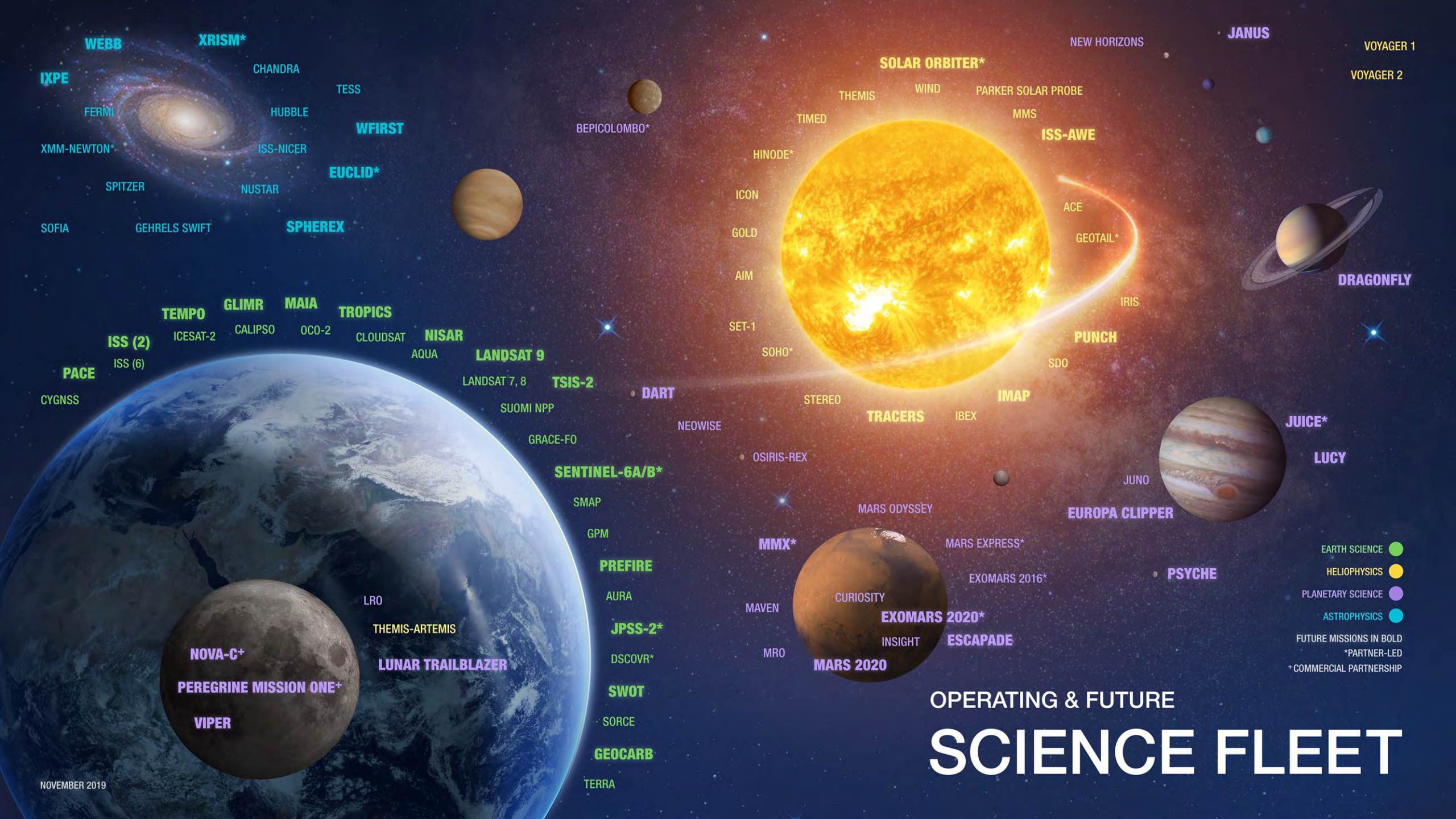

NASA
National Aeronautics and
Space Administration
EXPLORE
SCIENCE
THOMAS H. ZURBUCHEN
Associate Administrator
NASA Science Mission Directorate
@Dr_ThomasZ
December 10, 2019


NASA SCIENCE
AN INTEGRATED PROGRAM



OPERATING & FUTURE

SCIENCE FLEET


381

Announcement

Earth Science Division Director recruitment is live on USAJOBS

- Provides guidance, strategy, advocacy, and budget for NASA's Science Program
- Plans, presents, and implements $1.9 billion/year Earth Science Program
- Coordinates and aligns key functions and activities across SMD

To apply, go to:
https://www.usajobs.gov
Announcement number: HQ20S0005

Research and Analysis Initiatives

Dual Anonymous Peer Review

- SMD is strongly committed to ensuring that review of proposals is performed in an equitable and fair manner that reduces the impacts of any unconscious biases

High-Risk/ High-Impact (HR/HI)

- To reinforce SMD's interest in High-Risk/High-Impact research, a special review process will be implemented in ROSES 2020 to review and select HR/HI proposals

Proposal Selection Metrics for ROSES 2018

- Overall, just under 50% of selections featured new PIs
- Majority of division selection rates were between 25 – 30%, and we are continuing to evaluate

Request for Information:

Research That Falls in Gap between current SMD Solicitations

- Release Date: Dec 2, 2019 (Solicitation: NNH20ZDA003L)
- Response Date: Jan 31, 2020
- NASA SMD is soliciting information on research aligned with agency mission and SMD's Science Plan but falls in a gap between current solicitations, possibly because it's interdisciplinary or interdivisional
- Responses will be used by NASA to inform decision as to whether portfolio of current program elements in ROSES needs to be modified and/or expanded to provide the proper avenue for such research
- Full text of RFI and response instructions on the NSPIRES website

Mission Principal Investigator Development

Seek to increase the diversity of mission principal investigators and develop the next generation of mission leaders to ensure that new ideas and mission concepts are brought forward

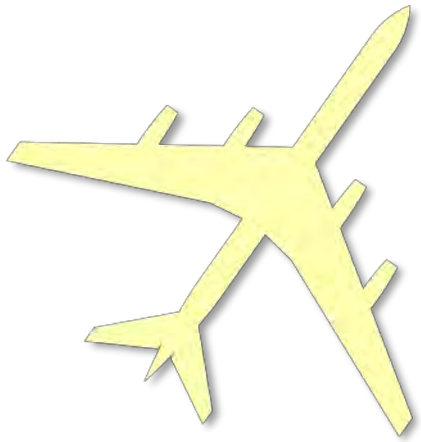
- NASA Science has:
  - Developed a consolidated PI resources webpage at https://science.nasa.gov/researchers/new-pi-resources, which also includes SMD presentation on lessons learned from past selections
  - Introduced a pre-reviews of mission peer review panels to ensure diversity and reduce conflicts of interest
  - Included career development positions and associated evaluation criteria as part Discovery and New Frontiers AOs
- Upcoming activities include:
  - Making videos and slides from the November 2019 workshop available
  - Looking to host two Launchpad Workshops per year


EXPLORE
with us

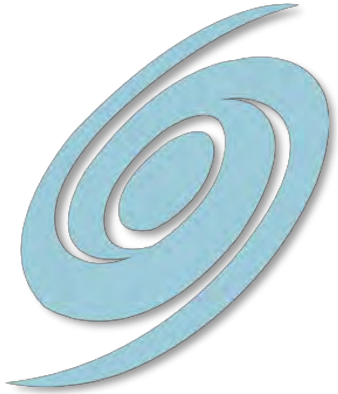

National Aeronautics and
Space Administration
NASA
EXPLORE SCIENCE
Sandra Cauffman
Director (Acting)
Earth Science Division
AGU Fall Meeting 2019
December 10, 2019

Earth Movements

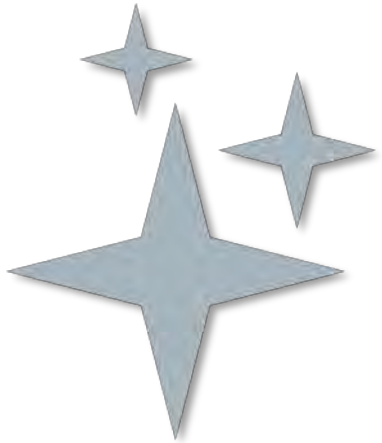
Welcome to ESD:
Tahani Ahmed
Marissa Herron
Thorsten Marcus
Nadya Vinogradova Shiffer
Amanda Whitehurst
Jamie Wicks



Godspeed ESD Retirees:
Michael Freilich
Patricia Jacobberger-Jellison
Eric Lindstrom



Good Luck to Colleagues Moving in SMD:
Brittany Bridges
Darcia Brown
Jamie Favors
Eric Ianson
David Jarrett
Thomas Wagner

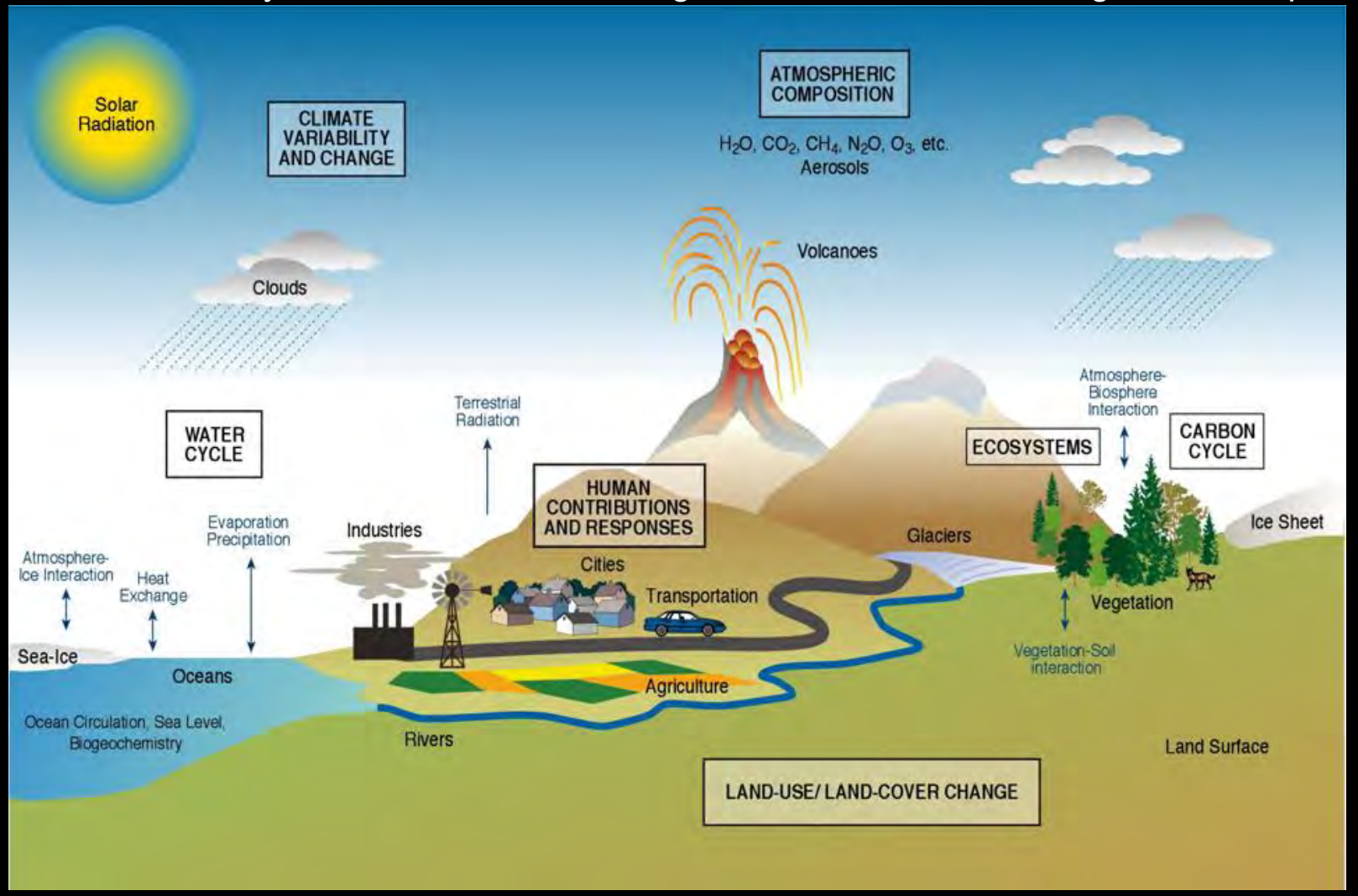


In Memoriam:
Nand Topiwala

Earth as a Complex Inter-related System

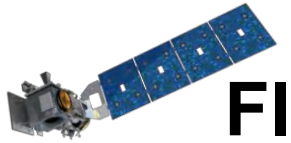
Earth Science Division Strategic Objective

