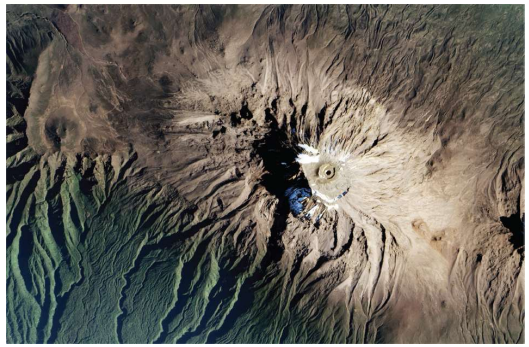
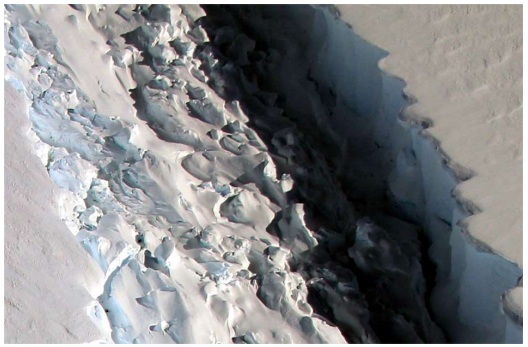
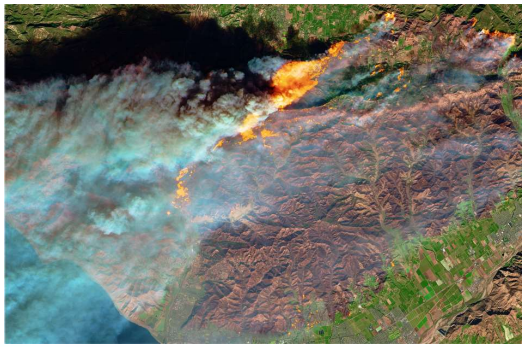
SCIENCE

Decadal Survey Community Forum

Sandra Cauffman
Acting Director, Earth Science Division

March 4, 2019

Questions Process

- This call is monitored by an Operator. When you enter the call, the Operator will ask for your name.
- When it is time for questions, please press *1 on your phone to indicate to the Operator that you have a question.
- The Operator will introduce by name, then you can ask your question and any follow up questions you may have.
- When done, the Operator will re-mute your line and introduce the next person.
- Please also email your question to **Amy Treat at Amy.A.Treat@nasa.gov** so we can record the question and it's answer on our website.

Outline

- ESD Budget News
- ESD Flight Program
- Recap: 2017 Earth Science and Applications Decadal Survey
- Updates on Designated Observables (DO) (one slide per study)
- Industry Engagement in DO Studies
- Earth Venture Continuity (EVC)-1
- Incubation Program Strategy
- International Engagement
- What's next?
- Questions

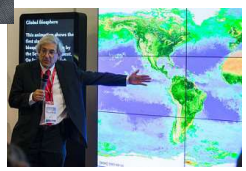
Thank you, Mike!

Michael H. Freilich

On February 28, 2019, Mike Freilich retired as the Director of the Earth Science Division at NASA Headquarters.

Over his 12 years as Director, Mike made a strong, lasting impression on the Division and its character and operations. Achievements throughout the Earth Science community reflect his impact and leadership.

Thank you, Mike, for your service to NASA, the nation, and Earth science!



ESD Leadership Team

Sandra Cauffman
Director (Acting), Earth Science Division
Science Mission Directorate
NASA Headquarters

Pat Jacobberger
Senior Advisor

Eric Ianson
Associate Director for Flight

Jack Kaye
Associate Director for Research

Pam Millar
Associate Director for Technology (ESTO)

