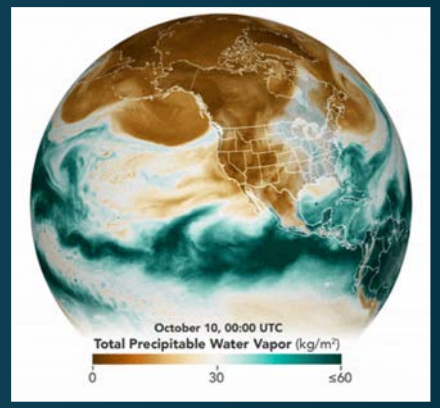


Advancing Earth System Science

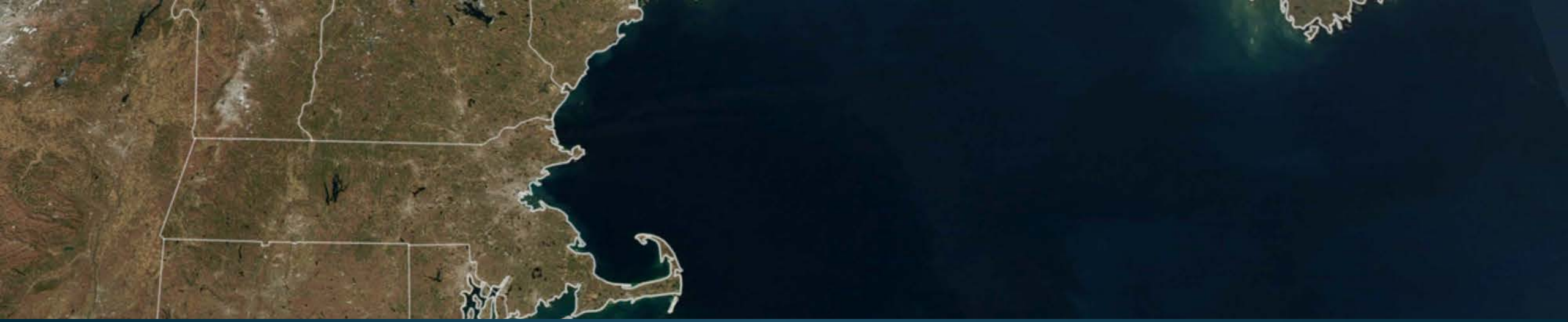
- End-to-end capability, from launch to science to applications, delivering actionable science to decisionmakers at every level

Strategic Objectives

- Delivering on Our Commitments
- Robust Research and Applications Opportunities
- Developing Next-Gen Capabilities
- Building Bridges through Open-Source Science
- Power of Partnerships