Advance knowledge of Earth as a system to meet the challenges of environmental change and to improve life on our planet



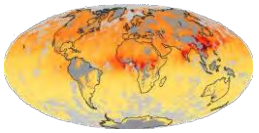
Earth System Science: Requires quantitative understanding of *interactions between processes* in order to define the Earth system – nonlinearities link spatial and temporal scales

NASA Earth Science Division Elements



Flight (incl. Data Systems)

Develops, launches, and operates NASA's fleet of Earth-observing satellites, instruments, and aircraft. Manages data systems to make data and information products freely and openly available.

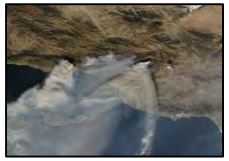


Research & Analysis

Supports integrative research that advances knowledge of the Earth as a system. Six focus areas plus field campaigns, modeling, and scientific computing.

Technology

Develops and demonstrates technologies for future satellite and airborne missions: Instruments, Information Systems, Components, InSpace Validation (CubeSat and small-sat form factors).



Applied Sciences

Develops, tests, and supports innovative uses of Earth observations and scientific knowledge to inform private and public sector planning, decisions, and actions. Activities include disaster response support and capacity building.

NASA EARTH FLEET

OPERATING & FUTURE THROUGH 2023

LANDSAT-9
NISAR
TROPICS (6)
SENTINEL-6A/B
SWOT
TSIS-2
MAIA
PREFIRE (2)
PACE
GEOCARB
TEMPO
GLIMR
ICESAT-2
GRACE-FO (2)
CYGNSS (8)
NISTAR, EPIC (DSCOVR/NOAA)
SORCE
CLOUDSAT
TERRA
AQUA
AURA
CALIPSO
GPM
LANDSAT 7 (USGS)
LANDSAT 8 (USGS)
OCO-2
SMAP
SUOMI NPP (NOAA)

ISS INSTRUMENTS

EMIT
CLARREO-PF
GEDI
SAGE III
OCO-3
TSIS-1
ECOSTRESS
LIS

JPSS-2, 3 & 4 INSTRUMENTS

OMPS-Limb

INVEST/CUBESATS

RAVAN
RainCube
CSIM
CubeRRT
TEMPEST-D
CIRiS
HARP
CTIM
HyTI
SNoOPI
NACHOS

(PRE) FORMULATION
IMPLEMENTATON
PRIMARY OPS
EXTENDED OPS

10.04.19

INTERNATIONAL SPACE STATION

EARTH SCIENCE OPERATING MISSIONS

EXPRESS Logistics Carriers: ELC-1, ELC-2, ELC-3
External Stowage Platforms: ESP-3
Alpha Magnetic Spectrometer: AMS
Columbus External Payload Facility: Columbus-EF
Kibo External Payload Facility: JEM-EF

10.04.19

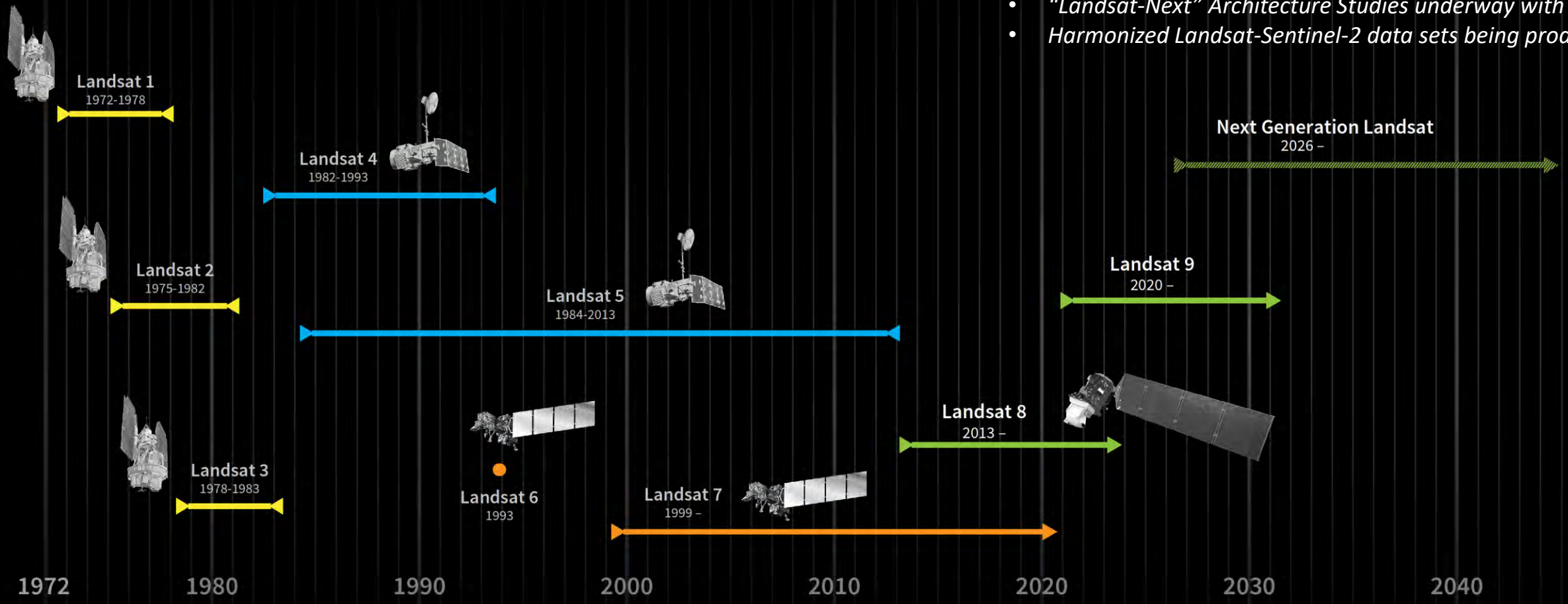
- (PRE) FORMULATION
- IMPLEMENTATON
- PRIMARY OPS
- EXTENDED OPS

NASA EARTH FLEET

INTERNATIONAL COLLABORATIONS

Building on the Landsat Legacy

- NASA-USGS Interagency Partnership
  - NASA: Space Segment and Launch
  - USGS: Operations & Data Processing/Distribution
- *Landsat-9 continues on-track for 12/2020 launch*
- *"Landsat-Next" Architecture Studies underway with USGS*
- *Harmonized Landsat-Sentinel-2 data sets being produced*



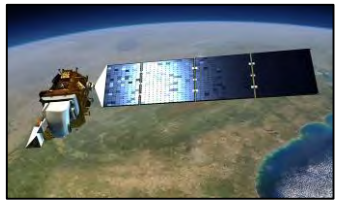
ESD Partnership Missions in Development

Sentinel 6A/B
ABC: 2021/2026
Ocean Altimetry

Partner: NOAA
Science data dissemination
Ground stations

Partner: ESA
Spacecraft bus
Science instruments
(Poseidon-4 Altimeter, DORIS, GNSS POD)
Satellite control center (during LEOP)

Partner: EUMETSAT
Mission/System coordinator,
Satellite control center (Ops)
Science data processing
Science data dissemination
Data archiving
Ground stations



Landsat 9
ABC: 2021
Land Imaging

Partner: USGS
Ground system
Mission Operations

SWOT
ABC: Apr 2022
Sea surface & fresh water height, slope

Partner: CNES
Spacecraft bus
Science instruments
(Nadir Altimeter, DORIS, KaRIn RF Unit subsystem)

Partner: CSA
Klystrons for KaRIn

Partner: UKSA
Duplexers for KaRIn

NISAR
ABC: Sep 2022
Cryosphere, ecosystems, deformation

Partner: ISRO
S-Band SAR
Spacecraft bus
Spacecraft operations
Science Downlink
S-Band processing

PACE
ABC: 2022
Ocean Color (ocean, aerosols, clouds), Polarimetry

Partner: SRON
SPEXOne polarimeter

Partner: UMBC
HARP-2 polarimeter

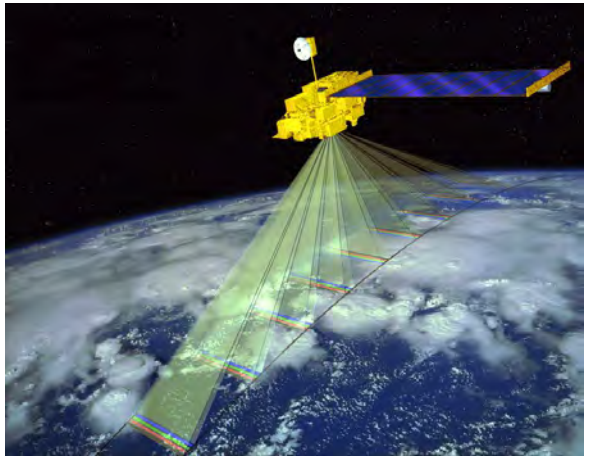
ABC=Agency Baseline Commitment

Recent and Upcoming Notable Flight Program Events

- OCO-3 instrument successfully launched to **ISS May 4, 2019** - operating
- Earth Science Decadal Survey Designated Observable studies are **underway**
- CYGNSS successfully **completed its prime mission** in April 2019 and moved into extended operations
- TEMPO instrument **delivered to storage** December 2018 – **host contract awarded** to MAXAR July 2019, with planned launch in 2022
- LIS on ISS successfully **completed its prime mission** in June 2019 and moved into extended operations
- EVC-1 proposals were received in July 2019 and currently **under review**
- EVI-5 selection: **GLIMR** (ocean biology, chemistry, and ecology from geostationary orbit)
- ECOSTRESS successfully **completed its prime mission** in August 2019 and moved into extended operations
- OSTM/Jason-2 **mission ended** October 2019 after 11 years
- HARP CubeSat **launched to ISS** on 2 November 2019 deployment expected late January 2020
- CIRiS-BATC CubeSat **manifested for launch** December 2019
- TROPICS scheduled **to be delivered to storage** in December 2019 – evaluating launch options
- Terra will **celebrate 20 years** in orbit on Dec. 18, 2019
- **SORCE mission will end** in February 2020, after 17 years in-orbit
- Sentinel-6A **launch scheduled for September 2020**
- Senior Review – ESD's mission extension process – **will be conducted in 2020**

Thank you, OSTM/Jason-2 for 11 years of amazing ocean science!