Lawrence Friedl
Associate Director for Applied Sciences

Kim Hurst
ESD International Relations Lead

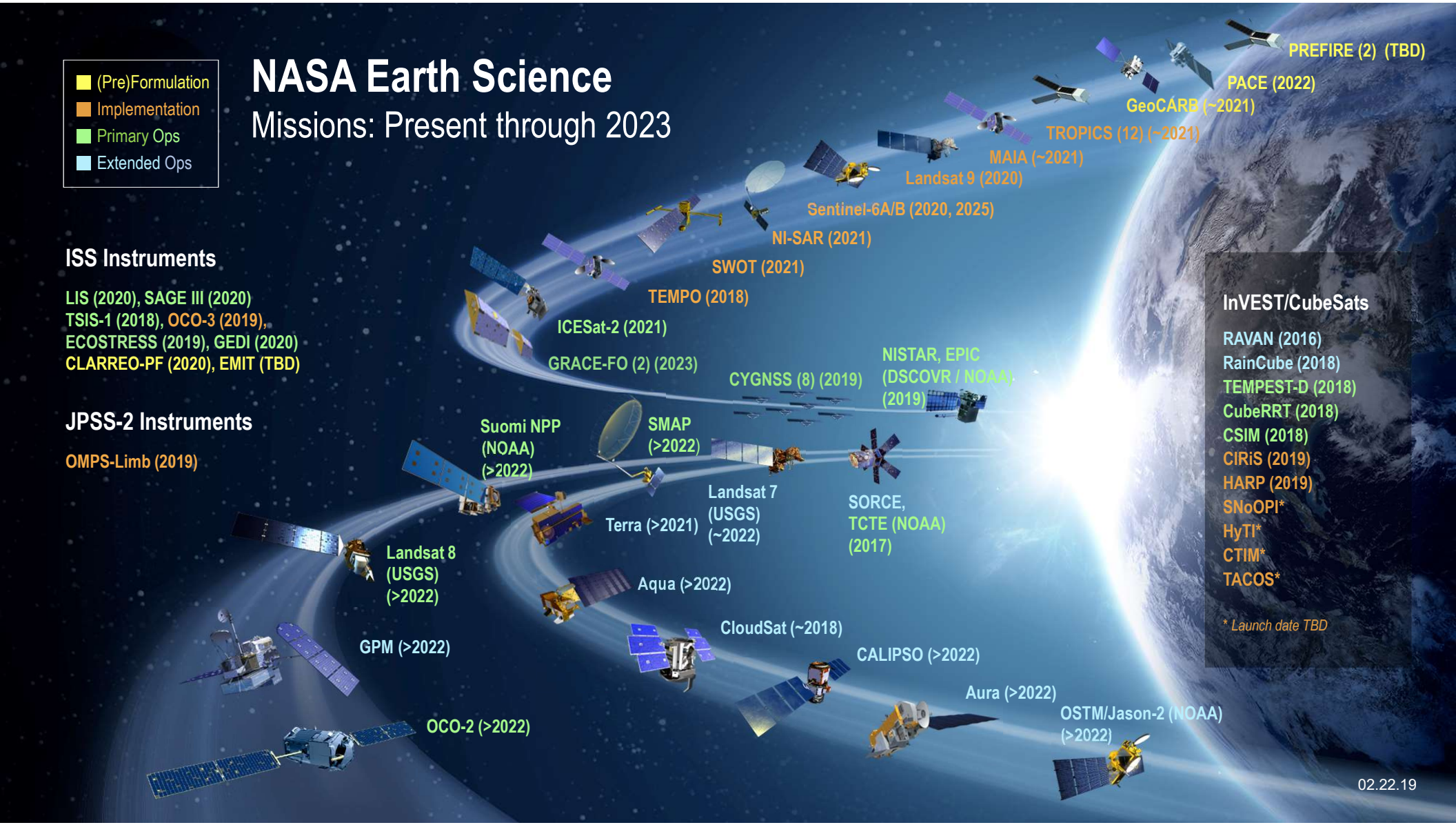
ESD Budget News

NASA/ESD Appropriation: FY19

- FY19 (1 Oct 2018 – 30 Sept 2019) funding approximately at the FY17/FY18 level (~$1.93B)

- The budget is consistent with, and partially addresses, the 2017 Decadal Survey recommendations
  - Continues operations and development of Program of Record (including DSCOVR EPIC/NISTAR, PACE, CLARREO-PF, OCO-3 (to launch NET April 25)
  - Supports DO study activities, EVC-1 solicitation, and incubation planning

