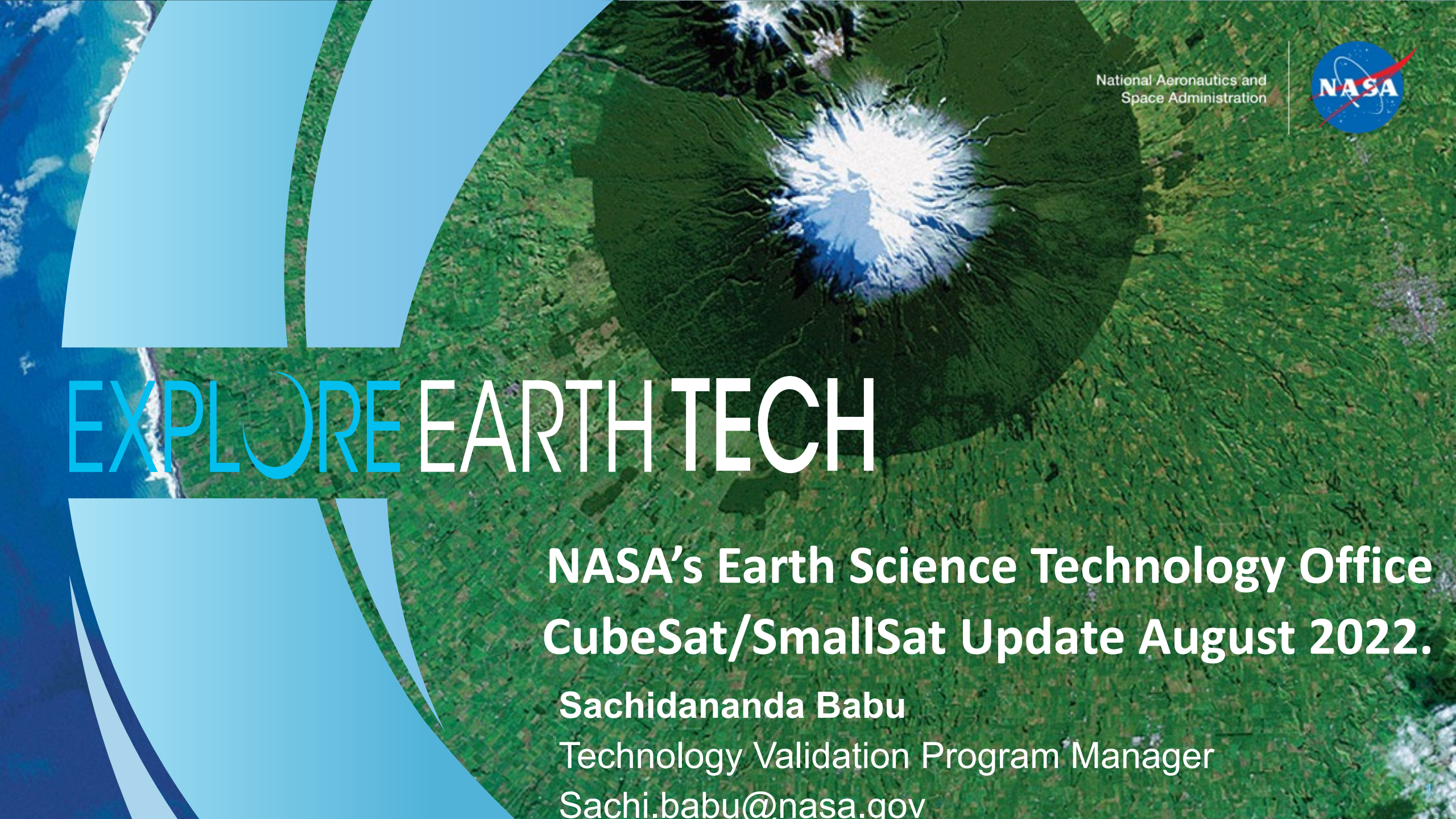