Congratulations, Terra, NASA's EOS Flagship, for 20 years in orbit!



ESD Launches

Past: OCO-3

May 4, 2019

Investigate important questions about the distribution of carbon dioxide on Earth as it relates to growing urban populations and changing patterns of fossil fuel combustion

Future: Jason-CS/Sentinel-6A

November 2020

Provide ongoing measurements of global sea level rise, and support operational oceanography, improving forecasts of ocean currents as well as wind and wave conditions

Earth Science Division's Venture Opportunities

Mission	Mission Type	Release Date	Selection Date	Major Milestone
EVS-1 (EV-1) (AirMoss, ATTREX, CARVE, DISCOVER-AQ, HS3)	5 Suborbital Airborne Campaigns	2009	2010	N/A
EVM-1 (CYGNSS)	SmallSat Constellation	2011	2012	Launched Dec. 2016
EVI-1 (TEMPO)	Geostationary Hosted Payload	2011	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, MAAMES, ORACLES, OMG, CORAL)	6 Suborbital Airborne Campaigns	2013	2014	N/A
EVI-3 (MAIA & TROPICS)	Class C LEO Instrument & Class D CubeSat Constellation	2015	2016	Delivery NLT 2021
EVM-2 (GeoCarb)	Geostationary Hosted Payload	2015	2016	Launch ~2021
EVSI-4 (EMIT & PREFIRE)	Class C ISS-hosted Payload & Class D Twin CubeSats	2016	2018	Delivery NLT 2021
EVS-3 (ACTIVATE, DCOTTS, IMPACTS, Delta-X, SMODE)	5 Suborbital Airborne Campaigns	2017	2018	N/A
EVI-5 (GLIMR)	Geostationary Hosted Payload	2018	2019	Delivery NLT 2024
EVC-1	Radiation Budget Measurement	2018	2019	Delivery NLT 2024
EVM-3	Full Orbital	2019	2020	Launch ~2025
EVI-6	Instrument Only	2020	2021	Delivery NLT 2025
EVS-4	Suborbital Airborne Campaigns	2021	2022	N/A
EVC-2	Continuity Measurements	2021	2022	Delivery NLT 2027
EVM-4	Full Orbital	2021	2024	Launch ~2029
EVI-7	Instrument Only	2023	2024	Delivery NLT 2028
EVC-3	Continuity Measurements	2024	2025	Delivery NLT 2030
EVS-5	Suborbital Airborne Campaigns	2025	2026	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)

Open solicitation - In Review

Completed solicitation

CubeSats, SmallSats, and Constellations

Small Satellite Solutions

- **Venture Class Launch Services:** Investment in new, low-cost (<$15M/launch), commercial launch vehicles capable of orbiting small payloads to LEO – science control of launch schedule and orbits
- **CYGNSS (Cyclone Global Navigation Satellite System)**: Homogeneous tropical constellation of 8 ***micro-satellites*** using reflected GPS to measure surface winds/air-sea interactions, especially valuable/unique in the precipitation-dominated, dynamic, eyewalls of tropical storms and hurricanes – frequent tropical sampling from 1 orbit plane
- **TROPICS (Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of SmallSats):** Homogeneous tropical constellation of 6 ***CubeSats*** to measure atmospheric profiles in storms/hurricanes – frequent sampling from 2-3 orbit planes
- **PreFIRE:** 2-satellite CubeSat constellation to measure Far-IR emissions primarily from the Arctic
- **In-Space Validation of Earth Science Technologies (InVEST):** On-orbit ***CubeSat-based*** technology validation and risk reduction that could not otherwise be fully tested using ground/airborne systems; leading to miniaturized science payload development
  - CSIM/CTIM provide a new SmallSat architecture approach for future TSI and SSI continuity measurements
  - SLI-T instrument development for Landsat-10, future SLI consideration (6 projects ongoing)
  - Tempest-D produced exceptional precipitation measurements of Hurricane Dorian

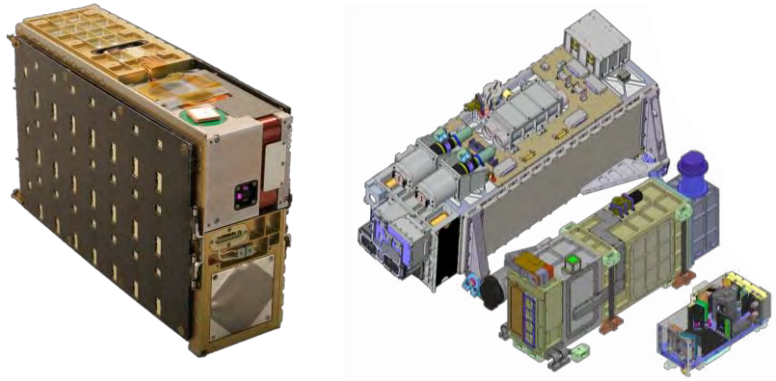
Hosted Payload solutions

- TEMPO (instrument on NASA-arranged geo comsat) - MAXAR
- MAIA (instrument on NASA-arranged LEO satellite) – General Atomics, Electromagnetics Systems Group.
- GeoCarb (instrument on PI-arranged geo comsat)

Calibrated CSIM Data Compared to TSIS SIM

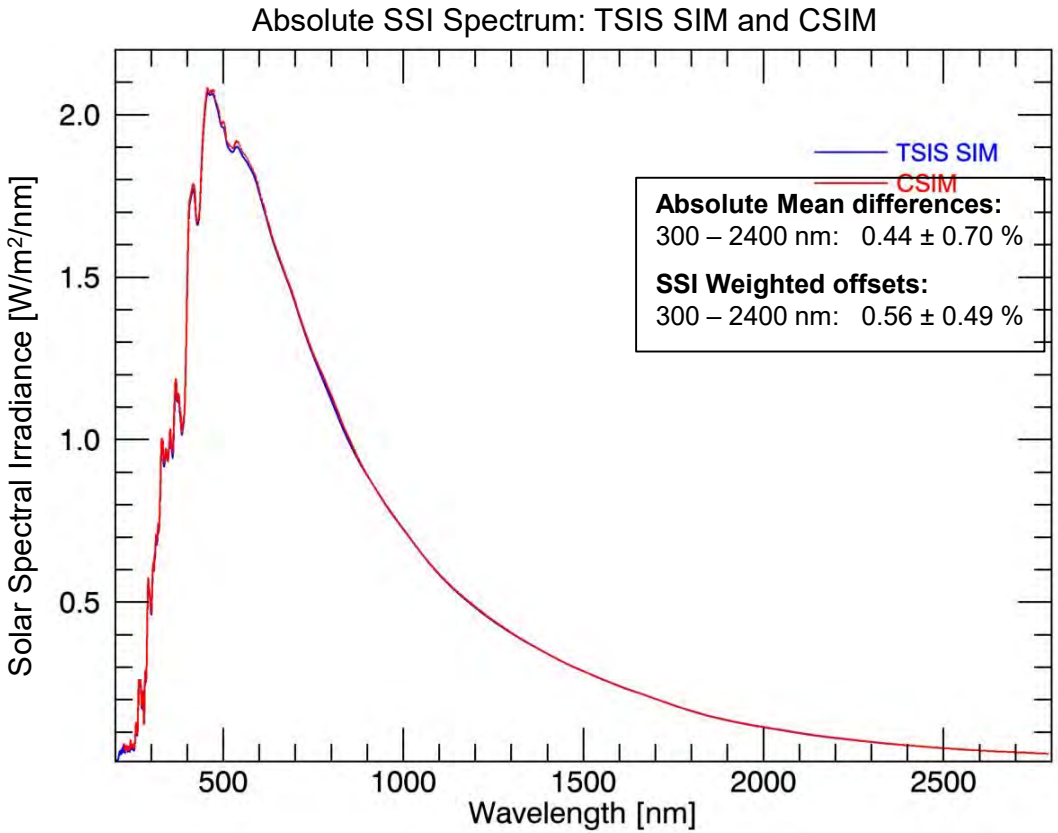
The Compact Spectral Irradiance Monitor (CSIM), launched December 3, 2018, is an ultra-compact, solar spectral irradiance (SSI) monitor covering 200-2400 nm with the SI-traceable accuracy and on-orbit stability to meet solar input measurement requirements for establishing benchmark climate records.

Launched on 12/03/2018 onboard a SpaceX Falcon 9 rocket, the CSIM instrument design marks a significant departure from the previous SIM instruments – those onboard SORCE and TSIS – and achieves large reductions in mass, volume, and power requirements, enabling climate data record SSI measurements from a CubeSat-sized instrument. In September/October 2019, the project team calibrated the CSIM full-spectrum data and compared it to TSIS-1 SIM, **showing excellent agreement (< %1 difference).**



Above: CSIM flight hardware, and the relative sizes of (left to right) SORCE, TSIS, and CSIM.

Right: absolute SSI agreement between the CSIM spectrum compared to the TSIS-1 SIM 300 – 2400 nm spectrum (< 1% difference). Both TSIS-1 SIM and CSIM have calibration tied to NIST-Standards



Principal Investigator: Erik Richard, LASP

Earth Science Technology Highlight

TEMPEST-D: A Year On Orbit

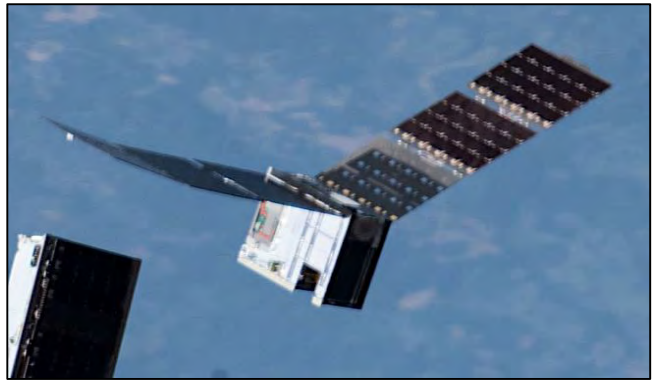
The Temporal Experiment for Storms and Tropical Systems Demonstration (TEMPEST-D) CubeSat, a NASA Earth Venture Technology project led by Steven Reising at Colorado State, is testing a new five-frequency, millimeter-wave radiometer for observations of the time evolution of clouds and precipitation processes. The 6-unit CubeSat was launched to the International Space Station on May 21, 2018, deployed from ISS on July 13, 2018, and took first light data on Sept. 05, 2018.

