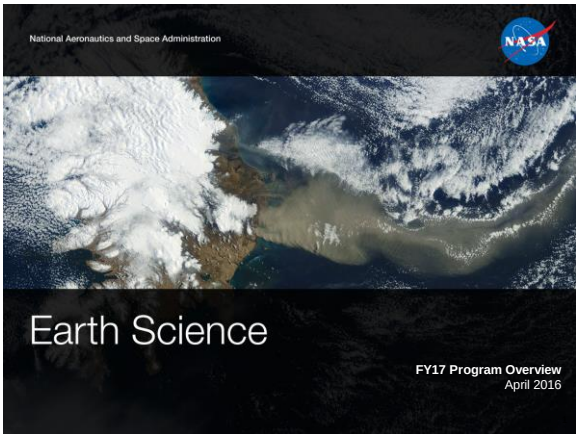
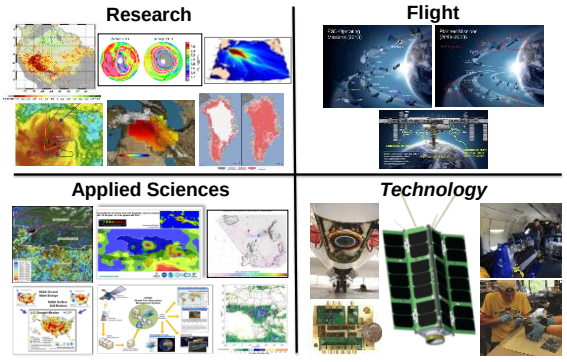


NASA's Earth Science Division



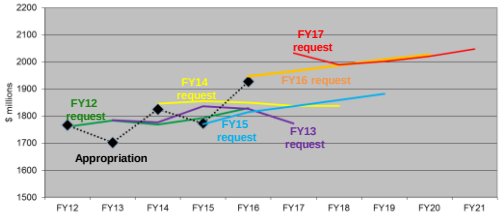
ESD Budget/Program Overview

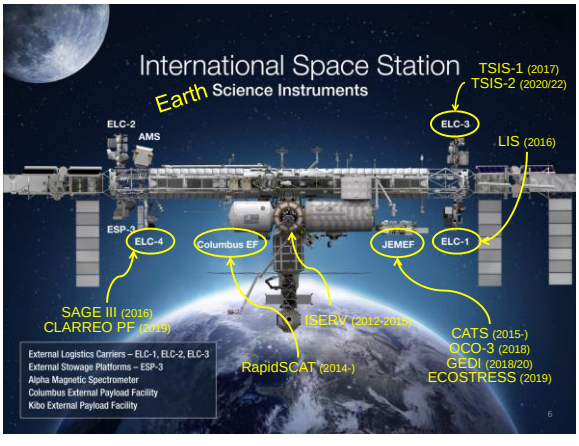
- The FY17-21 ESD program is executable and balanced, *informed by and consistent with Decadal Survey and national Administration priorities*:
  - **advances Earth system science**
  - **delivers societal benefit through applications development and testing**
  - **provides essential global spaceborne measurements supporting science and operations**
  - **develops and demonstrates technologies for next-generation measurements, and**
  - **complements and is coordinated with activities of other agencies and international partners**
- Funds operations and core data production for on-orbit missions in prime and extended phases, in keeping with 2015 Senior Review recommendations/decisions. Funds NASA portal for Copernicus and other international missions, increasing DAAC capability to host added NASA missions
- Completes high priority missions**: SAGE-III/ISS, ICESat-2, CYGNSS, GRACE-FO, SWOT, TEMPO, RBI, OMPS-Limb, TSIS-1 and -2, CLARREO Pathfinder, Jason-CS/Sentinel-6A,Landsat-9, NISAR**
- Develops (for launch beyond budget window)**: PACE, Landsat-10, Jason-CS/Sentinel-6B**
- Continues all originally **planned Venture Class** solicitations/selections on schedule
- Conducts limited Decadal mission studies, pending release of the 2nd ESAS Decadal Survey ~Jul 2017
- Supports non-flight elements**: Research, Applied Sciences, and Technology Development**
- Provides support to **National Climate Assessment, USGCRP**, international coordination activities **(CEOS and GEO)**, **USGEO, Carbon Monitoring System**, data-related activities (**CDI, BEDI, GCIS**) in support of the Administration's climate initiative, and **GLOBE**