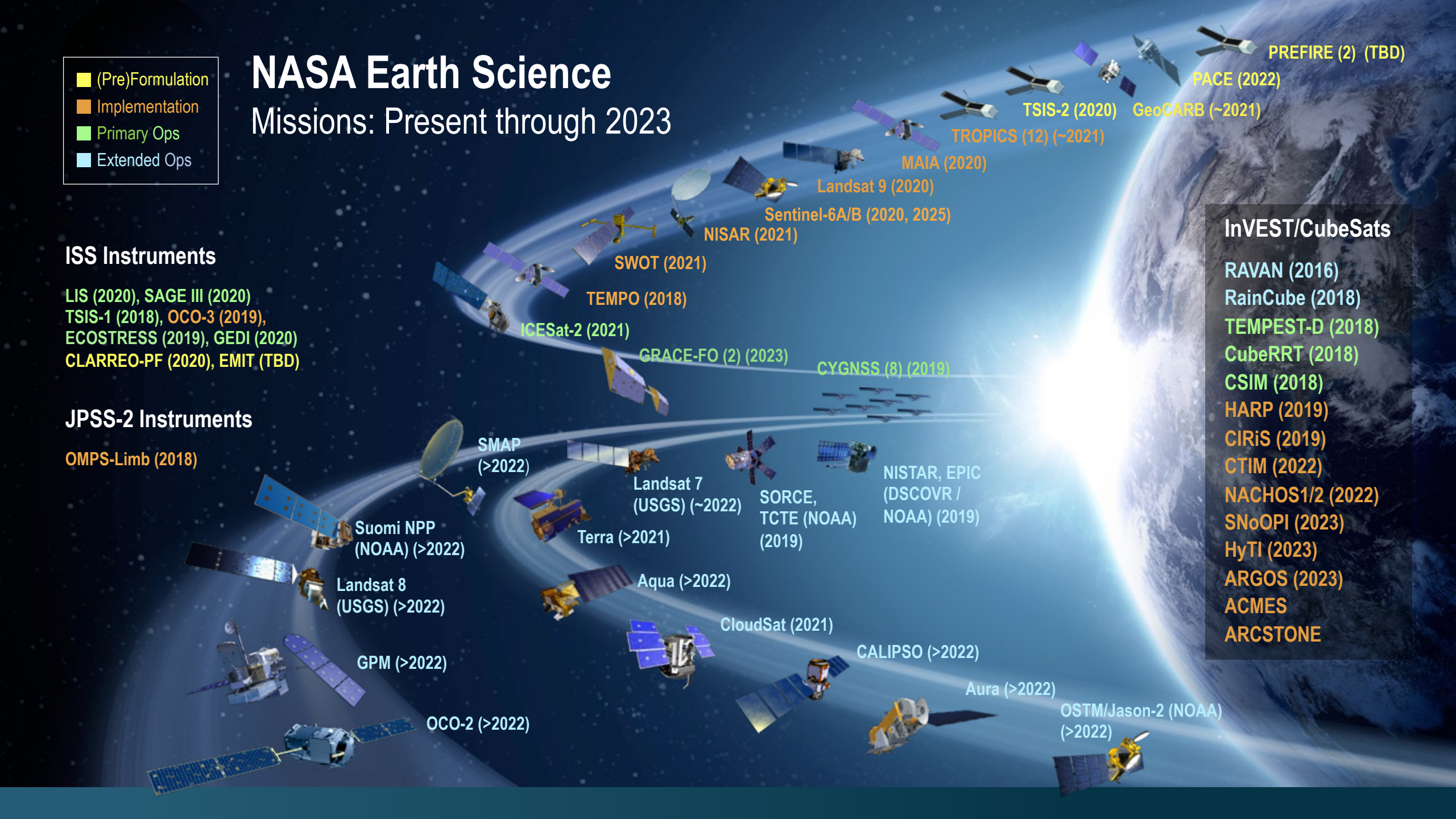