ESD Flight Program


(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 (2019)
PREFIRE (2) (TBD)
PACE (2022)
GeoCARB (~2021)
TROPICS (12) (~2021)
MAIA (~2021)
Landsat 9 (2020)
Sentinel-6A/B (2020, 2025)
NI-SAR (2021)
SWOT (2021)
TEMPO (2018)
ICESat-2 (2021)
GRACE-FO (2) (2023)
CYGNSS (8) (2019)
NISTAR, EPIC
(DSCOVR / NOAA)
(2019)
Suomi NPP
(NOAA)
(>2022)
SMAP
(>2022)
Landsat 7
(USGS)
(~2022)
Terra (>2021)
SORCE,
TCTE (NOAA)
(2017)
Landsat 8
(USGS)
(>2022)
Aqua (>2022)
GPM (>2022)
CloudSat (~2018)
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)
CIRiS (2019)
HARP (2019)
SNoOPI*
HyTI*
CTIM*
TACOS*
* Launch date TBD
02.22.19

Recent ESD Launches

ICESat-2

September 2018

GEDI

November 2018

ICESat-2 *Quantify polar ice-sheet contributions to sea-level change & measure vegetation canopy height as a basis for estimating large-scale biomass and biomass change*

GEDI *Characterize the effects of changing climate and land use on ecosystem structure and dynamics, providing the first global, high-resolution observations of forest vertical structure*