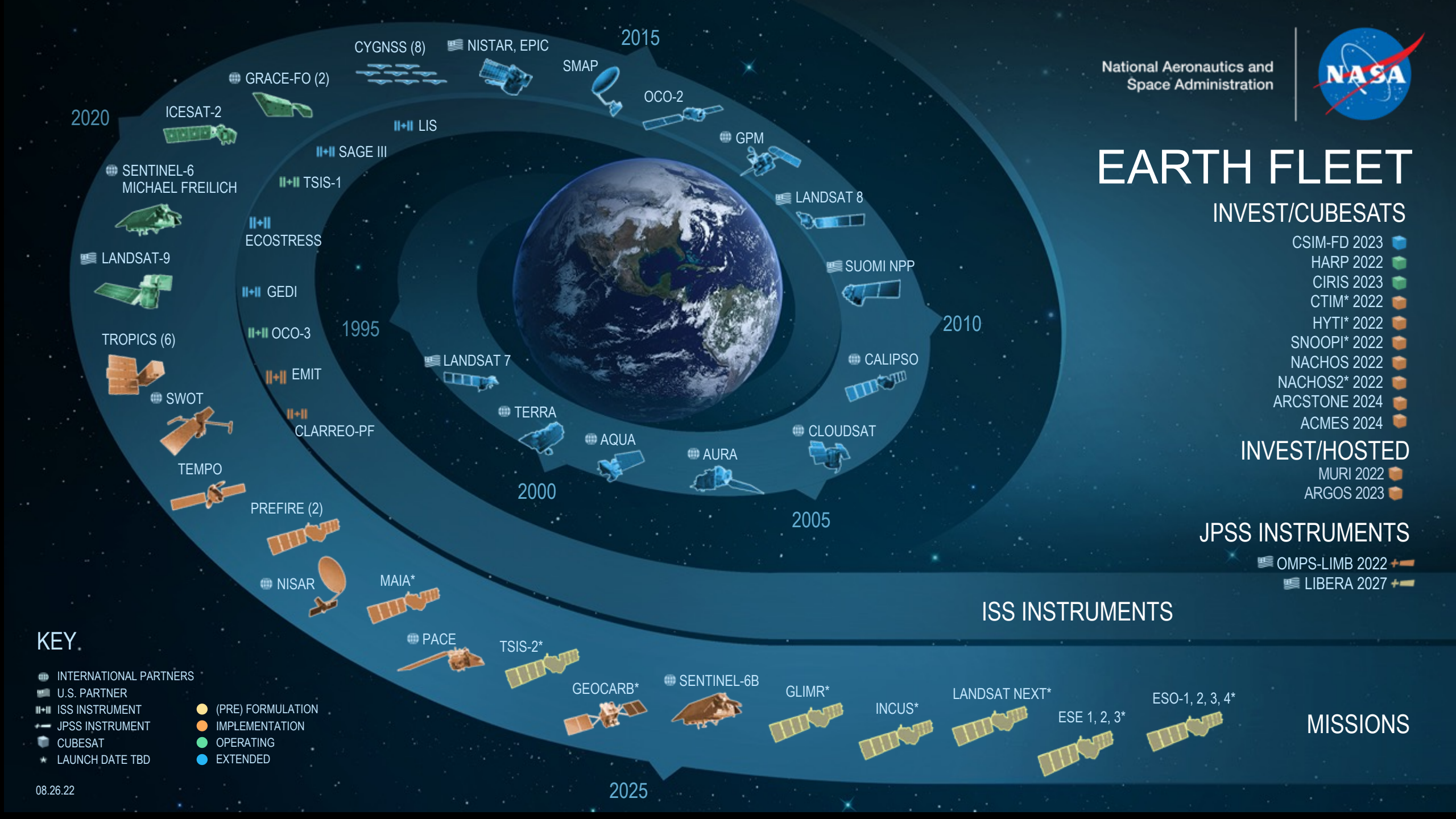




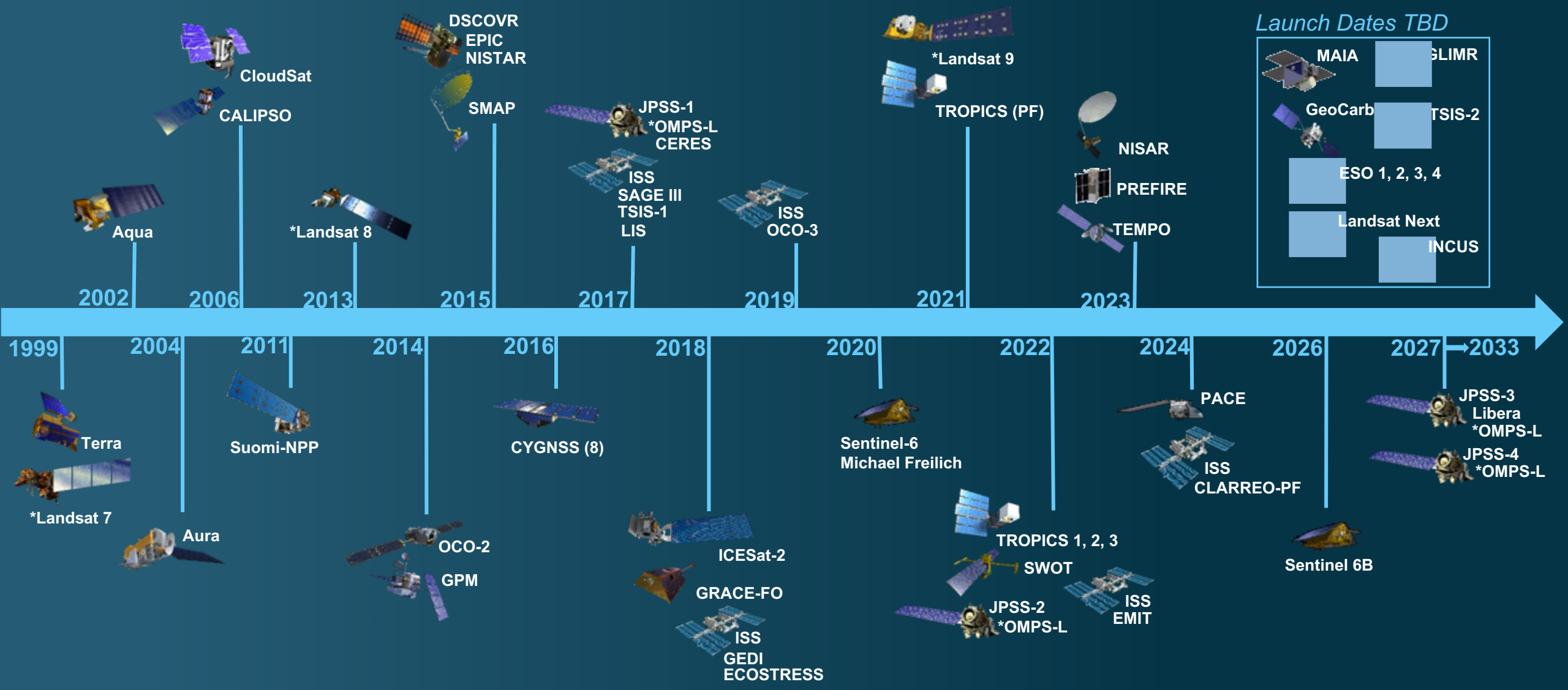


DELIVERING ON OUR COMMITMENTS: Advancing Earth Science Program of Record




National Aeronautics and Space Administration
NASA
EARTH FLEET
INVEST/CUBESATS
CSIM-FD 2023
HARP 2022
CIRIS 2023
CTIM* 2022
HYTI* 2022
SNOOPI* 2022
NACHOS 2022
NACHOS2* 2022
ARCSTONE 2024
ACMES 2024
INVEST/HOSTED
MURI 2022
ARGOS 2023
JPSS INSTRUMENTS
OMPS-LIMB 2022
LIBERA 2027
ISS INSTRUMENTS
MISSIONS
2020
2015
2010
2005
2000
1995
2025
ICESAT-2
GRACE-FO (2)
CYGNSS (8)
NISTAR, EPIC
SMAP
OCO-2
GPM
LANDSAT 8
SUOMI NPP
CALIPSO
CLOUDSAT
AURA
AQUA
TERRA
LANDSAT 7
SENTINEL-6 MICHAEL FREILICH
LANDSAT-9
TROPICS (6)
SWOT
TEMPO
PREFIRE (2)
NISAR
MAIA*
PACE
TSIS-2*
GEOCARB*
SENTINEL-6B
GLIMR*
INCUS*
LANDSAT NEXT*
ESE 1, 2, 3*
ESO-1, 2, 3, 4*
LIS
SAGE III
TSIS-1
ECOSTRESS
GEDI
OCO-3
EMIT
CLARREO-PF
KEY
INTERNATIONAL PARTNERS
U.S. PARTNER
ISS INSTRUMENT
JPSS INSTRUMENT
CUBESAT
LAUNCH DATE TBD
(PRE) FORMULATION
IMPLEMENTATION
OPERATING
EXTENDED
08.26.22