ESD Budget: FY17 Request/Appropriation

ESD Total						
$M	FY16 (op plan)	FY17	FY18	FY19	FY20	FY21
FY16 PBS	$ 1,927	$ 1,966	$ 1,988	$ 2,009	$ 2,027	
FY17 PBS		$ 2,032	$ 1,990	$ 2,001	$ 2,021	$ 2,048

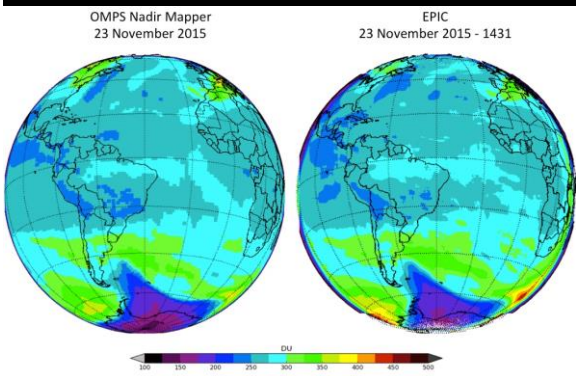
- *ESD budget jumps significantly in FY17 – then becomes consistent with FY16 President's Budget Request for the out-years*

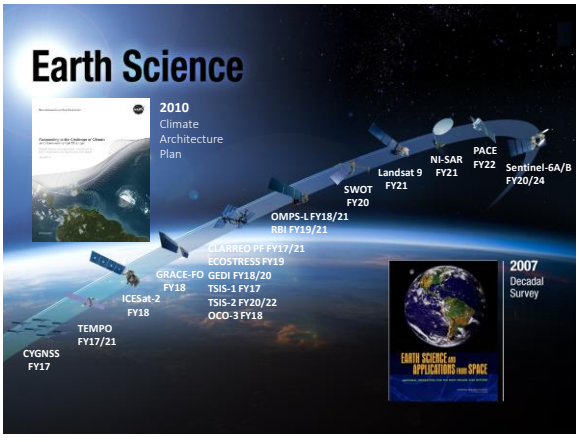




DSCOVR – EPIC Camera: Lunar Transit from Earth-Sun L1

Stratospheric Ozone from LEO (OMPS) and L1 (EPIC)





ELEMENT SUMMARY: Flight

- Continues development and launch of: SAGE-III/ISS, ECOSTRESS/ISS, GEDI/ISS, CYGNSS, TEMPO, RBI, OMPS-Limb, TSIS-1/2, GRACE-FO, ICESat-2, SWOT, NISAR, PACE, CLARREO Pathfinder/ISS, Sentinel-6A **and -6B**

- Sustainable Land Imaging Program (w/USGS; NASA funds flight hardware):
  - Full Class-B Landsat-9 to launch in FY2021
  - Focused technology development to inform designs of Landsat-10+
  - Begins Landsat-10 late in budget window, for launch in 2027-2028
- Continues Venture Class - on schedule with full funding
- Completes OCO-3 delivered 3/2018, launched to ISS ~6/2018
- Initiates Small Satellite Constellation effort (FY17 only! – ESSP-PO)

Venture Class Selections/Solicitations

Mission	Mission Type	Release Date	Selection Date	Major Milestone
EV-1, aka EVS-1	CARVE, ATTREX, HS3, AirMOSS, DISCOVER-AQ	2009	2010	N/A
EVM-1, CYGNSS	Smallsat constellation	2011	2012	LRD October 2016
EVI-1, TEMPO	Geosynchronous hosted payload	2011	2012	Delivery NLT 2017
EVI-2, ECOSTRESS & GEDI	Class C & Class D ISS-hosted Instruments	2013	2014	Delivery NLT 2019
EVS-2	OMG, ORACLES, CORAL, NAAMES, ATom, ACT-America	2013	2014	Ended (KDP-F)
EVI-3	MAIA, TROPICS	2015	2016	Delivery NLT 2021
EVM-2	Full Orbital	2015	2016	Launch ~2021
EVI-4	Instrument Only	2016	2017	Delivery NLT 2021
EVS-3	Suborbital Airborne Campaigns	2017	2018	Initiating/Confirmation Rev.
EVI-5	Instrument Only	2018	2019	Delivery NLT 2023
EVM-3	Full Orbital	2019	2020	Launch ~2025
EVI-6	Instrument Only	2019	2020	Delivery NLT 2024