NASA's Earth Science Technology Office CubeSat/SmallSat Update August 2022.

Sachidananda Babu
Technology Validation Program Manager
Sachi.babu@nasa.gov


(Pre)Formulation
Implementation
Primary Ops
Extended Ops
NASA Earth Science
Missions: Present through 2023
ISS Instruments
LIS (2020), SAGE III (2020)
TSIS-1 (2018), OCO-3 (2019),
ECOSTRESS (2019), GEDI (2020)
CLARREO-PF (2020), EMIT (TBD)
JPSS-2 Instruments
OMPS-Limb (2018)
PREFIRE (2) (TBD)
PACE (2022)
TSIS-2 (2020)
GeoCARB (~2021)
TROPICS (12) (~2021)
MAIA (2020)
Landsat 9 (2020)
Sentinel-6A/B (2020, 2025)
NISAR (2021)
SWOT (2021)
TEMPO (2018)
ICESat-2 (2021)
GRACE-FO (2) (2023)
CYGNSS (8) (2019)
SMAP
(>2022)
Landsat 7
(USGS) (~2022)
SORCE,
TCTE (NOAA)
(2019)
NISTAR, EPIC
(DSCOVR /
NOAA) (2019)
Suomi NPP
(NOAA) (>2022)
Terra (>2021)
Landsat 8
(USGS) (>2022)
Aqua (>2022)
CloudSat (2021)
GPM (>2022)
CALIPSO (>2022)
Aura (>2022)
OCO-2 (>2022)
OSTM/Jason-2 (NOAA)
(>2022)
InVEST/CubeSats
RAVAN (2016)
RainCube (2018)
TEMPEST-D (2018)
CubeRRT (2018)
CSIM (2018)
HARP (2019)
CIRiS (2019)
CTIM (2022)
NACHOS1/2 (2022)
SNoOPI (2023)
HyTI (2023)
ARGOS (2023)
ACMES
ARCSTONE

Earth Science Division: SmallSat Missions & Investment, 2010-2021

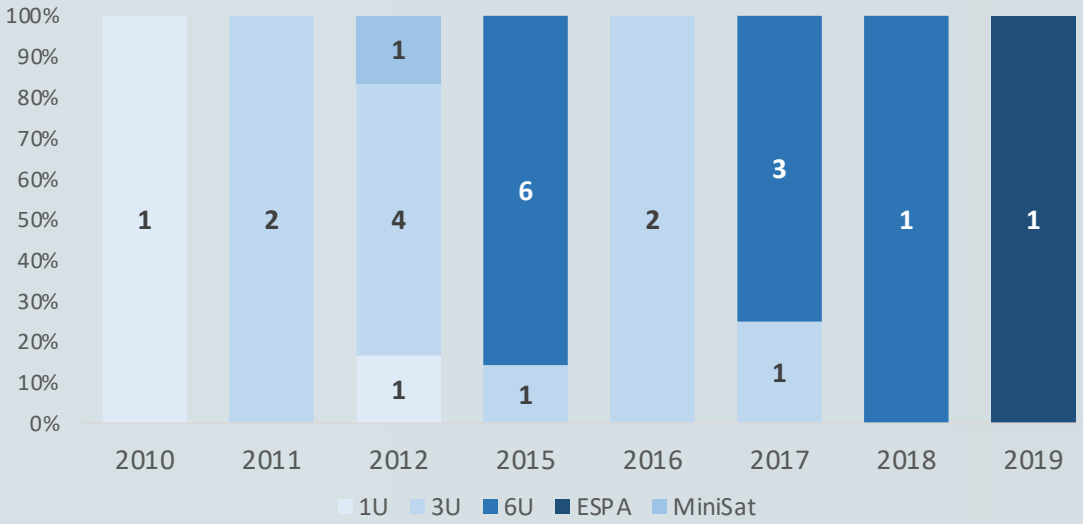
EXPLORE EARTH TECH

25 TOTAL MISSIONS *Over 11 Years*

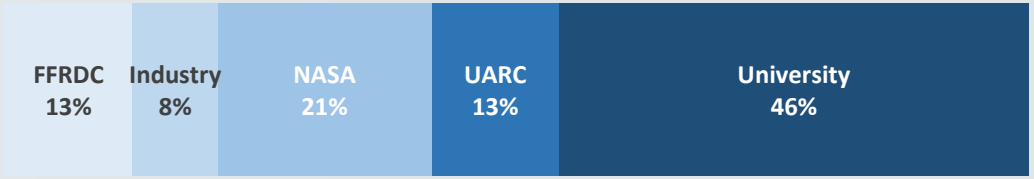
- **8** COMPLETED
- **9** IN IMPLEMENTATION
- **5** OPERATION
- **3** CANCELLED/FAILED