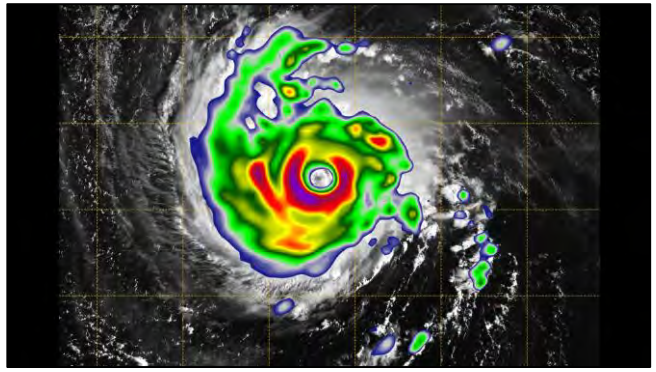
Within 90 days of operation, TEMPEST-D had met its level-1 mission success criteria:

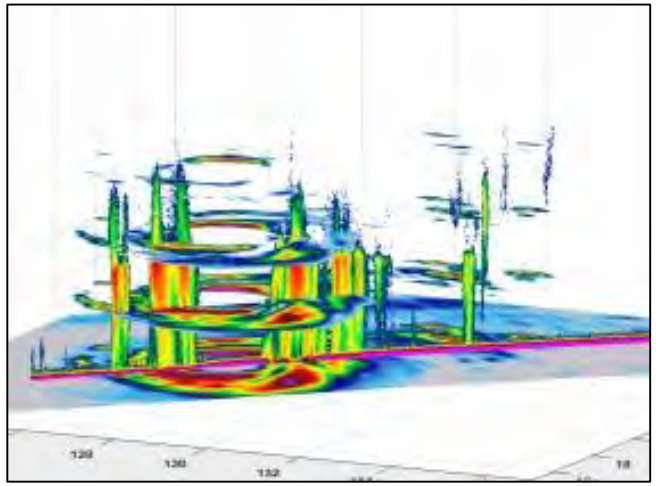
- Cross-calibration with the GPM Microwave Imager (GMI), the NOAA-19 Microwave Humidity Sounder (MHS), and ESA's MetOp-A and MetOp-B MHS instruments demonstrated calibration stability within 0.7 K and accuracy within 1.3 K (Goal: 2 K with accuracy of 4 K);
- Demonstrated the feasibility of orbital drag maneuvers to control TEMPEST-D altitude to 50 m or better (Goal: 100 m);
- Surpassed minimum operations goal of 90 days.

Following nearly a year on orbit, TEMPEST-D has demonstrated ***performance that is indistinguishable from operational-class imaging radiometers.*** TEMPEST-D data are also being distributed to atmospheric scientists at NOAA/NESDIS STAR and NRL Monterey for collaborative analysis.

Assuming continued spacecraft health, the project plans to operate through March 2020.







Top: TEMPEST-D is deployed from ISS
Middle: TEMPEST-D data of Hurricane Florence (9/11/18) taken shortly after the instrument became operational.
Bottom: Co-located data taken by TEMPEST-D and RainCube of Typhoon Trami just off the coast of Japan (9/28/18).

Commercial SmallSat Data Acquisition

NASA recognizes the growing importance and potential of new and unique Earth observation data products provided by the commercial sector and believes that a vibrant commercial Earth observation ecosystem of open and commercial data from this growing market segment benefits NASA and its partners.

Program Objectives:

- **Continuous** and **repeatable** process to onramp, evaluate and purchase data from commercial satellites to advance Earth Science research and applications

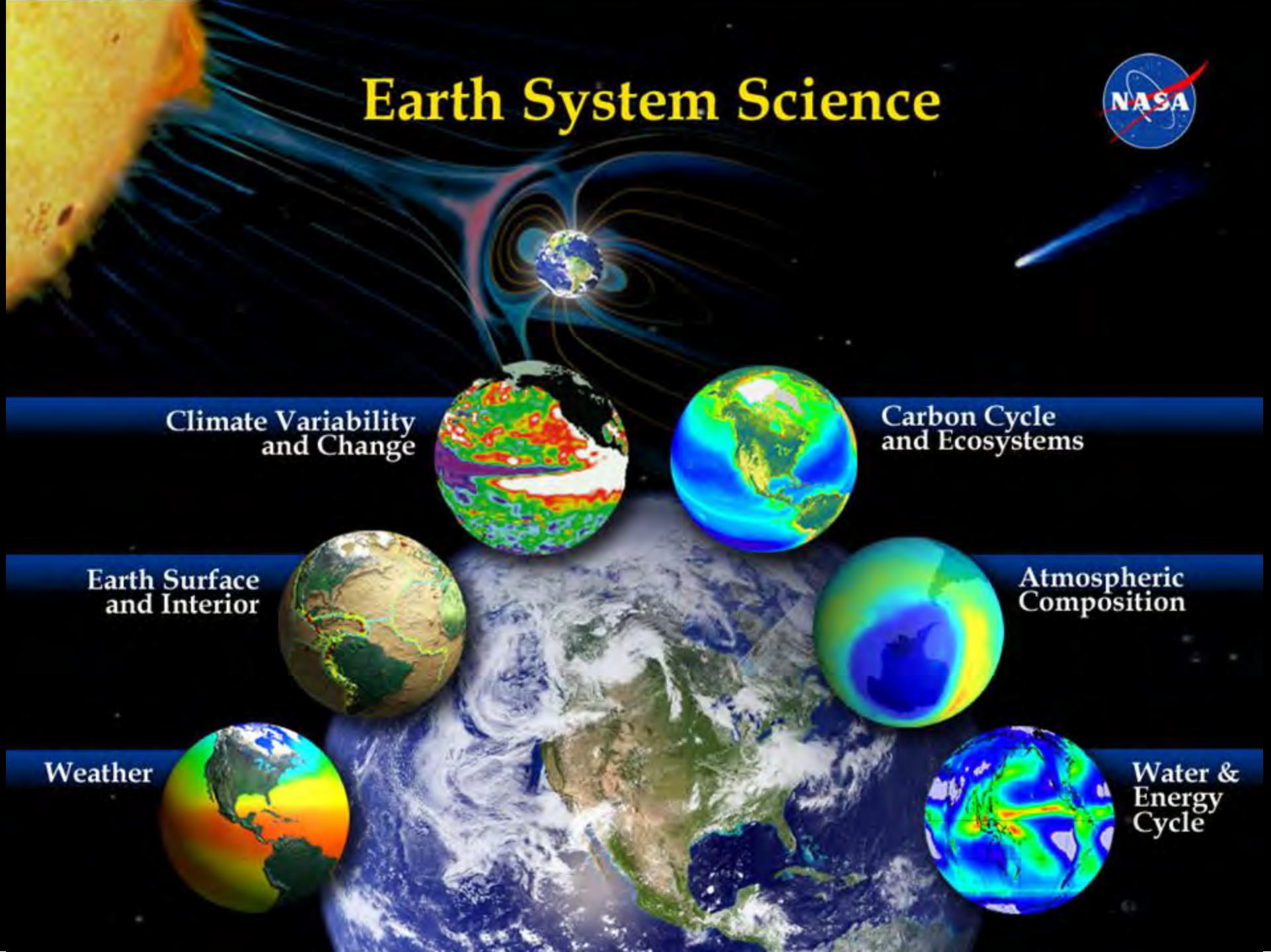
Status:

- Request for Information (RFI) for a pilot released in Winter 2017 → contracts awarded to **Planet, DigitalGlobe (Maxar), and Spire Global** in October 2018 → PI evaluations initiated January 2019
- An independent assessment of calibration and geolocation conducted
- Evaluations will be completed in January 2020 → **Longer-term contracts for sustained scientific use**

Future:

- Each 12-18 months a RFI will be issued
- All contracts will contain a ***standardized scientific use license*** to minimize the effort by NASA and confusion by users on how data can be used
- Data from selected vendors will be evaluated by teams of Principal Investigators (PIs) ***selected through the annual Research Opportunities in Space and Earth Science***
- All ***data purchased*** by NASA will be made ***available to NASA funded researchers*** with a uniform scientific use license.
- **RFI for second on-ramp released September 2019**

Earth System Science



R&A Selected Highlights

Field Work

- 2019 (Selected)
  - *SNOWEx* – Grand Mesa November campaign completed, including NASA SWESARR instrument, NOAA Gamma Airborne Survey, and significant ground work
  - *NASA/ISRO L/S Radar Campaign* – instrument arrived in U.S., first phase (snow, solid Earth, ocean first)
  - *ACT-AMERICA* – flew over 200 hours (B200, C-130)
  - *FIREX-AQ* (joint with NOAA) – flew over 200 hours (DC-8, ER-2) from ID and KS (DC-8) and CA (ER-2)
  - *CAMP^{2}Ex* – flew over 220 hours from Philippines on NASA P-3
  - *ABoVE* – flew 55 hours on GIII from locations in Alaska and Canada
  - ***OIB* – completed final Arctic (76 hours on G-V in early fall 2019) and Antarctic (231 hours on G-V in late fall 2019) campaigns**
- 2020 Wind Lidar (w ESA), AVIRIS-ng/HyTES/SLAP (w ESA), L/S Radar (with ISRO), SNOWEx (also 2019)

Competed Science Programs (highlights only – many ROSES calls)

- Confirmed 3rd round of Earth Venture Suborbital Science investigators (EVS-3)
- Selected science teams for ECOSTRESS and DSCOVR; Solicited science team for ICESat-2; recompeted existing science teams (GRACE FO, Cloudsat/CALIPSO, PMM, Aura, SMAP, High Mountain Asia); Solicited for NASA/ISRO L/S-Band Radar Mission, IDS and AITT
- Soliciting jointly with NOAA for Earth Science Research from Operational Geostationary Satellite Systems (Due 1/10/20)

Modeling and Data Assimilation

- Simulations from 3 different Model E configurations totaling 44 TB of output have been submitted to the CMIP6 archive for use by the Earth science community
- GMAO officially initiated a new "composition forecast" system (GEOS-CF) in September, providing near real-time global up to 5-day forecasts of air pollutants including O_3, CO, NO_2, and PM2.5
- Added constituent data assimilation task at JCSDA. Committed and supported the development of a Joint Efforts for Data assimilation Integration (JEDI) at the JCSDA

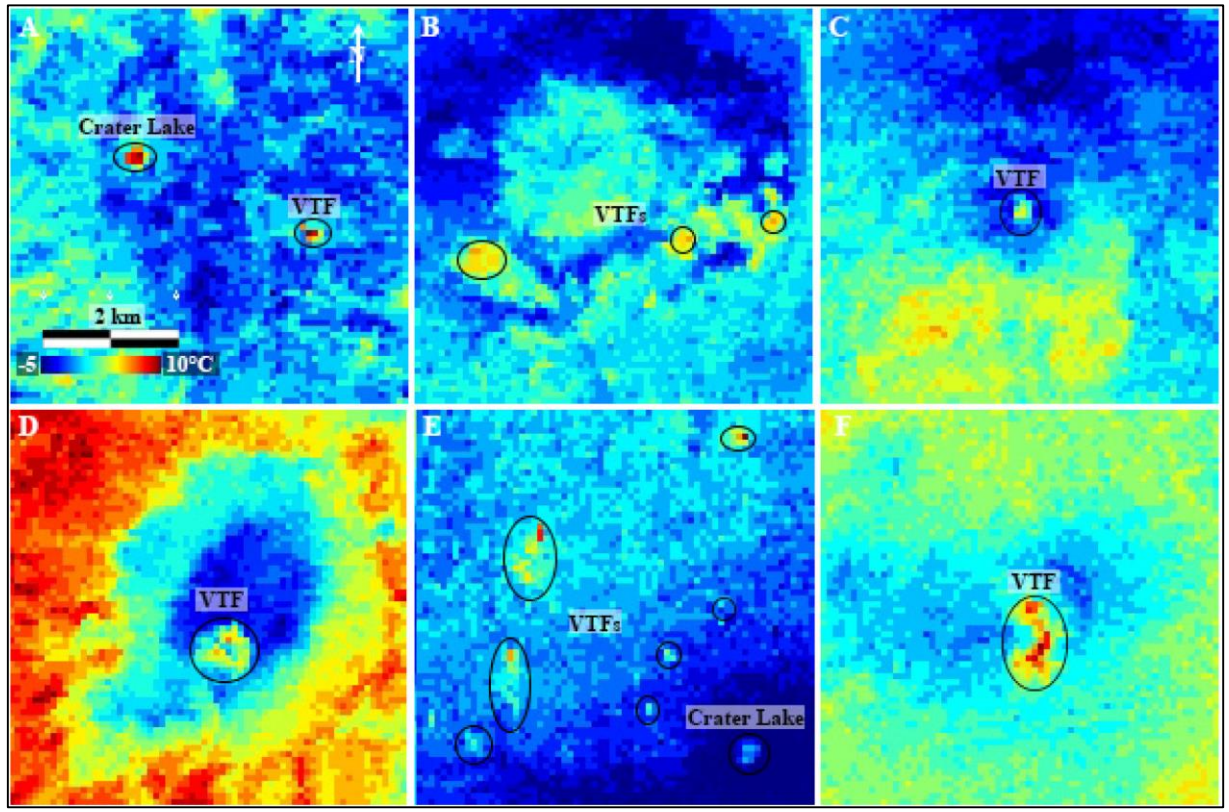
Enabling Capabilities

- Completed the construction of the second modular computing facility at ARC; added a new module on site
- Completed deployment of the new VLBI Global Observing System (VGOS) antenna at the McDonald Geodetic Observatory, Texas; Installed the first new Space Geodesy Satellite Laser Ranging (SGSLR) gimbal and telescope assembly for testing at GGAO
- Langley G-III with 2 nadir ports and JSC G-V (jointly with HEOMD) with 2 nadir ports now available; SIERRA UAS also now available