Timeline of Current and Future Earth Science Missions



01.31.22

*Operations not funded by ESD

2022 SCIENCE LAUNCHES & MILESTONES

BIO EXP-1
ARTEMIS 1

LUNAH-MAP
ARTEMIS 1


ARTEMIS 1


PEREGRINE-1


FIRST LIGHT

SOFIE
SPX-25


JPSS-2


EARTH FLYBY


IMPACT


EMIT


GUSTO


GOES-T


TROPICS (3)


1ST NOVA-C


PSYCHE


EUCLID


2ND NOVA-C


JANUS


MOMA-MS

LAUNCH
DELIVERY
MILESTONE

2023 SCIENCE LAUNCHES & MILESTONES


XRISM

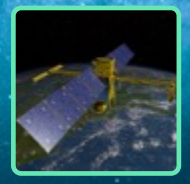

TEMPO

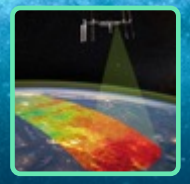

SAMPLE RETURN


VENUS FLYBY


BLUE GHOST


VIPER


SWOT


AWE


NISAR

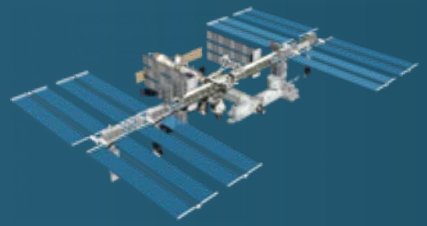

XL-1


RECORD PERIHELION

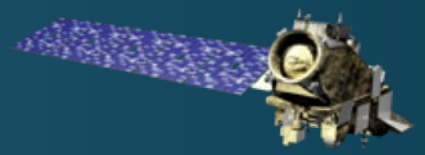

PREFIRE

- LAUNCH
- DELIVERY
- MILESTONE

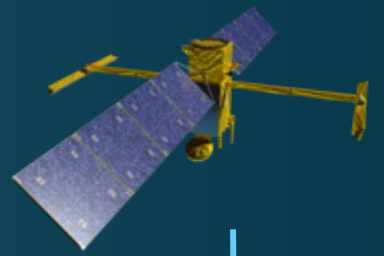
Earth Science Launch Timeline



EMIT (ISS)



OMPS-Limb
(JPSS-2/NOAA)



SWOT



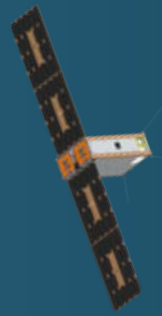
TEMPO

2022

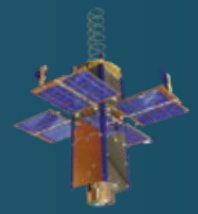
2023

May June July September October November December

CTIM-FD



NACHOS-1 & 2



MURI
(hosted)



HyTI



SNOOPI



08.17.22

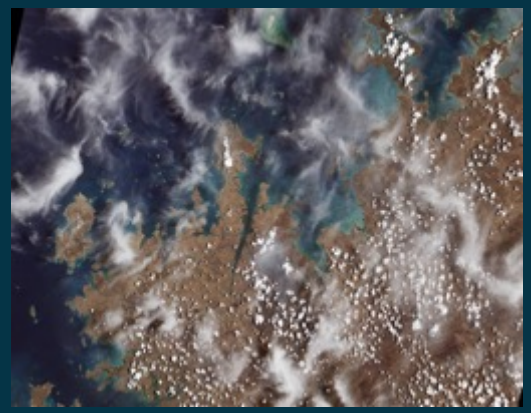


Landsat 9 Data Released

- First-light images captured Oct. 31
- Began releasing data to public in mid-February
- Instrument handover to USGS completed in February; spacecraft handover expected in late May