$442M TOTAL INVESTMENT *Over 11 Years*

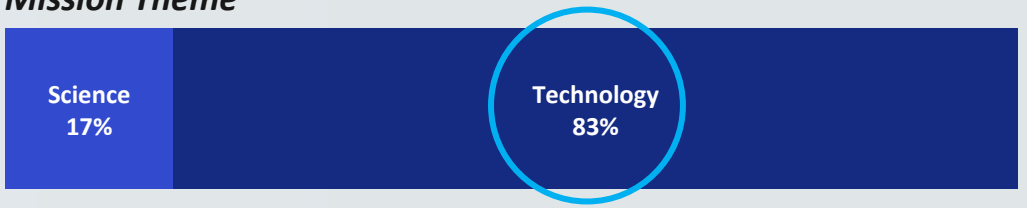
Earth Science Missions: *Trended Mission Size*



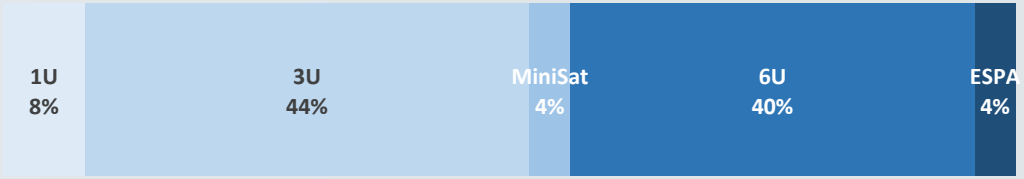
Sponsoring Organization



Mission Theme



Spacecraft Size



Constellations

Hosted payloads are not included in data shown.

Constellations include two or more spacecraft.

* Data as of April 2021

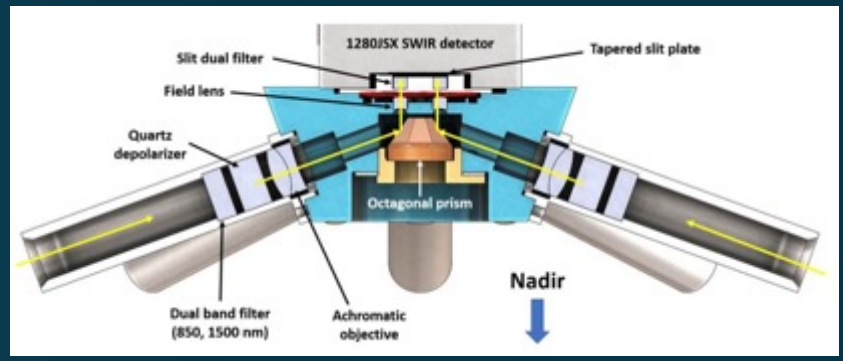
Three New Projects Selected Under InVEST-20

In late June 2021, three new projects were selected, from a total of 13 proposals, under the In-Space Validation of Earth Science Technologies (InVEST) program. The solicitation targeted small instruments and instrument subsystems that can advance technology to enable relevant Earth science measurements. Total funding for these investigations is approximately $16.6 million:

The Aerosol Radiometer for Global Observation of the Stratosphere (ARGOS) Instrument

PI: Matthew DeLand, Science Systems And Applications, Inc., in partnership with GSFC and Loft Orbital

Stratospheric aerosols impact Earth's energy budget through their direct radiative effects. ARGOS instrument will collect limb scattering data of atmospheric aerosols at several wavelengths in multiple viewing directions simultaneously. Such dense sampling could reduce the uncertainty in climate model calculations of post-volcanic eruption global aerosol loading by a factor of 2-3. ARGOS can be considered as a next generation OMPS limb profiler. This is the InVEST program's first hosted payload (via Loft Orbital), the instrument and measurement concept leverages GSFC's IRAD Program and ESTO's Instrument Incubator Program, IIP.