Planned for Launch in 2019

OCO-3

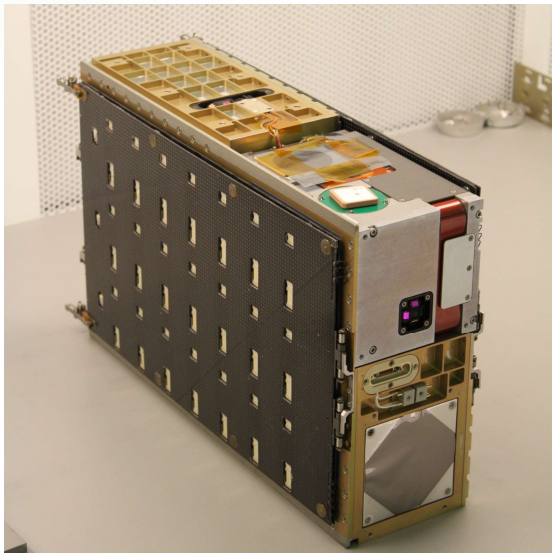
February 2019

OCO-3 *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.*

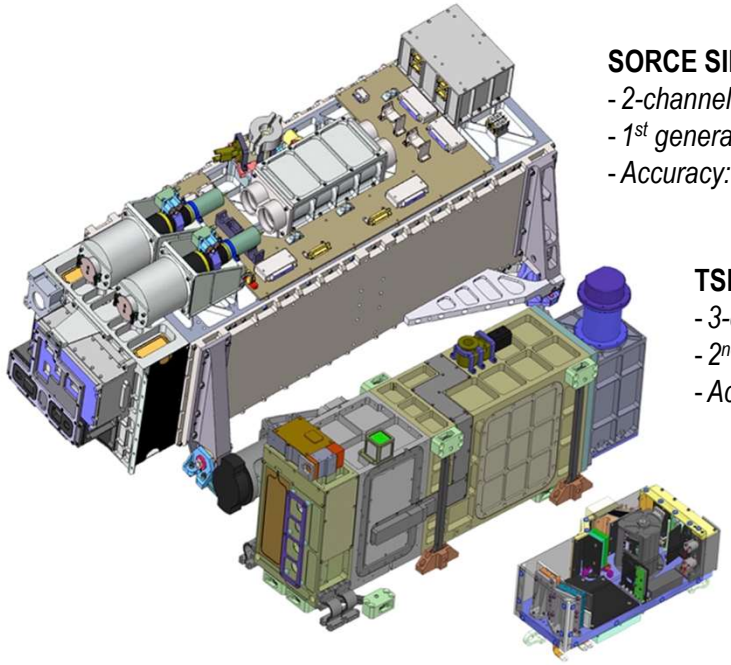
Earth Science Technology Highlight

Compact Spectral Irradiance Monitor CubeSat Launched

On December 3, 2018, the Compact Spectral Irradiance Monitor (CSIM) CubeSat was launched into a sun-synchronous orbit onboard a SpaceX Falcon 9 rocket as part of a ride-share mission (Spaceflight SmallSat Express). Developed through a 2013 IIP grant at LASP/UC-Boulder, CSIM is an ultra-compact, solar spectral irradiance (SSI) monitor covering 200-2400 nm with the required SI-traceable accuracy and on-orbit stability to meet solar input measurement requirements for establishing benchmark climate records. The instrument design and layout marks a significant departure from the previous SIM instruments, ***achieving large reductions in mass, volume, and power requirements***, ***and enabling a flight-qualified instrument in a 6U CubeSat package***. With operations planned to extend for one year, the CSIM project will validate performance against SSI measurements being made by the SORCE SIM (Solar Radiation and Climate Experiment Spectral Irradiance Monitor) and the TSIS SIM (Total and Spectral Solar Irradiance Sensor Spectral Irradiance Monitor), and demonstrate that climate data record SSI measurements can be maintained by a CubeSat-sized instrument.



The CSIM CubeSat



SORCE SIM (launched 2003)
- *2-channel instrument*
- *1st generation absolute ESR detector (NiP bolometer)*
- *Accuracy: 2-10% wavelength dependent (no SI validation)*

TSIS SIM (2018 planned launch)
- *3-channel instrument*
- *2nd generation absolute ESR detector (NiP bolometer)*
- *Accuracy: 0.2% (SI-traceable validation)*

CSIM (2018 planned launch)
- *2-channel instrument*
- *3rd generation absolute ESR detector (best noise performance to date)*
- *Accuracy: 0.2% (SI-traceable validation)*

Principal Investigator: Erik Richard, LASP

Earth Science Division's Venture Opportunities

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)
(~18 months)

Mission	Mission Type	Release Date	Selection Date	Major Milestone
EV-1, aka EVS-1	5 Suborbital Airborne Campaigns	2009	2010	N/A
EVM-1, CYGNSS	Smallsat constellation	2011	2012	Launched Dec 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	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
EVI-4, EMIT, PREFIRE	Instrument Only	2016	2017	Delivery NLT 2021
EVS-3	Suborbital Airborne Campaigns	2017	2018	N/A
EVI-5	Instrument Only	2018	2019	Delivery NLT 2023
EVC-1	Radiation Budget Measurement	2018	2019	Delivery NLT 2024
EVM-3	Full Orbital	2019	2020	Launch ~2025
EVS-4	Suborbital Airborne Campaigns	2021	2022	N/A
EVI-6	Instrument Only	2020	2021	Delivery NLT 2026
EVC-2	Continutity Measurment	2021	2022	Delivery NLT 2027

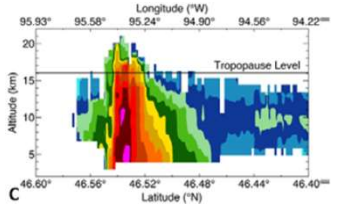
5 investigations selected for EVS-3

Open solicitation - In Review
Completed solicitation

Earth Venture Suborbital-3 Selections

On September 25, 2018, Five 5-year investigations were selected from 30 proposals under the 2017 Earth Venture Suborbital-3 (EVS-3) solicitation, which sought complete, suborbital, principal investigator-led investigations to conduct innovative, integrated, hypothesis or science question-driven approaches to pressing Earth system science issues. A total of six NASA centers and 27 educational institutions are participating in these five Earth Venture projects. Four of these investigations include infusions of ESTO technologies.

DCOTTS - Dynamics and Chemistry of the Summer Stratosphere – Kenneth Bowman, Texas A&M University
The primary goal of the mission is to understand how dynamical and chemical processes interact to determine the composition of the extratropical stratosphere, and how that composition may change in response to ongoing changes in the climate system.

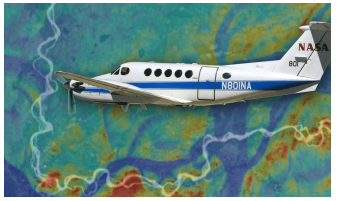


S-MODE (Submesoscale Ocean Dynamics and Vertical Transport) – Thomas Farrar, Woods Hole Oceanographic Institute. *S-MODE will test the hypothesis that submesoscale ocean dynamics make important contributions to vertical exchange of climate and biological variables in the upper ocean. The experiment will utilize several new instruments developed under ESTO, including the Ka-band Doppler Scatterometer (DopplerScatt: Perkovic-Martin, JPL; see left) and the the Portable Remote Imaging Spectrometer (PRISM: Mouroulis, JPL) to provide an unprecedented view of submesoscale eddies and fronts and their effects on vertical transport in the upper ocean.*