First light image, Australian Coast



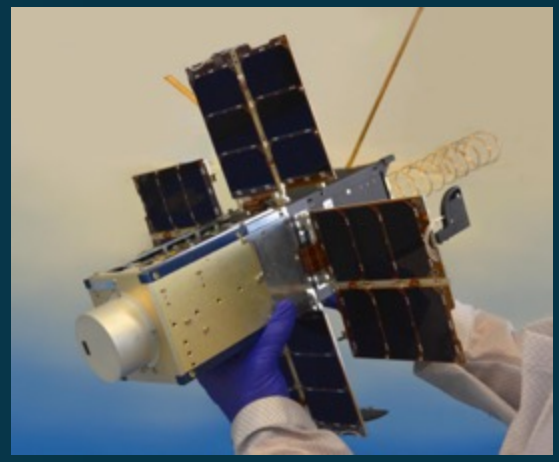
Other Recent Launches

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 & 2

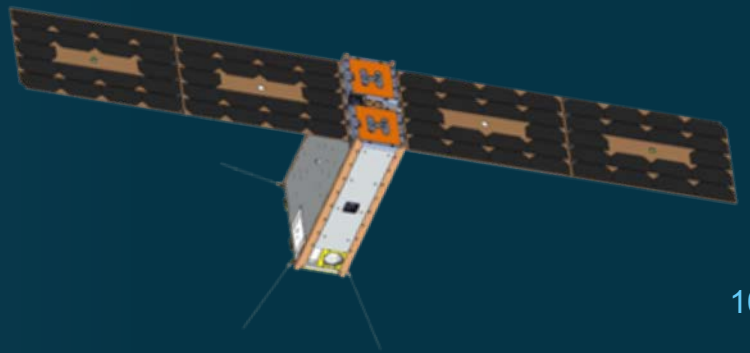
- **NACHOS-1** Launched Feb. 19, 2022; deployment from ISS on June 29, 2022. **NACHOS-2** Launched July 2, 2022
- 3U-sized, ultra-compact, high-resolution hyperspectral imager for measuring atmospheric trace gases (NO_2, SO_2, O_3, CH_2O, and more)



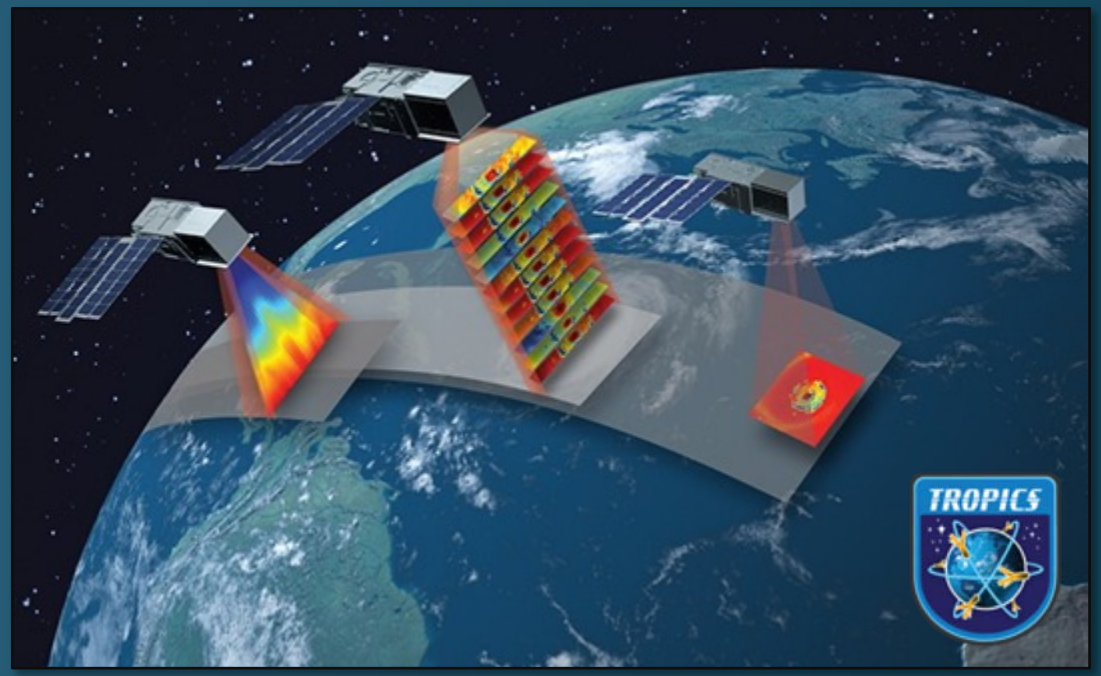
NACHOS-1 (Credit: Los Alamos National Laboratory

CTIM

- Launched July 2, 2022 on Virgin Orbit STP-28A
- 6U-sized, ultra-compact, will demonstrate carbon nanotube-based bolometers that dramatically reduce size and weight and enable the measurement of total solar irradiance



Upcoming Launches



TROPICS Constellation

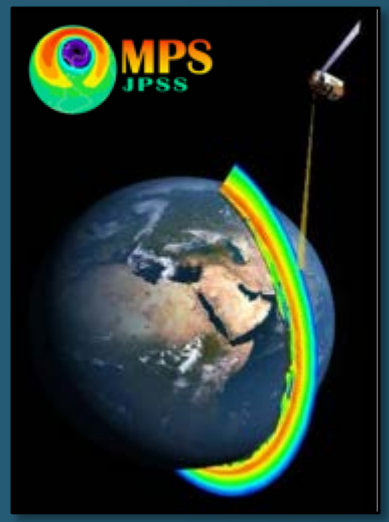
Each launch will carry two CubeSats to three orbital planes (6 total) to study tropical cyclones