ARCSTONE: Calibration of Lunar Spectral Reflectance from Space

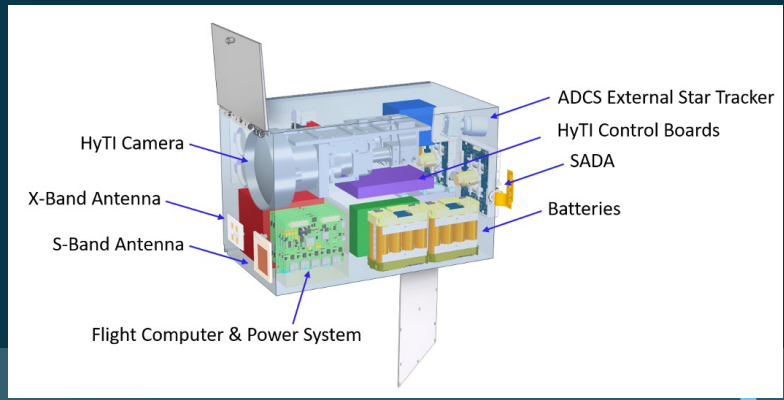
Constantine Lukashin, NASA Langley Research Center

Calibration accuracy and long-term stability are the primary on-orbit performance metrics for all Earth observing sensors. ARCSTONE, a hyperspectral instrument spanning the VSWIR spectral range that was designed to be integrated into a 6U CubeSat in low Earth orbit (LEO), will provide lunar spectral reflectance measurements with a target accuracy < 0.5% (k=1), sufficient to establish an absolute, on-orbit lunar calibration standard for current and future Earth observing sensors. This project is a transition from ESTO's Instrument Incubator Program, IIP and STMD's SBIR Program.

Active Cooling for Multi-spectral Earth Sensors (ACMES)

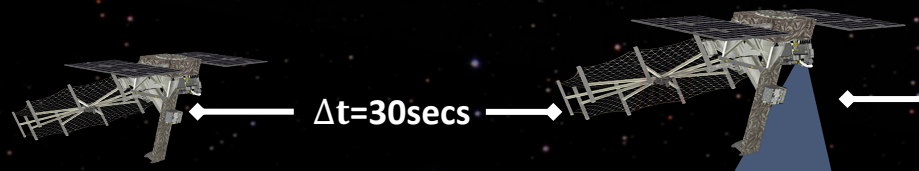
Charles Swenson, Utah State University

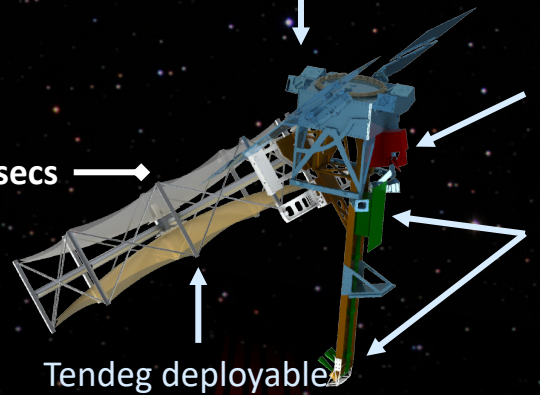
The 6U ACMES CubeSat will demonstrate two technologies: an active architecture for thermal control of instruments on small satellites, which aims to reduce radiator size by 70% for a given application; and a filter incidence narrow-band infrared spectrometer for the detection of methane sources, which will utilize differential absorption to achieve sensitivity equivalent to larger missions, but with a much finer spatial resolution and in a compact form factor. The active thermal architecture in this project is a transition from STMD's Small Spacecraft technology Program, SSTP