Community Engagement

- The inaugural Solid-Earth Team Meeting brought 130 participants together for research talks, training on new datasets, and discussion of future mission concepts

Taking a Volcano's Temperature From Space



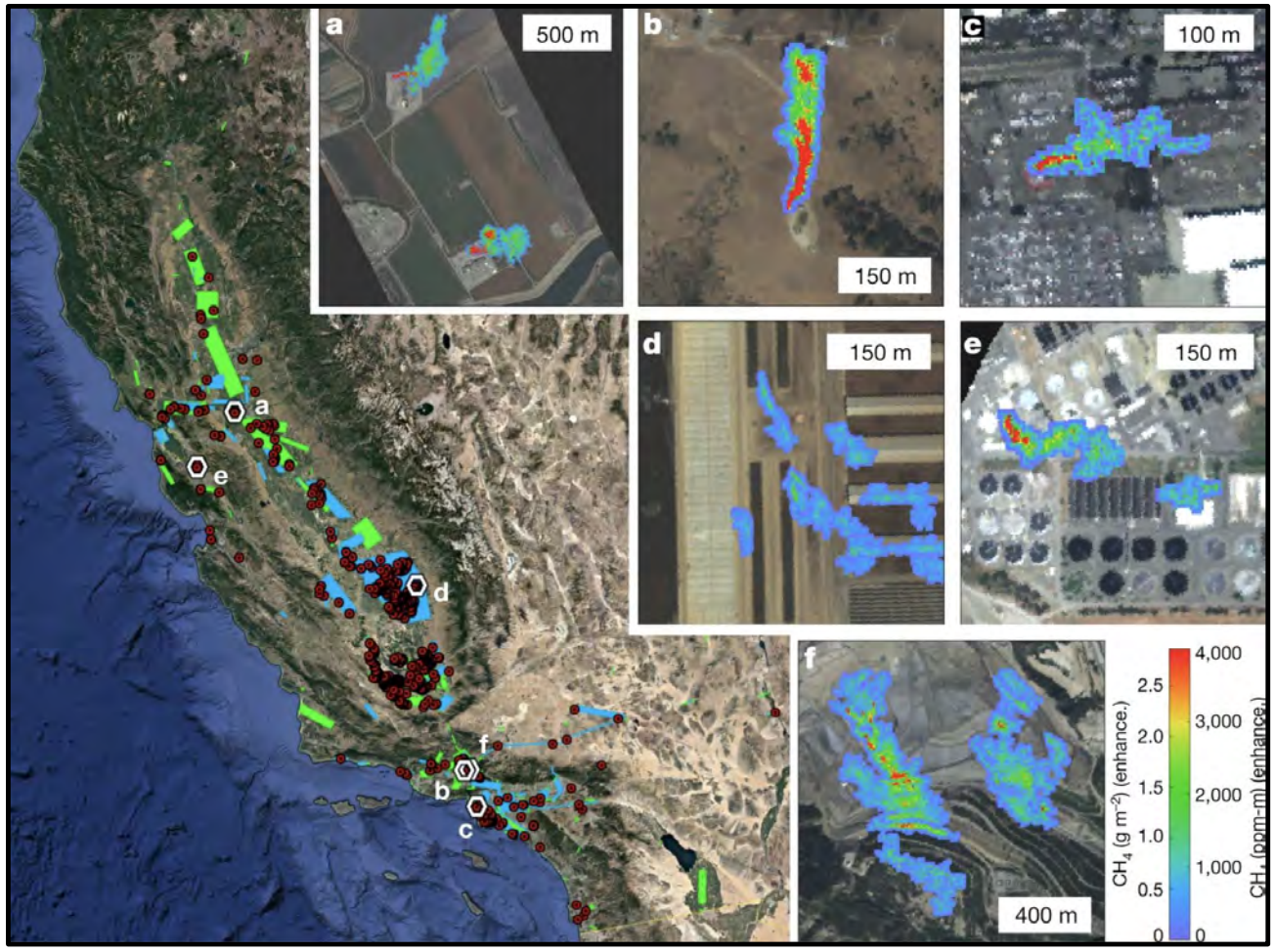
- NASA scientists have developed a first-of-its-kind ASTER Volcanic Thermal Output Database to identify and collect data for volcanic thermal output at high spatial resolution for 330 potentially active volcanoes.
- Of the volcanoes studied, 88 were found to have some type of volcanic thermal feature, including 16 that were detected from space for the very first time.
- This database provides new insights about volcanic activity, as well as a data-driven approach to improve key features in future space-based volcanic monitoring.

Cold Water Slowing the Fastest-thinning Greenland Glacier

- NASA research shows that Jakobshavn Glacier, which has been Greenland's fastest-flowing and fastest-thinning glacier for the last 20 years, is now flowing more slowly, thickening, and advancing toward the ocean instead of retreating farther inland.
- Researchers conclude that the slowdown occurred due to cooler ocean currents in 2016.
- Water temperatures in the vicinity of the glacier are now colder than they have been since the mid-1980s.

The calving front of Jakobshavn Glacier, center.
Credits: NASA/OIB/John Sonntag

California Methane Traced to a Few Super-emitters



- NASA, in partnership with the California Air Resources Board (CARB) and the California Energy Commission, used the AVIRIS-NG instrument to identify the major sources of methane in the state
- The team identified more than 550 individual point sources emitting plumes of highly concentrated methane
- 10% of these sources, considered super-emitters, contributed the majority of the emissions detected
- The team estimates that statewide, super-emitters are responsible for about a third of California's total methane budget

Applied Sciences Program: Selected Highlights

Ecological Forecasting, Health & Air Quality, Disasters, and Water Resources

Call for land and marine conservation apps projects. Call for next Health & Air Quality Applied Sciences Team. Disasters adding more risk and resilience.

Missions & Applications

More Early Adopter events to engage applications communities during mission development – users prepare for data, learn about new research coming, and advocate.

Communications

Applied Sciences is releasing a ***COMPLETELY*** redesigned website.

Western Water

Applications Office doing user assessments for Rio Grande and Missouri River basins in 2020.

NASA Harvest

Food Security team advancing uses of Earth obs for humanitarian pursuits, domestic economy, and resilience in food systems.

Impact Assessments

Chances for Earth scientists and economists to work together on projects calculating value and benefits – in societal and economic terms – from uses of Earth obs.
Website: RFF.org/VALUABLES

SERVIR

3rd SERVIR Applied Science Team supporting 20 projects across 5 hubs on 3 continents; Amazonia newest hub. SERVIR Annual Global Exchange in February 2020.

ARSET Trainings

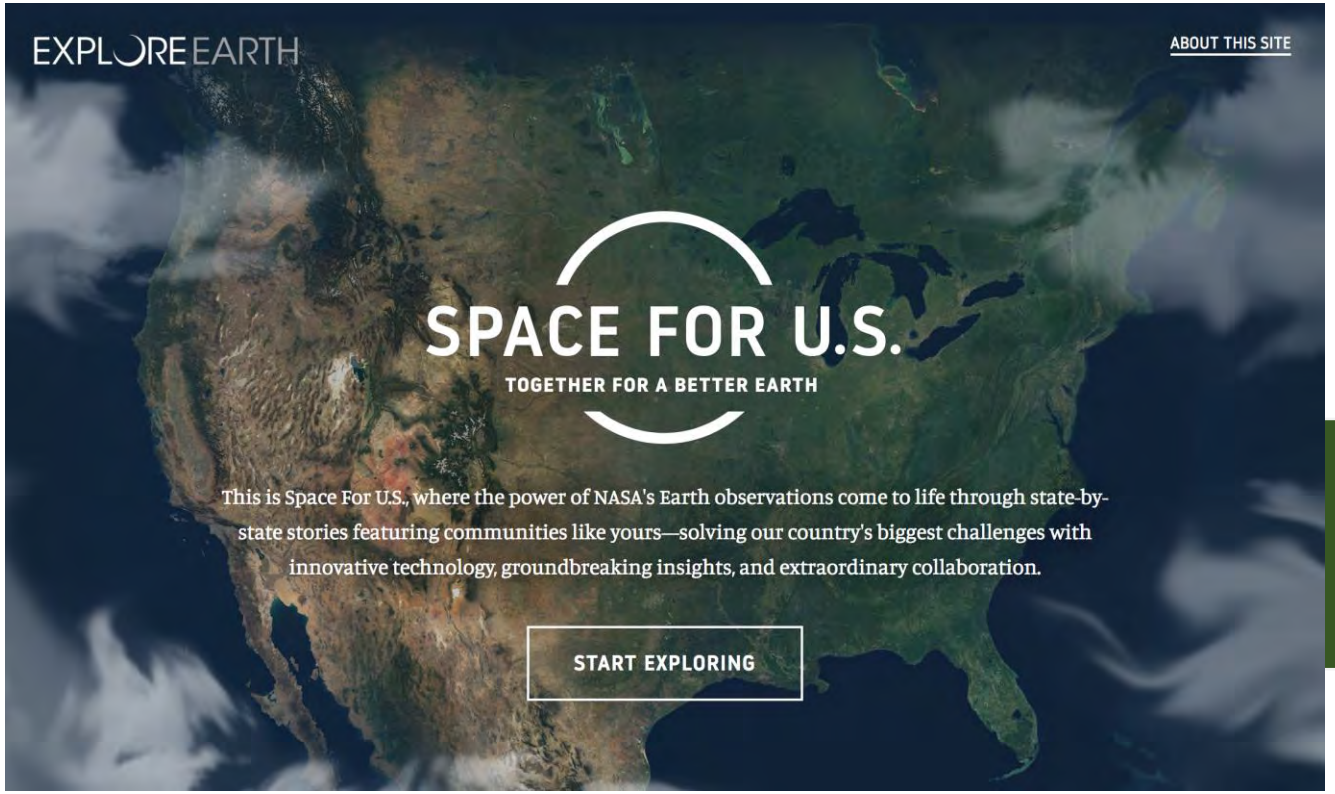
10+ professional-level hands-on events for 10,000+ people in 130+ nations. Incl. trainings on IMERG for flood and drought hazards; agriculture; air qual. Most delivered in English & Spanish.

DEVELOP

Will again conduct 50+ feasibility studies applying Earth obs. with local decision making in 35+ U.S. states.

http://AppliedSciences.NASA.gov

APPLICATIONS AREAS | MISSION SUPPORT | CAPACITY BUILDING



SPACE FOR U.S.