EMIT on the ISS

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



Upcoming Launches



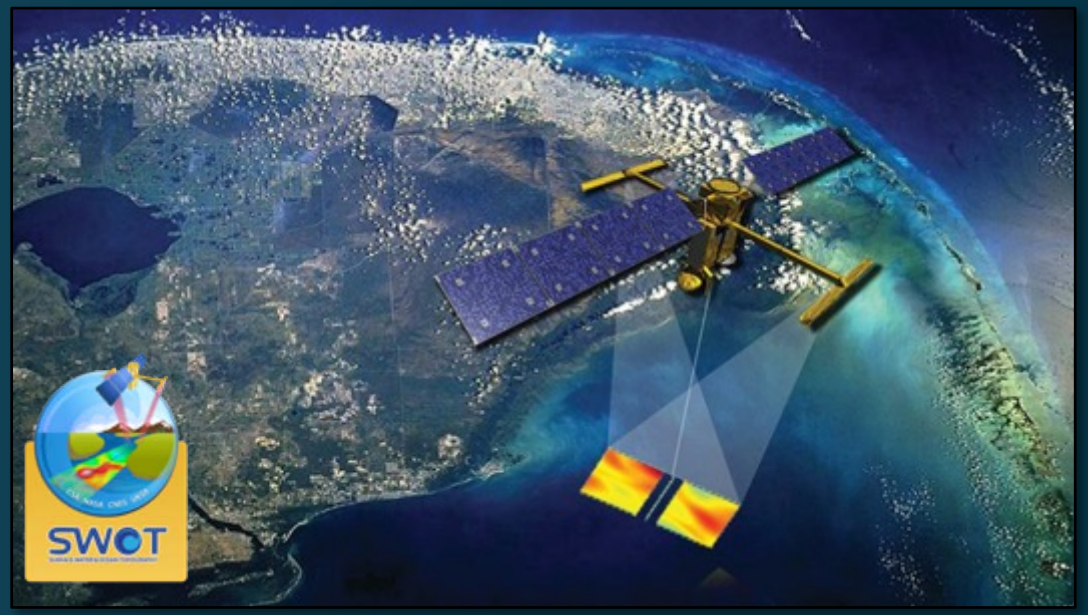
OMPS-Limb on JPSS-2

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



TEMPO

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



SWOT

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

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

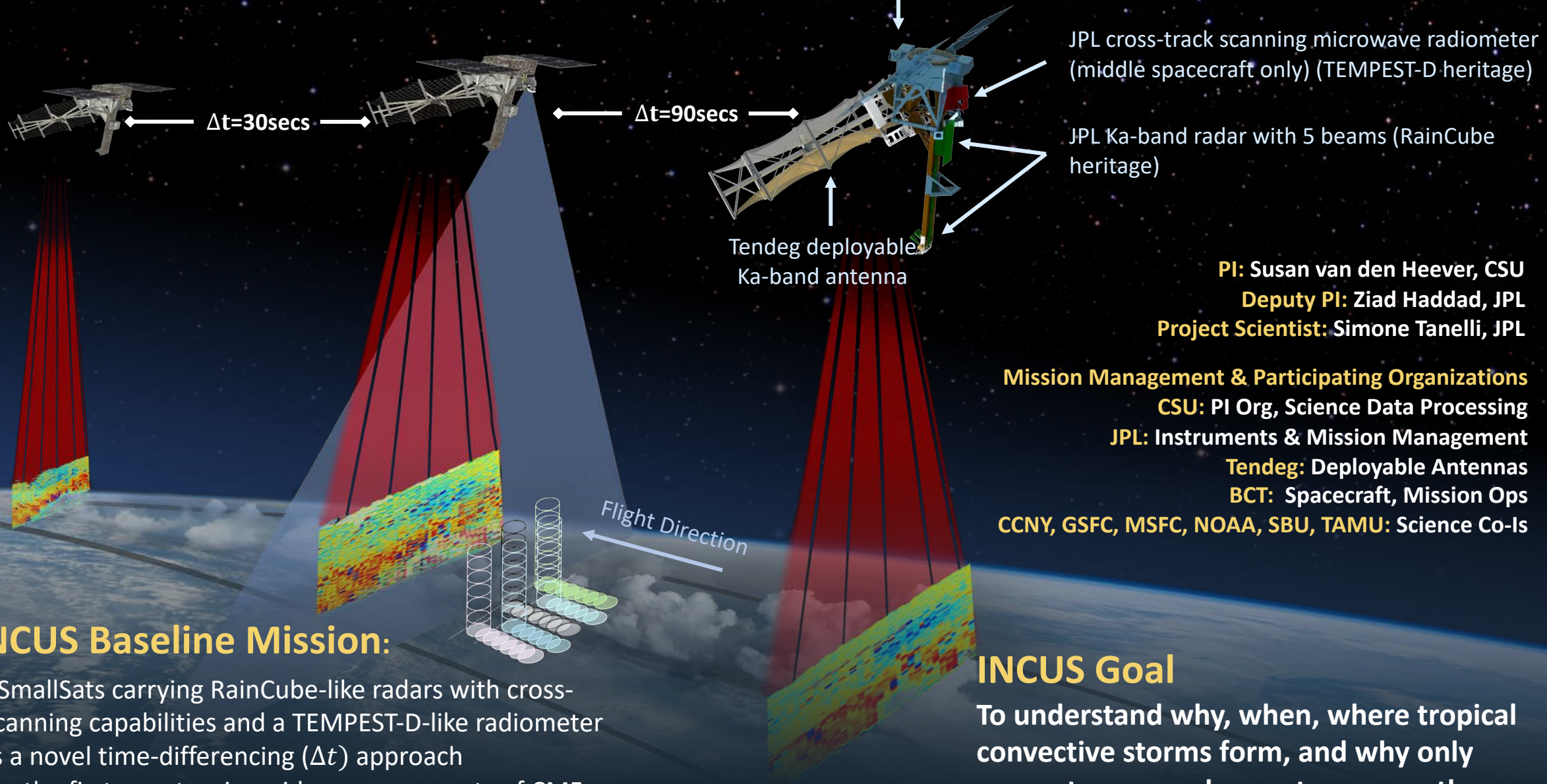
Addressing why convective storms, heavy precipitation, and clouds occur exactly when and where they do

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

INCUS Investigation of Convective Updrafts



PI: Susan van den Heever, CSU
Deputy PI: Ziad Haddad, JPL
Project Scientist: Simone Tanelli, JPL

Mission Management & Participating Organizations
CSU: PI Org, Science Data Processing
JPL: Instruments & Mission Management
Tendeg: Deployable Antennas
BCT: Spacecraft, Mission Ops
CCNY, GSFC, MSFC, NOAA, SBU, TAMU: Science Co-Is