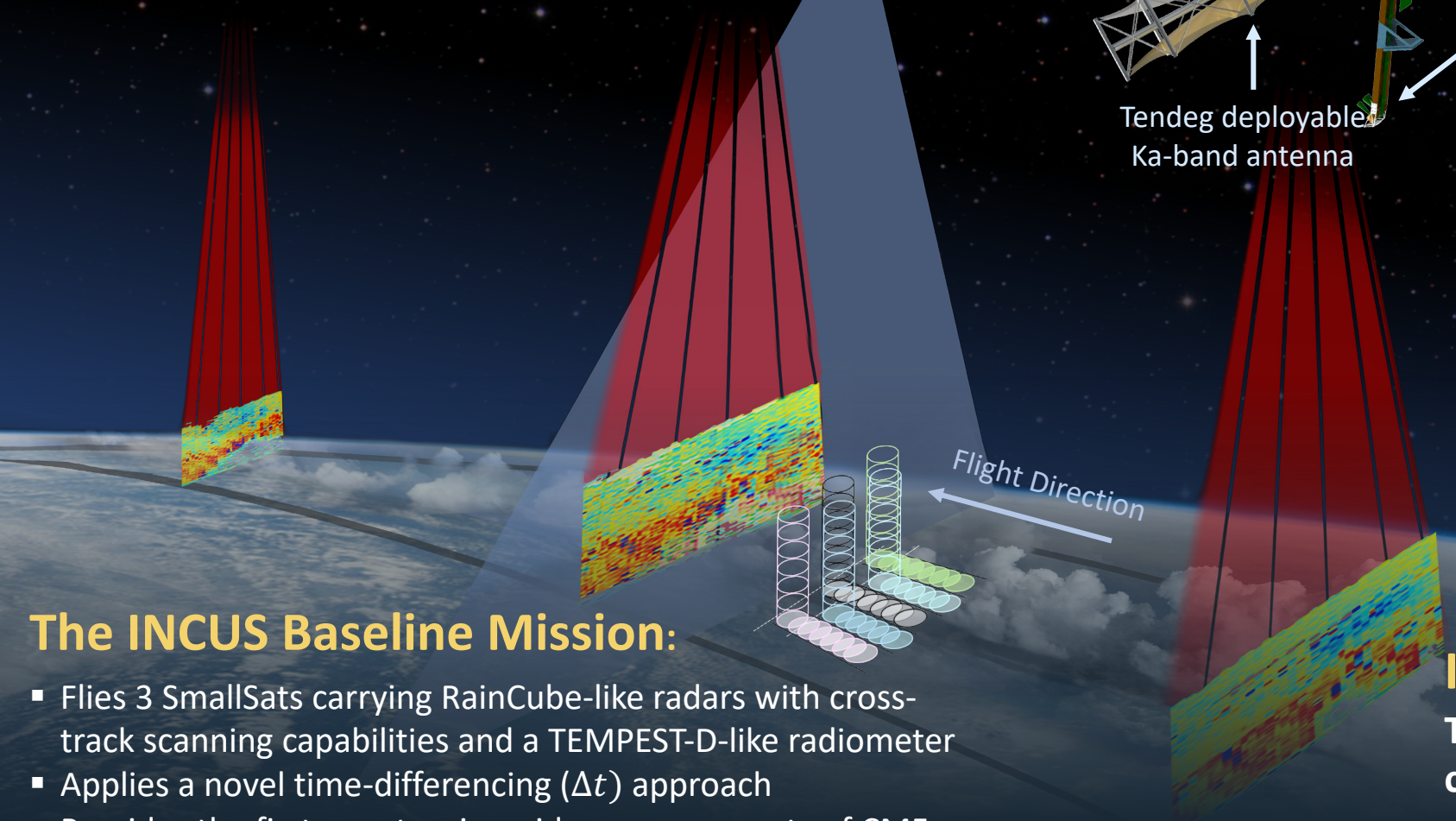


For more details: https://esto.nasa.gov/selections-invest20/

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

Colorado State University
NASA Jet Propulsion Laboratory, California Institute of Technology

The INCUS Baseline Mission:

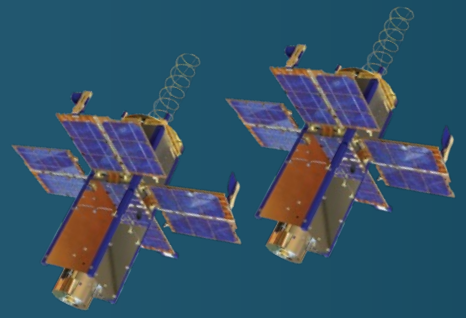
- Flies 3 SmallSats carrying RainCube-like radars with cross-track scanning capabilities and a TEMPEST-D-like radiometer
- Applies a novel time-differencing (Δt) approach
- Provides the first ever tropics-wide measurements of CMF

INCUS Goal

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

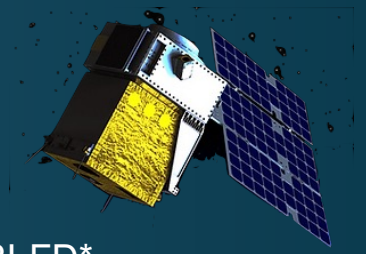
Upcoming ESTO InVEST-17 CubeSat Launches