Open solicitation
Completed solicitation

EVS-1: CARVE, ATTREX, DISCOVER-AQ, AirMOSS, HS-3
EVM-1: CYGNSS (10/2016 LRD)
EVI-1: TEMPO (2019-; 2017 instrument delivery)
EVI-2: GEDI (2019; 2018 del.); ECOSTRESS (10/2017; 5/2017 del.)
EVS-2: ATom, NAAMES, OMG, ORACLES, ACT-America, CORAL
EVI-3: MAIA (polarimeter), TROPICS (12-sat cubesat constellation) selected
EVM-2: *Selection(s) likely by end of FY2016*

Earth Science Research

Focus Areas

Carbon cycle and Ecosystems

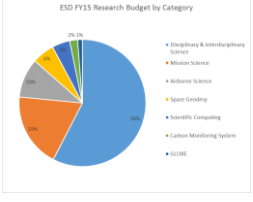
Climate Variability and Change

Atmospheric Composition

Global Water and Energy Cycle

Earth Surface and Interior

Weather



Mission	Location(s)	Date(s)	Platform(s)	Summary of Mission
Aviris NG India	Hyderabad India	Dec 15 – Spring 16	~200-250D aircraft	Imaging spectroscopy science and application investigation over Indian territory
AfriSAR/G-TEC	Gabon Africa	Feb – Mar 16	B200, C20A	NASA/ESA collaboration on algorithm development and future mission cal/val activities for above-ground biomass and ecosystem structure and dynamics usint radar and lidar.
Korus-AQ	Korea	Spring 16	DC8, B200	Study sources of pollution in atmosphere over Korea and Western Pacific region using a mix of in situ and remote sensing capability while enhancing understanding of future geostationary atmospheric composition observations
Atmospheric Carbon and Transport – America	Eastern and Midwestern US	Summer 16, Spring 17, Fall 17, Summer 18	B200, C-130	Quantify the sources of regional carbon dioxide, methane and other gases, and document how weather systems transport these gases in the atmosphere; improve identification and predictions of carbon dioxide and methane sources and sinks over the eastern US
North Atlantic Aerosols and Marine Ecosystems Study (NAAMES)	Atlantic Ocean, flown from Canada	Sep 17, Mar/Apr 18,	C-130, Ship ((UNOLS) research vessel)	Environmental and ecological controls on plankton communities in the North Atlantic Ocean
Coral Reef Airborne Laboratory (CORAL)	FL, HI, Mariana Is., Palau, Australia	Apr 16 – Jan 17	Contracted GIV	Provide critical data and new models needed to analyze the status of coral reefs and to predict their future
Observations of Aerosols Above Clouds and Their InteractionS (ORACLES)	Namibia, Africa	Aug/Sep 16, Jul/Aug 17, Sep/Oct 18	P-3, ER-2	Investigate how smoke particles from massive biomass burning in Africa influences cloud cover over the Atlantic.
Oceans Melting Greenland (OMG)	Greenland	Sep/Oct 16 - + multiple till Sept/Oct 2019	Contracted Twin Otter, GIII, Ship (MV Cape Race)	Investigate the role of warmer saltier Atlantic subsurface waters in Greenland glacier melting. The study will help pave the way for improved estimates of future sea level rise.
Atmospheric Tomography Experiment (ATom)	Around the Globe	Aug 16, Jan/Feb 17, Sep/Oct 17, Apr/May 18	DC-8	Study the impact of human-produced air pollution on multiple greenhouse gases, addressing transformation of various air pollutants, especially methane and ozone.
CO2/N2 Ratio and CO2 Airborne Southern Ocean (ORCAS)	Southern Ocean	Jan/Feb 16	GV (NSF)	NASA brings remote sensing (PRISM) capability to NSF-led mission to investigate the large-scale tropospheric distributions, gradients, and fluxes of O2 and CO2 over Southern Ocean.
HyspIRI	Hawaii	Summer 16	ER-2	Study the optical characteristics of coral reef and volcanic systems in and around Hawaii using MASTER and AVIRIS to assess value of HyspIRI-like observations.
Operation IceBridge	Alaska, Greenland, Antarctica	Mar – May, Oct/Nov – FY16,17,18,19	P-3, DC-8	Study ice sheet thickness, sea ice distributions, and related parameters over Arctic and Antarctic to bridge gap between ICESat-1 and ICESat-2, complement lidar observations with those using related techniques (e.g., radar) and obtain coincident data with ESA CryoSat-2
UAVSAR	Various US and South America	Year round	C-20	Radar data collected for multiple NASA focus areas (Earth Surface and Interior, Carbon Cycle and Ecosystems, Global Water and Energy Cycle, Climate Variability and Change) and for Applications Uses (e.g., levee monitoring)
SPURS II	Eastern Sub-Tropical Pacific Ocean	Starting spring 2016, multiple sailings covering 18 month period	Schooner Lady Amber plus in-water observations (e.g., gliders, drifters, buoys)	Study processes that control sea surface salinity in higher salinity region than that sampled in SPURS I (sub-tropical North Atlantic)
AllceVE	Alaska, NW Canada	Beginning 2016, continuing	Surface measurements; airborne to follow	Study vulnerability and resilience of Arctic ecosystems to environmental change in the Arctic and boreal region of western North America