The INCUS Baseline Mission:

- Flies 3 SmallSats carrying RainCube-like radars with cross-track scanning capabilities and a TEMPEST-D-like radiometer
- Applies a novel time-differencing (Δt) approach
- Provides the first ever tropics-wide measurements of CMF

INCUS Goal

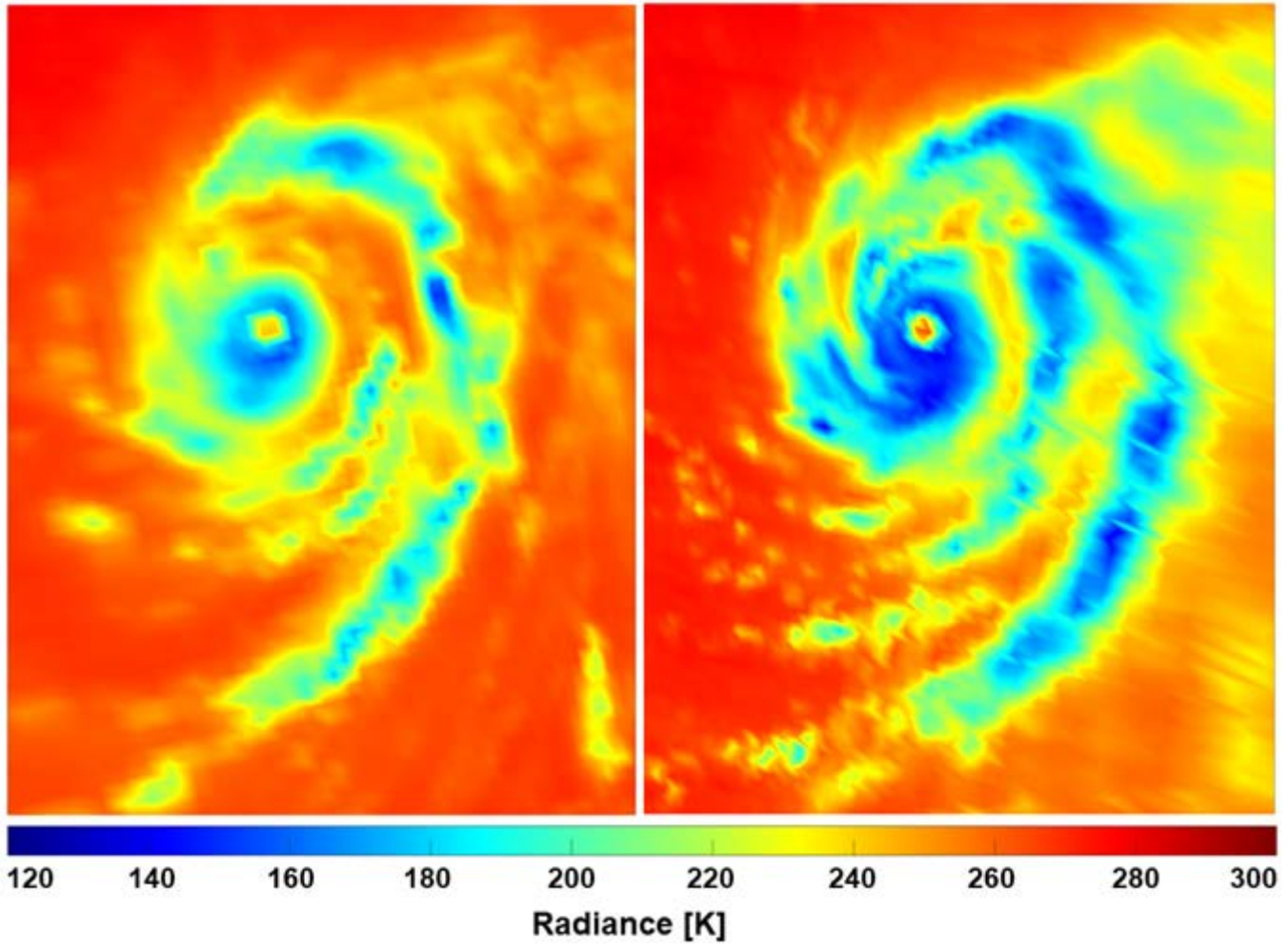
To understand why, when, where tropical convective storms form, and why only some storms produce extreme weather.

TROPICS is Lighting a Path to Future Observing Systems

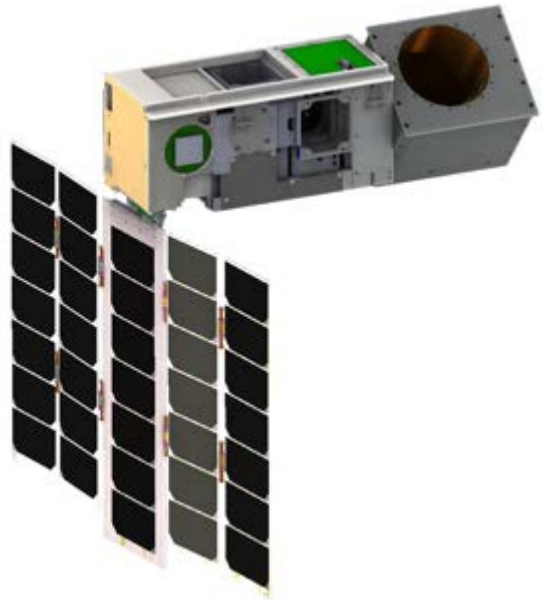
Super Typhoon Mindulle (Sep 26, 2021)