For project details see: https://esto.nasa.gov/invest/

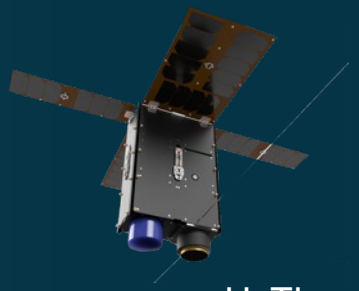


CTIM

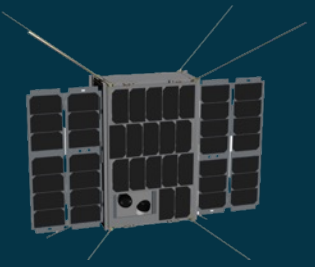
NACHOS-1 & 2



MURI-FD*



HyTI



SNOOPI

2022

June/July

November

2023

February

NASA Earth Science Focus Areas

Atmospheric Composition		Earth Surface and Interior
Carbon Cycle and Ecosystems		Water and Energy Cycle
Climate Variability and Change		Weather and Atmospheric Dynamics

*SLIT, Hosted Payload on YAM5

07.24.22

HARP updates

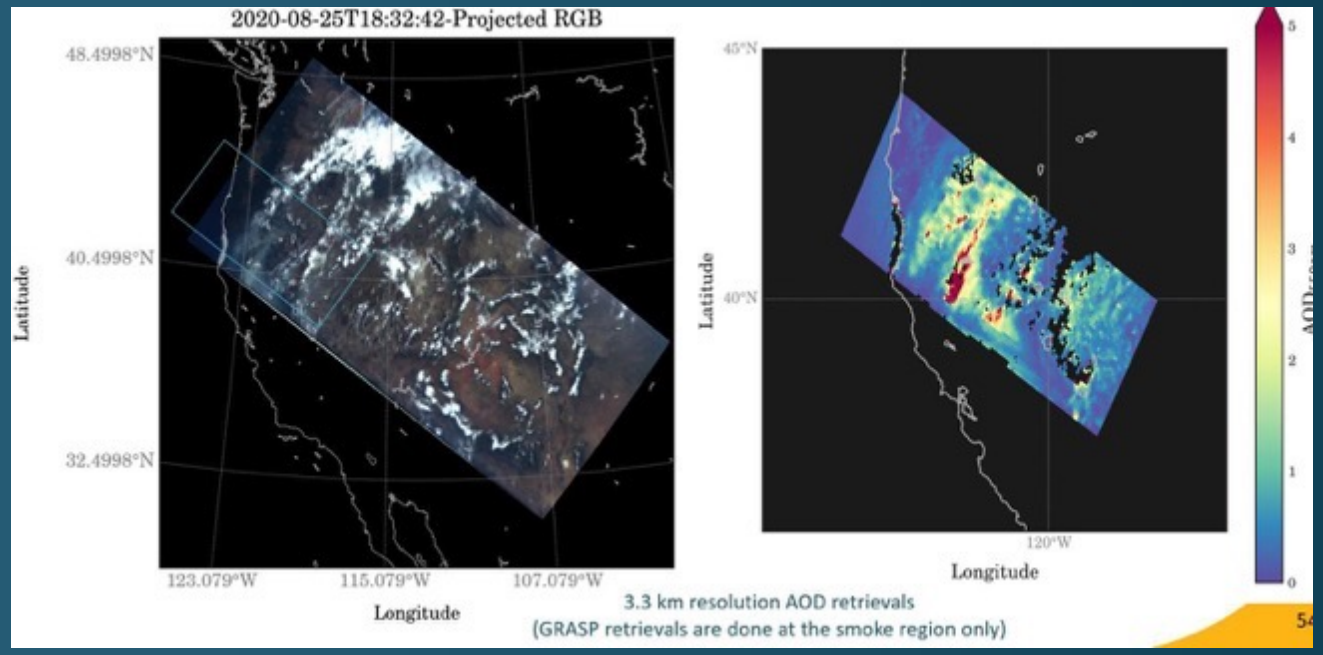
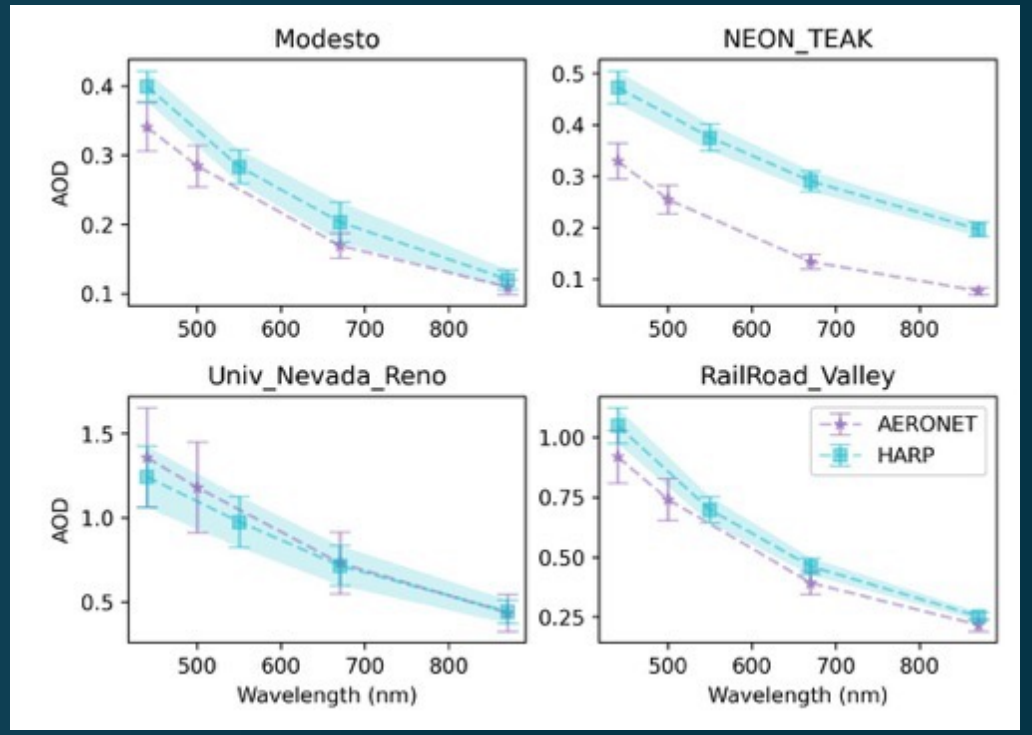