A NASA Special Website

nasa.gov/SpaceForUS

Examples where NASA Earth Science is used in each of the 50 U.S. states plus D.C., Puerto Rico, and major bodies of water

Award Winning – 2 Gold Awards

Academy of Interactive and Visual Arts

MARCOM Awards for marketing and communication

International Space Apps Challenge

Space Apps 2019 included over 29,000 participants at 225 events in more than 80 countries

An international hackathon for coders, scientists, designers, storytellers, makers, builders, technologists, and others in cities around the world, where teams engage with NASA's free and open data to address real-world problems on Earth and in space.

https://www.spaceappschallenge.org

2019 featured many Earth Science challenges, asking solvers to:

- Identify factors that affect harmful algal blooms
- Develop games that creatively explore NASA's Earth data
- Create disaster-resilient green infrastructure plans
- Identify populations at risk from environmental hazards
- Develop tool to connect people with NASA satellites and their applications;
- Integrate Earth science and crowdsourced data to address SDGs.

2019 Stats:

- Event total participants: Over 29,000 (vs. 18K last year) – *a 60% increase*
- Locations: 225 (vs. 200 last year) – *a 12.5% increase*
- Projects: 3,379 (vs. 1,375 last year) – *a 245% increase*
- Countries: 80 (vs. 75 last year) – *a 5% increase*
- Virtual participants: 2,298 (vs. 900 last year) – *a 255% increase*
- Social media reach: ~55 Million people (vs. 50M last year) – *a 10% increase*

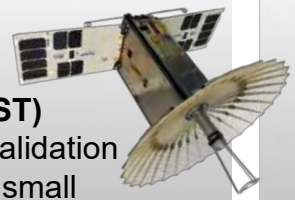
Earth Science Technology Program Elements

ESTO manages, on average, 120 active technology development projects. Over 830 projects have completed since 1998.

Advanced Technology Initiatives: ACT and InVEST

Advanced Component Technologies (ACT)
Critical components and subsystems for advanced instruments and observing systems

12 projects awarded in 2018
***Solicitations planned in FY20** and FY22*
Average award: $1.2M (2-3 years)
Average selection rate: 16.4%



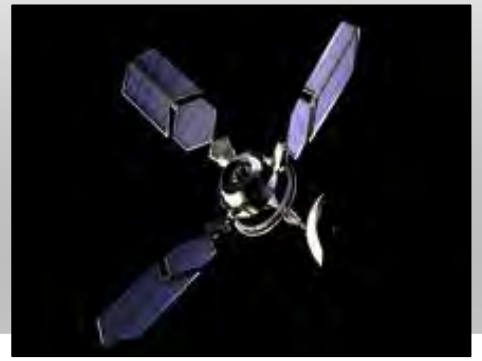
In-Space Validation of Earth Science Technologies (InVEST)
On-orbit technology validation and risk reduction for small instruments and instrument systems.

Four projects selected in FY18
***Solicitations planned in FY21** and FY24*
Average award: $3-5M (3 years)
Average selection rate: 18.3%

Instrument Incubator Program (IIP)

Earth remote sensing instrument development from concept through breadboard and demonstration

19 projects awarded in Oct 2019
Solicitations planned in FY21 and FY23
Average award: $4.5M (3 years)
Average selection rate: 23.2%



Advanced Information Systems Technology (AIST)

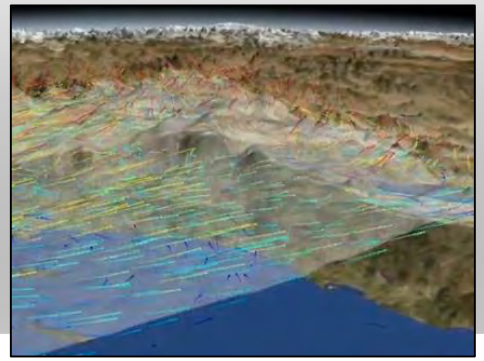
Innovative on-orbit and ground capabilities for communication, processing, and management of remotely sensed data and the efficient generation of data products

22 projects awarded in Sept 2019
Solicitations planned in FY21 and FY23
Average award: $1.2M (2 years)
Average selection rate: 19.6%

Decadal Incubation

Maturation of observing systems, instrument technology, and measurement concepts for Planetary Boundary Layer and Surface Topography and Vegetation observables through technology development, modeling/system design, analysis activities, and small-scale pilot demonstrations

2 Study teams awarded in FY20
Solicitation planned in FY21



Earth Science Technology Highlight

HARP CubeSat Launched

The **Hyper-Angular Rainbow Polarimeter (HARP)** CubeSat was launched on Saturday, Nov. 2, on board the Cygnus NG-12 resupply mission to the ISS, where it will wait for deployment (likely January 2020). It is the first hyper-angle, multi-wavelength, wide field-of-view cloud-aerosol CubeSat mission.

On orbit, HARP will validate the in-flight capabilities of the highly accurate and precise wide field of view hyper-angular polarimeter for characterizing aerosol and cloud properties, and move HARP from TRL 6 (airborne) to TRL 7/8 (space). Developed under the In-Space Validation of Earth Science Technologies (InVEST) program, HARP will demonstrate a new polarimeter that can view Earth using up to 80 viewing angles, four wavelengths, and three polarization angles.

Specifically, HARP will demonstrate its ability to characterize aerosol particles and measure properties of cloud particles including their thermodynamic phase (ice or water) and the size of cloud water droplets. The HARP payload is fully programmable allowing for the selection of different spatial resolutions and combinations of wavelengths and viewing angles depending on the science interest and total amount of data to downlink.

This flight validation will show that CubeSat technology can provide science-quality multi-angle imaging data paving the way for lower cost aerosol-cloud instrument developments. HARP is a precursor to HARP-2, the instrument targeted to fly on NASA's Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission.

Principal Investigator: Vanderlei Martins
University of Maryland Baltimore County

Inset Above: A model of the HARP flight hardware.
Right: The Cygnus NG-12 launch on Nov. 2, 2019.

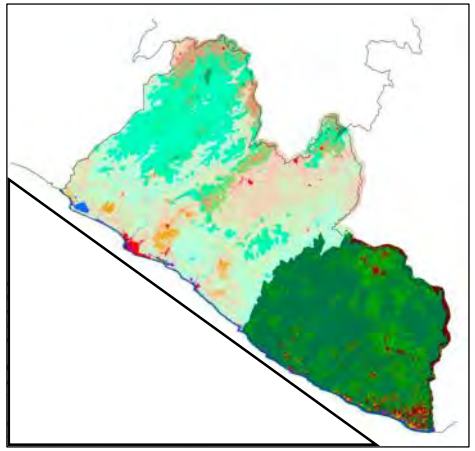
Earth Science Partnerships

Harnessing commercial and non-governmental partnerships to amplify our work to understand the Earth as an integrated system and enable societal benefit by essentially leveraging the expertise of NASA and the partners to achieve together what neither could alone.

Current Partners

CONSERVATION INTERNATIONAL · Google · MercyCorps · Microsoft

Key 2019 Accomplishments



Advancing the ability of remote sensing to inform economic valuation of ecosystem services.

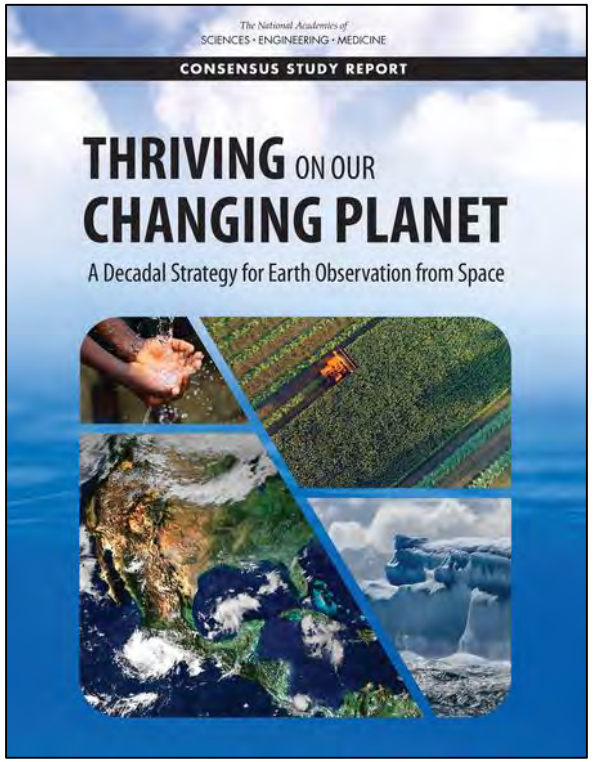
Increasing the public's access to and use of Earth observations to explore our planet. Published three Google Earth stories aligned with NASA's *Earth* book.

Integrating Earth observations into humanitarian decision making to strengthen global resilience to environmental shocks and stressors. Signed Space Act Agreement with Mercy Corps.

Supporting decision making in smart cities by integrating Earth observations into cloud-based services. Microsoft Azure now offering NASA and other Earth observations.

2017 DECADAL SURVEY

2017 Decadal Survey Snapshot



ESD is interacting with the community to translate the recommendations into an executable program and, for Flight, a portfolio of specific, realistic, launch-ordered missions and solicitations

- Publicly released Jan. 5, 2018
- Supports the ESD (and international) Program of Record and endorses existing balances in ESD portfolio
- Prioritizes observations rather than specific missions and allows implementation flexibility
- Emphasis on competition as cost-control method
- Explicitly encourages and notes value of international partnerships
- Recommends “Continuity Measurement” strand ($150M full mission cost cap) as an addition to the existing Venture-class program
- Identifies 5 “Designated” Observables for mandatory acquisition (Aerosols; Clouds, Convection & Precipitation; Mass Change; Surface Biology & Geology; Surface Deformation & Change)
- Introduces a new competed “Explorer” flight line with $350M cost constraint, 3 observables to be chosen by ESD from among 6 identified
- Calls for “Decadal Incubation Program” between Technology, R&A, and Flight to mature specific technologies for important – but presently immature – measurements (preparation for next Decadal): Planetary Boundary Layer (PBL) and Surface Topography and Vegetation (ST&V)
- Decadal new mission budget wedge opens late FY21