NOAA SNPP Satellite
>2000 kg





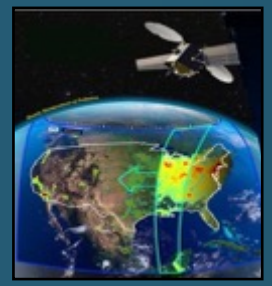
TROPICS Pathfinder Satellite
5.4 kg



EVI-6 Announcement of Opportunity (AO)

- Draft AO released Oct. 27, 2021
- Final AO expected to be released in Spring 2022
- Selection anticipated in early 2023

- PI-Managed Mission Cost Cap of $37M (FY24)
- NASA will determine platform and launch vehicle
- Solicits Class D instruments and CubeSats



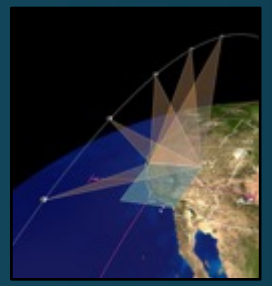
EVI-1
TEMPO



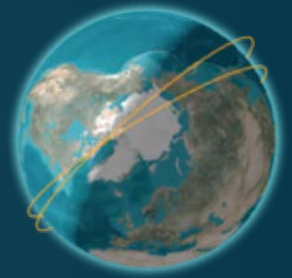
EVI-2
GEDI &
ECOSTRESS



EVI-3
TROPICS



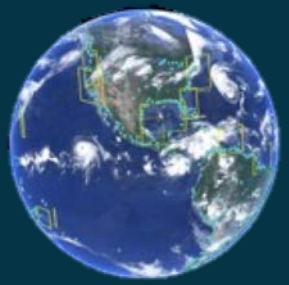
EVI-3
MAIA



EVI-4
PREFIRE



EVI-4
EMIT



EVI-5
GLIMR

EVI-6
TBD





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

Ocean Surface Winds and Currents

3D Ecosystem Structure

Snow Depth and Water Content

ESO Updates

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

ACCP, MC and SBG continue in Pre-Phase A

- Conducting instrument RFIs (Requests for Information) and Mission Design Labs
- Meeting with international partners
- Planning underway for ESO-leve IRB
- Preparing for ESO Pre-ASM (Acquisition Strategy Meeting) in April 2022

Mission Concept Reviews

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

Earth System Explorers (ESE) *NEW*

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

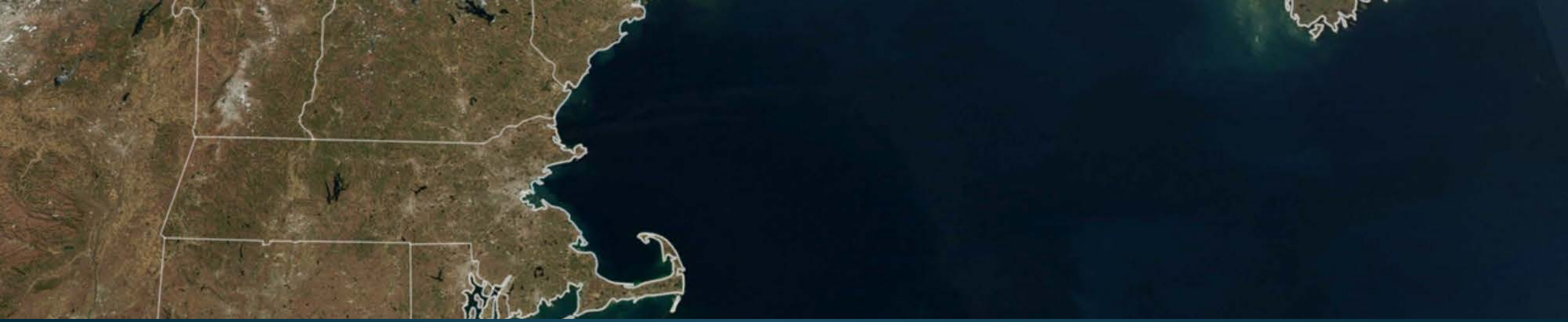
Step 1 Selection

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

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Step 2 Selection

- Up to 2 Missions
- Staggered phasing and funding

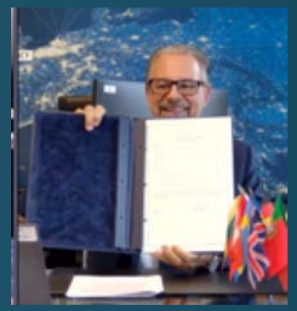


POWER OF PARTNERSHIP



NASA Pursues Strategic International Collaboration

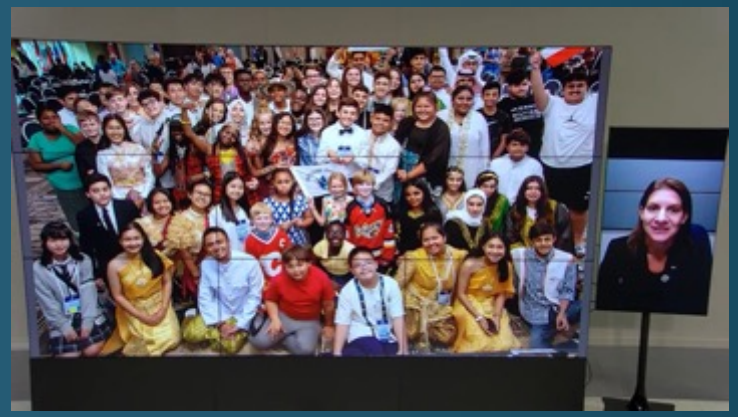




Screen grabs show NASA Administrator Nelson (L) and ESA Director General Aschbacher following the signing.