SMD Earth Science Division — Applied Sciences Program

Applications
Health & Air Quality
Ecological Forecasting
Water Resources
Disaster Applications & Response Team
Wildfires (through FY17)

Capacity Building
SERVIR (joint with USAID)
ARSET, Applied Remote Sensing Training
DEVELOP

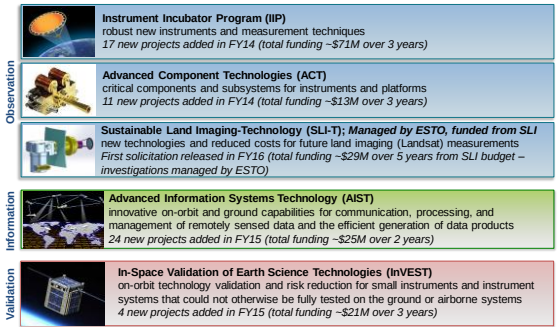
Satellite Mission Planning
Early Adopters, Apps. Workshops

Program-wide
Socioeconomic Impact Analyses
Community Utilities (ESIP, NEX, etc.)
Communications
GEO and USGEO Support

President's FY17 Budget Request

- **Re-establishes funds for full SERVIR Applied Sciences Team FY16-18; expands Team in FY19-21 for increase to 6 SERVIR hubs by 2018**
- **Increases funding for Applications Areas (via internal re-allocation)**
- **Implements Snow & Water Availability focused activity for Western States**
- **Implements Food Security Consortium**
- **Implements Disaster Response Plan for increased preparation-based approach**
- **Continues activities to develop techniques to quantify social and economic benefits from Earth science applications**

Earth Science Technology Office



ESM and ESSP Program Overviews

- The Earth Systematic Missions (ESM) ***development*** missions in this period include:
  - ICESat-2, SAGE III, GRACE-FO, SWOT, Landsat-9, RBI, TSIS-1 and -2, OMPS-Limb, NISAR, PACE, Jason CS/Sentinel 6A and -B, CLARREO Pathfinder
- The Earth Systematic Missions (ESM) ***on-orbit**** missions include:
  - SMAP (>2021), DSCOVR (2019), S-NPP (>2021), GPM (>2021), LDCM (>2021), Terra (>2021), Aqua (>2021), Aura (>2021), OSTM (>2021), QuikScat (2015), SORCE (2017), and EO-1 (2016); also RapidScat (2017) and CATS (>2016)

- The Earth System Science Pathfinder (ESSP) ***development*** missions in this period include:
  - OCO-3, CYGNSS, TEMPO, GEDI, ECOSTRESS
  - EVS-2 and -3 and Venture Technology selections (GrAOWL, Tempest), EVM-2 & 3, EVI-3, 4, 5, and 6
- The Earth System Science Pathfinder (ESSP) ***on-orbit*** missions include:
  - OCO-2 (>2021), GRACE (2018), CALIPSO (>2021), CloudSat (2018), Aquarius (>2021)

**On-orbit dates correspond to end-of-mission assumptions, consistent with 2015 Sr. Review*