Figure 6 – RGB image over forest fires in California (left hand side) and the aerosol optical thickness retrieval showing the thick smoke plumes in red (right hand side).



Preliminary inter-comparison between HARP aerosol measurements and AERONET in different locations. The HARP team is fine tuning calibration and the retrieval algorithms.

NASA ESD CubeSat Talks

Monday August 8, 3:00pm

FINIS: NEW METHANE DETECTOR TECHNOLOGY FOR POINT-SOURCE DETECTION AND LEAK RATE MEASUREMENTS

Tuesday August 9, 9:30am

ENABLING BIG SCIENCE IN A SMALL SATELLITE - THE GLOBAL L-BAND OBSERVATORY FOR WATER CYCLE STUDIES (**GLOWS**) MISSION

2:00pm

THE NASA TIME-RESOLVED OBSERVATIONS OF PRECIPITATION STRUCTURE AND STORM INTENSITY WITH A CONSTELLATION OF SMALLSATS (**TROPICS**) MISSION: RESULTS FROM THE PATHFINDER DEMONSTRATION AND LOOK AHEAD TO THE CONSTELLATION MISSION

3:00pm

NACHOS, A CUBESAT-BASED HIGH-RESOLUTION UV-VISIBLE HYPERSPECTRAL IMAGER FOR REMOTE SENSING OF TRACE GASES: SYSTEM OVERVIEW, SCIENCE OBJECTIVES, AND PRELIMINARY RESULTS

4:30pm

ACTIVE THERMAL CONTROL FOR THE MULTISPECTRAL EARTH SENSORS (**ACMES**) MISSION

NASA ESD CubeSat Talks

SWIFTY SESSION 2

Wednesday August 10, 9:45AM
The NACHOS CubeSat-Based Hyperspectral Imager: Laboratory Characterization and On-Earth Deployment

Compact Midwave Imaging System (CMIS) for Small-Satellite Applications