NASA, ESA partner to address global climate change

- Joint statement of intent signed July 13, 2021
- First of its kind strategic partnership



NASA program scientist Allison Leidner gives a virtual presentation about the GLOBE Program during COP26.

COP26: NASA integral to U.S. public diplomacy effort

- NASA leadership, scientists participated virtually and in-person Oct. 31-Nov. 12, 2021
- Hyperwall was the main attraction at the U.S. Center

CEOS
Committee on
Earth Observation Satellites

CEOS 2021: Theme of "Space-Based Earth Observation Data for Open Science and Decision Support" during NASA's year as chair

2022 Commodity Classic



Virtual Exhibit

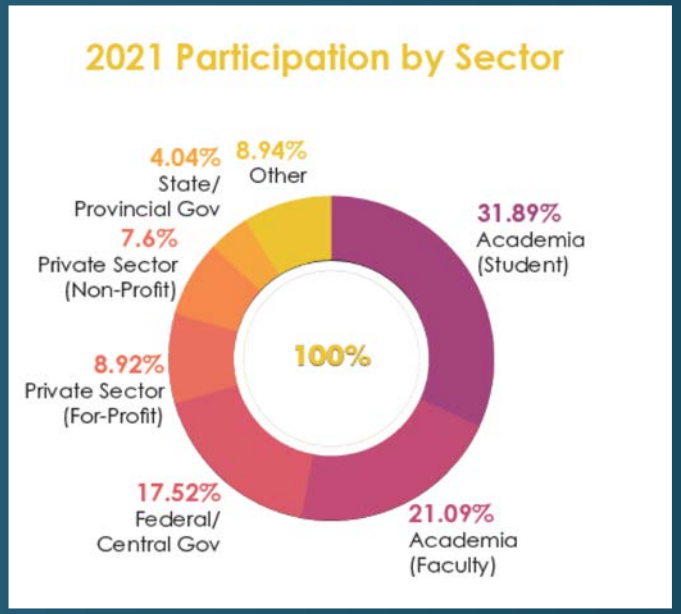


NASA Team Onsite

ARSET: Applied Remote Sensing Training

2021 Statistics:

- 14 Virtual trainings
- 27,182 Participants
- 166 Countries, 50 U.S. States
- 98% of participants say their knowledge improved



2022 Trainings: January-May









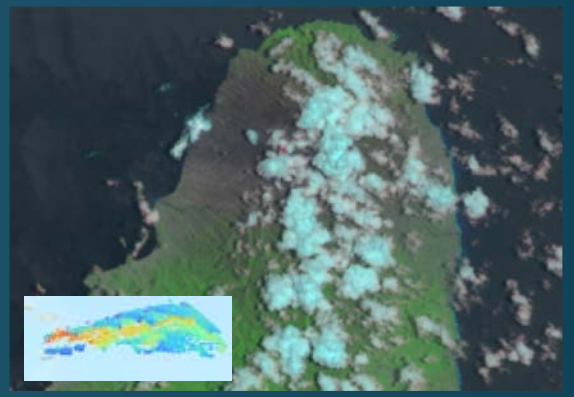


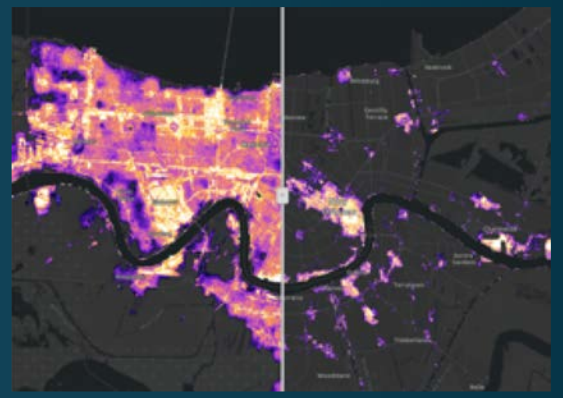
Disasters: Response Support

Major Disaster Events Supported in 2021

- Tropical Cyclones: 9; Volcanoes: 9; Flooding: 8; Fires: 5
- 12 other events including: earthquakes, landslides, severe weather, oil spills, tsunamis, severe weather
- CY2021: 43 Total Activations (12 domestic; 31 international)

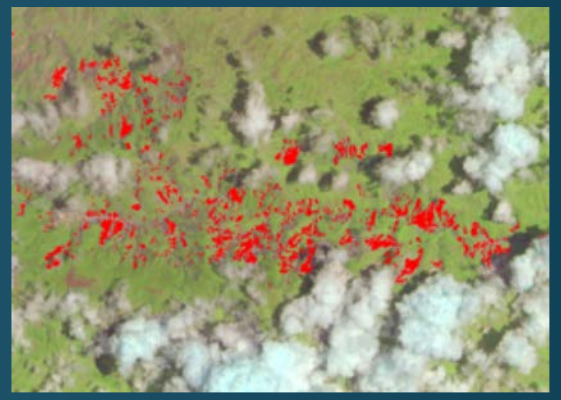
April: TIER 2
La Soufriere eruption, Saint Vincent
Damage proxy maps, OMPS, MISR, Imagery





August : TIER 2
Hurricane Ida
Damage proxy maps, Black Marble NRT&HD, UAVSAR, Water Extents

August: TIER 2
Haiti Earthquake
Damage proxy maps, ASTER Imagery, Landslides, Surface Dsp.





December: TIER 2
Tornado Outbreak
Damage proxy maps; use of Sentinel-2, Planet

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




NASA
NASA EARTH
Your Home. Our Mission.