Observing System Priorities

TARGETED OBSERVABLE	SCIENCE/APPLICATIONS SUMMARY	CANDIDATE MEASUREMENT APPROACH	Designated	Explorer	Incubation
Aerosols	**Aerosol properties, aerosol vertical profiles, and cloud properties** to understand their direct and indirect effects on climate and air quality	Backscatter lidar and multi-channel/multi-angle/polarization imaging radiometer flown together on the same platform	X		
Clouds, Convection, & Precipitation	**Coupled cloud-precipitation state and dynamics** for monitoring global hydrological cycle and understanding contributing processes	Radar(s), with multi-frequency passive microwave and sub-mm radiometer	X		
Mass Change	**Large-scale Earth dynamics** measured by the changing mass distribution within and between the Earth's atmosphere, oceans, ground water, and ice sheets	Spacecraft ranging measurement of gravity anomaly	X		
Surface Biology & Geology	**Earth surface geology and biology,** ground/water temperature, snow reflectivity, active geologic processes, vegetation traits and algal biomass	Hyperspectral imagery in the visible and shortwave infrared, multi- or hyperspectral imagery in the thermal IR	X		
Surface Deformation & Change	**Earth surface dynamics** from earthquakes and landslides to ice sheets and permafrost	Interferometric Synthetic Aperture Radar (InSAR) with ionospheric correction	X		
Greenhouse Gases	**CO_2 and methane fluxes and trends,** global and regional with quantification of point sources and identification of source types	Multispectral short wave IR and thermal IR sounders; or lidar**		X	
Ice Elevation	**Global ice characterization** including elevation change of land ice to assess sea level contributions and freeboard height of sea ice to assess sea ice/ocean/atmosphere interaction	Lidar**		X	
Ocean Surface Winds & Currents	**Coincident high-accuracy currents and vector winds** to assess air-sea momentum exchange and to infer upwelling, upper ocean mixing, and sea-ice drift.	Radar scatterometer		X	
Ozone & Trace Gases	**Vertical profiles of ozone and trace gases** (including water vapor, CO, NO_2, methane, and N_2O) globally and with high spatial resolution	UV/IR/microwave limb/nadir sounding and UV/IR solar/stellar occultation		X	
Snow Depth & Snow Water Equivalent	**Snow depth and snow water equivalent** including high spatial resolution in mountain areas	Radar (Ka/Ku band) altimeter; or lidar**		X	
Terrestrial Ecosystem Structure	**3D structure of terrestrial ecosystem** including forest canopy and above ground biomass and changes in above ground carbon stock from processes such as deforestation & forest degradation	Lidar**		X	
Atmospheric Winds	**3D winds in troposphere/PBL** for transport of pollutants/carbon/aerosol and water vapor, wind energy, cloud dynamics and convection, and large-scale circulation	Active sensing (lidar, radar, scatterometer); passive imagery or radiometry-based atmos. motion vectors (AMVs) tracking; or lidar**		X	X
Planetary Boundary Layer	**Diurnal 3D PBL thermodynamic properties and 2D PBL structure** to understand the impact of PBL processes on weather and AQ through high vertical and temporal profiling of PBL temperature, moisture and heights.	Microwave, hyperspectral IR sounder(s) (e.g., in geo or small sat constellation), GPS radio occultation for diurnal PBL temperature and humidity and heights; water vapor profiling DIAL lidar; and lidar** for PBL height			X
Surface Topography & Vegetation	**High-resolution global topography** including bare surface land topography ice topography, vegetation structure, and shallow water bathymetry	Radar; or lidar**			X

** Could potentially be addressed by a multi-function lidar designed to address two or more of the Targeted Observables

Other ESAS 2017 Targeted Observables, not Allocated to a Flight Program Element

Aquatic Biogeochemistry	**Radiance Intercalibration**
Magnetic Field Changes	**Sea Surface Salinity**
Ocean Ecosystem Structure	**Soil Moisture**

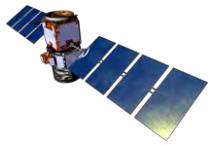
2017 Decadal Survey Progress Highlights

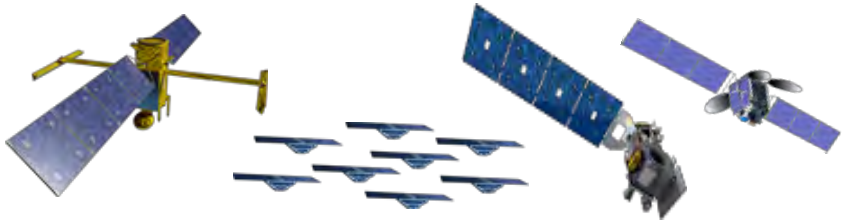
Earth Venture-Continuity

- DS recommended new Earth Venture Continuity Measurement strand ($150M full mission cost cap)
- In December 2018, ESD released EVC-1 solicitation **targeted for radiation budget** measurements
- Proposals were received in July 2019

Earth Science Explorers

- DS recommended a new competed Explorer flight line with $350M cost constraint
- Framework for program established
- **Implementation on hold pending budget developments**





Designated Observables

- DS identified 5 Designated Observables for mandatory acquisition
- In 2018 ESD initiated **4 multi-center Designated Observables studies**, continued in 2019:
  1. Combined: Aerosols-Clouds, Convection & Precipitation
  2. Mass Change
  3. Surface Biology & Geology
  4. Surface Deformation & Change

Decadal Incubation

- DS calls for Incubation Program to mature specific technologies for important — but presently immature — measurements (preparation for *next* Decadal)
- Solicitations for Study Teams (PBL and STV) released on March 14, 2019, **selections made**, AGU Town Halls set up for each

DO Annual Review Summary

- On Sept. 24-25, the DO Study Teams presented their year-one activities to the Earth Science Division
  - Teams have developed Science and Applications Traceability Matrices (SATMs)
  - Initial architectures and instrument capabilities have been developed
  - Teams have developed value frameworks to assess architectures
  - Some teams have identified (and/or issued) RFIs and/or needs for industry solicitations
  - Initial international engagement has started
  - Industry Engagement Working Group with members of the DO Teams will be established
  - Teams are ready to update their future plans

- The next DO meeting will be Jan. 29, 2020 to determine the ESD process for final architecture down selection

DO Study Points of Contact

Study	Program Executive	Program Scientist	Program Applications Lead	Technology POC	Centers Study Coordinator
ACCP	Tahani Amer	Hal Maring (*Alternates*: Gail Skofronick-Jackson, Barry Lefer)	John Haynes (*Alternate*: David Green)	Amber Emory (*Alternate*: Bob Connerton)	Vickie Moran (GSFC)
SBG	Marissa Herron	Woody Turner (*Alternates*: Ben Phillips, Laura Lorenzoni)	Woody Turner (*Alternate*: Brad Doorn)	Bob Connerton (*Alternate*: Mike Little)	Jamie Nastal (JPL)
SDC	Mitra Dutta	Gerald Bawden (*Alternates*: Hank Margolis, Mike Falkowski)	David Green	Bob Bauer (*Alternate*: Bob Connerton)	Paul Rosen (JPL)
MC	Amanda Whitehurst	Lucia Tsaoussi (*Alternate*: Jared Entin)	Brad Doorn	Bob Connerton (*Alternate*: Parminder Ghuman)	Bernard Bienstock (JPL)

International Engagement

- ESD leadership has conducted focused Decadal Survey telecons/meetings with international partners
  - JAXA, CNES, DLR, ESA, EUMETSAT, CSA
  - Further discussions with the broader international community continue

- Discussions are ongoing to explore potential international partnerships
  - Some directed international partnerships may originate from ESD
  - Multi-center DO studies are engaging potential international partners

- **ESD will make final partnership determinations** and then codify necessary international agreements

Federal-Civil Satellite Needs Assessment

Objective: Identify and communicate to NASA USG-civil agency requests for specific satellite-based Earth observation data and information products

Benefits:

- Captures information and insights regarding federal-civilian agency need and use of data acquired by Earth observing system satellites
- Allows focused discussion on creative approaches to meet the needs of federal partners
- Provides an opportunity for NASA to inform federal partners of current and future missions and data products that may be of relevance
- Provides an opportunity for the USG-civil agencies to identify and exploit synergies that may exist with NASA ESD strategy and programmatic goals

Scope: A 2-year cycle (biennial) was approved by USGEO. 2018 Satellite Need Survey Analysis and Response constitutes the second production cycle

Results:

- 2016-2017 Production Cycle identified 5 activities/data products funded in the FY19 budget cycle
- 2018-2019 Production Cycle identified 11 activities/data products yet to be funded

Big Data: Earth Science

Challenges

- Volume of data in NASA Earth science archives alone to increase to 250 Petabytes by 2025
- Multi-platform, multi-instrument, multi-program nature of the data

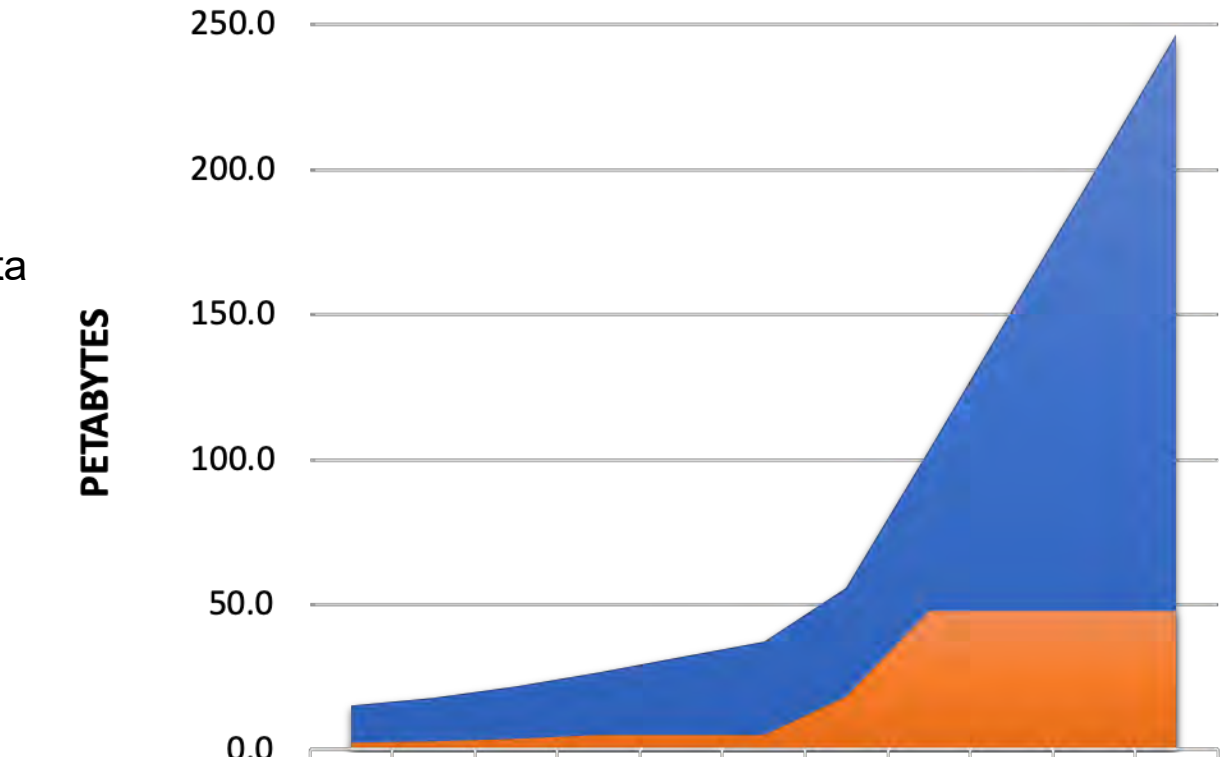
Need

- Efficiently handle storage and computation needs for large data volumes through new data management technologies and architectures

New paradigm is required

- Cloud offers performance and cost benefits
- Realize storage, processing and operational efficiencies
- Improve cross-archive center collaboration
- Enable users to work across multiple datasets managed by different archives without transmitting data over networks
- Supporting open science with open source software and open data

EARTH SCIENCE DATA SYSTEMS
earthdata.nasa.gov



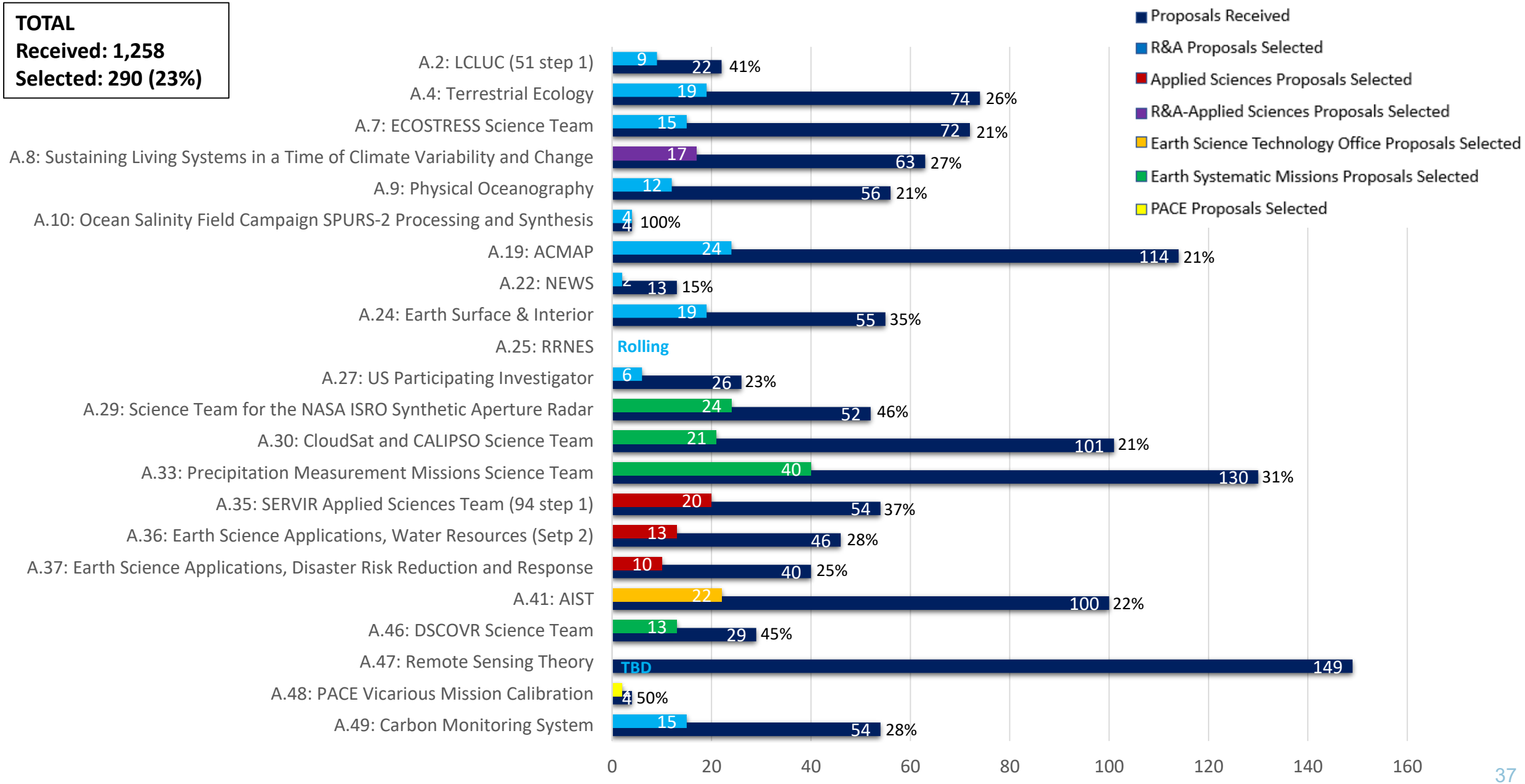
	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Archive Size (PB)	15.0	17.7	21.6	26.8	32.0	37.2	55.6	103.4	151.1	198.9	246.6
Annual Growth (PB)	2.6	2.8	3.9	5.2	5.2	5.2	18.4	47.7	47.7	47.7	47.7

NASA/ESD Funding/Appropriation

- FY19 (Oct.1, 2018-Sept. 30, 2019) funding – appropriated via an Omnibus – was $1.931B
- The FY19 budget supported continuation of a balanced ESD portfolio - Funding for all remaining elements of the ongoing Flight Program of Record
- The FY19 budget was consistent with, and partially addresses, the 2017 Decadal Survey recommendations
  - Supports DO study activities, EVC-1 solicitation, and incubation planning
  - Implementation of Earth Science Explorers is on hold pending budget developments
- President's FY20-24 detailed budget proposal released March 11, 2018
  - Proposes FY20 ESD funding at ~$1.78B
  - Continues to propose termination of PACE and CLARREO-PF
  - CR through Dec. 20

Summary of ROSES18 Selection Statistics

TOTAL
Received: 1,258
Selected: 290 (23%)

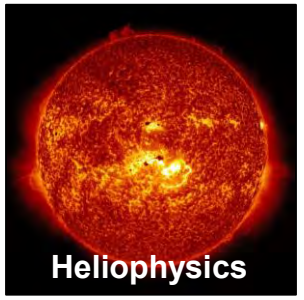


Dual-Anonymous Peer Review (DAPR) Pilot with ROSES-2020

- SMD is strongly committed to ensuring that the review of proposals is performed in an equitable and fair manner that reduces the impacts of any unconscious biases.
- ROSES-2020 will include dual-anonymous peer review pilot programs in all SMD science divisions.
- The process will be based on the successful Hubble Space Telescope dual-anonymous review process. In addition to proposers being unaware of the identity of reviewers, reviewers do not have explicit knowledge of the identities of the proposing teams.
  - Detailed instructions will be posted on the homepage of the program element in NSPIRES on how to anonymize their proposals.
  - SMD will hold a series of webinars on the process well in advance of proposal due dates.
- The Earth Science Division anticipates using the dual-anonymous peer review pilot with the Earth Science U.S. Participating Investigator program in ROSES-2020.
- Additional information will be forthcoming; contact Richard Eckman (richard.s.eckman@nasa.gov) or Daniel Evans (daniel.a.evans@nasa.gov) with any questions.

RFI: Research That Fills a Gap Between Current SMD Solicitations

- Release Date: Dec. 2, 2019 (Solicitation: NNH20ZDA003L)
- **Response Date: Jan. 31, 2020**
- The NASA Science Mission Directorate is soliciting information on research that is aligned with the Agency mission and SMD's Science Plan **but falls in a gap** between current solicitations, possibly because it is interdisciplinary or interdivisional
- Responses will be used by NASA to inform a decision as to whether the portfolio of current program elements in ROSES needs to be modified and/or expanded to provide the proper avenue for such research
- Full text of the RFI and response instructions at: https://nspires.nasaprs.com/external/solicitations/summary.do?solId=%7BD82B2B9A-5F6D-B0C6-741A-6950D1D6F0E1%7D&path=&method=init



AGU Selected Town Halls and Sessions

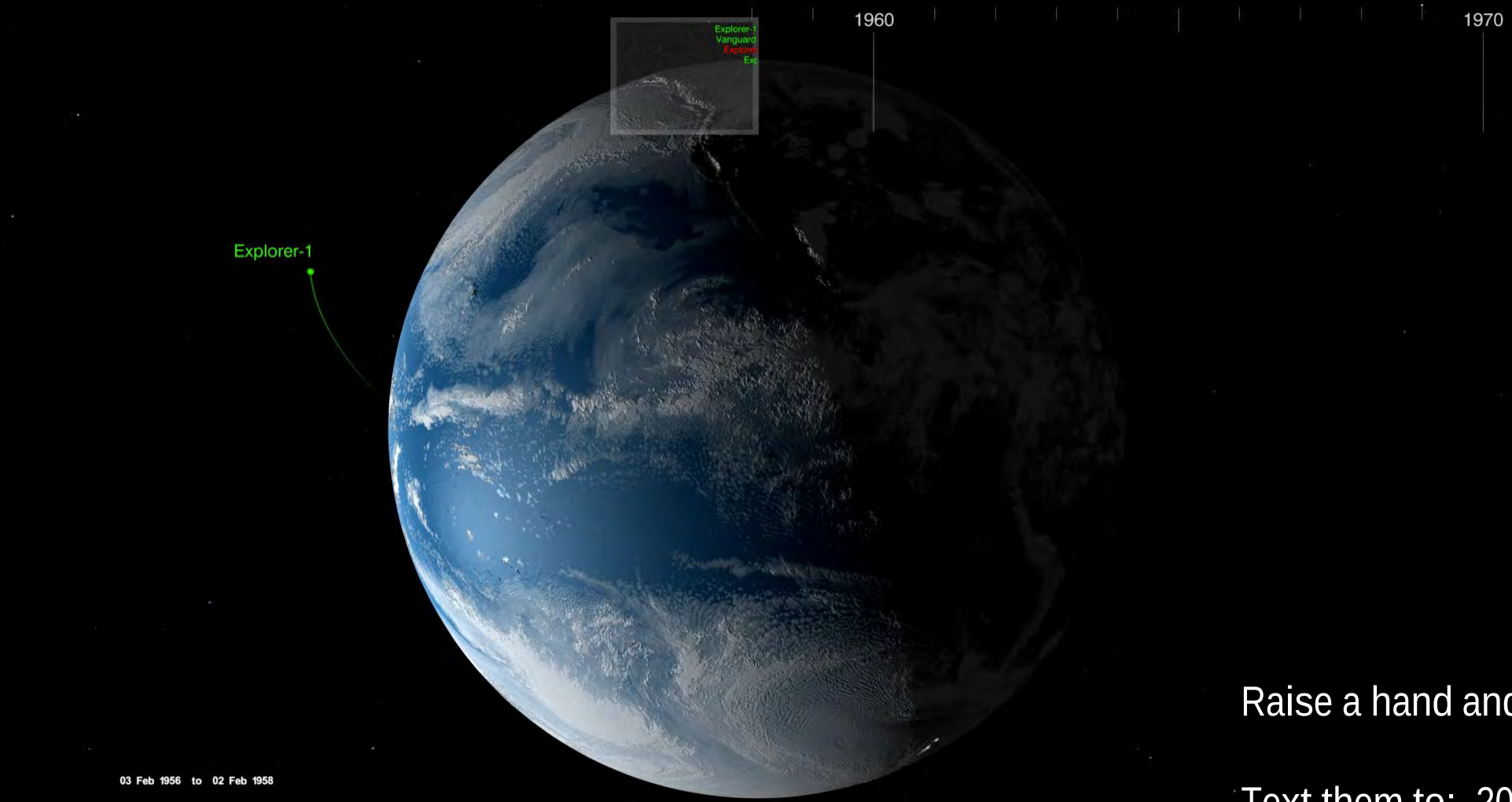
Decadal related:

- **Surface Deformation and Change (DO):** Monday, 12:30-1:30 (Moscone West 3005)
- **Aerosols, Clouds, Convection and Precipitation (DO):** Monday, 6:15-7:15 (Moscone West 3004)
- **Mass Change (DO):** Thursday, 12:30-1:30 (Moscone West 2004)
- **Incubation PBL:** Thursday, 6:15-7:15 (Moscone West 3004)
- **Incubation ST&V:** Tuesday, 6:15-7:15 (Moscone West 3004)
- **Surface Biology:** Friday
  - 08:00-12:20 Poster Session: **GC51E Advances Toward Global Imaging Spectroscopy and Thermal Infrared Measurements III (**Moscone South, Poster Hall)
  - 1:40-3:40 Oral Session: **GC53A Advances Toward Global Imaging Spectroscopy and Thermal Infrared Measurements I** (Moscone West 2003)
  - 4:00-6:00 Oral Session: **GC54A Advances Toward Global Imaging Spectroscopy and Thermal Infrared Measurements II** (Moscone West 2003)

Others:

- **NASA Sea Level Change Team:** Tuesday, 6:15-7:15 (Moscone West 2016)
- **NASA SnowEx Planning:** Thursday, 12:30-1:30 (Moscone West 2005)

Got comments? Got Questions?



Raise a hand and ask directly

Text them to: 202.997.4812

NASA Earth Observing Satellites since 1958