IMPACTS (Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms) – Lynn McMurdie, University of Washington, Seattle. Using instruments carried by the high-altitude ER-2 aircraft, IMPACTS will provide important observations for understanding the mechanisms of snow band formation and evolution within winter storms, as well as data for future mission design and model improvements. Among the instruments IMPACTS will utilize is the dual frequency (Ku- and Ka-band) High-Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP: Heymsfield, GSFC; see right) as well as a W-band antenna developed for the W-band Cloud Radar System (Racette and Li, GSFC).

ACTIVATE (Aerosol Cloud Meteorology Interactions Over the Western Atlantic Experiment) – Armin Sorooshian, University of Arizona. ACTIVATE will study interactions of aerosol particles and clouds, one of the largest uncertainties in global radiative forcing estimates. To characterize cloud and aerosols in the atmosphere, ACTIVATE will use the High Spectral Resolution Lidar-2 (HSRL-2: Hostetler, LaRC; see left), an operational instrument that has emerged through several rounds of technology investment.

Delta-X: Enabling Deltas to Thrive in a Century of Rising Seas – Marc Simard, Jet Propulsion Laboratory.
Delta-X will use state-of-the-art airborne remote sensing and in situ instruments to calibrate hydrology, sediment transport and plant productivity models around the Mississippi delta floodplain in order to understand potential impacts of sea-level rise. Delta-X will utilize the Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR: Hemsley and Lou, JPL) for land vegetation measurements, the Airborne Surface Water and Ocean Topography (AirSWOT: Rodriguez, JPL; see illustration at right) for water surface elevation measurements, and the Airborne Visible InfraRed Imaging Spectrometer - Next Generation (AVIRIS-NG: Green, JPL) for spectral measurements of ecosystem, geology and soil.



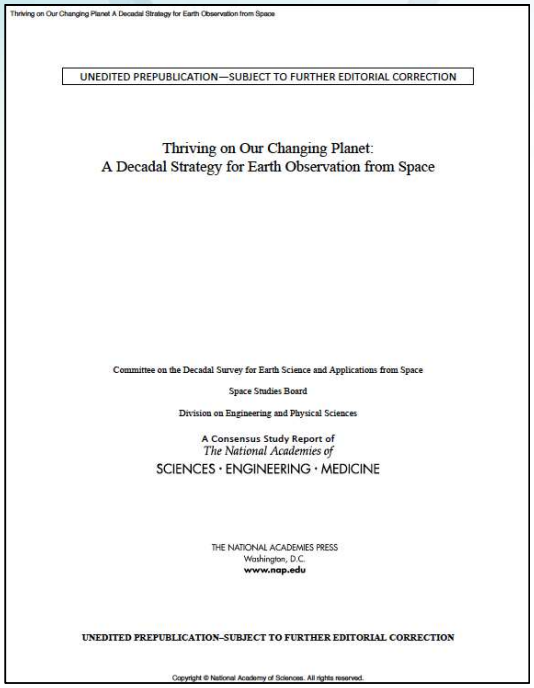
Private Sector Small-Satellite Constellation Pilot - Update

- Awarded contracts to three companies to buys ***existing*** data products related to ECVs, derived from private sector-funded small-satellite ***constellations*** (3-satellite minimum constellation, full longitude coverage); ***for evaluation by NASA researchers to determine value*** for advancing NASA research and applications activities and objectives;
  - Planet – three satellite constellations including 200+ satellites supplying imagery and derived products over the entire Earth
  - DigitalGlobe – operates five satellite constellations that provide very high-resolution (31-50-cm) images
  - Spire – constellation of 48 satellites collecting Radio Occultation soundings and ship reports
- Provides a cost-effective means to augment and complement the suite of Earth Observations
- Acquires data sets, and information products and associated meta-data, through industry partners
- **Have engaged broad set of ESD-funded researchers who will *assess the value of the geophysical information in the data products for advancing NASA research and applications objectives***
  - 1 year evaluation period
  - Participants primarily chosen from existing ESD-funded community – evaluation support as budget augmentation
  - Written reports to ESD (not scientific papers)
  - Quality of geophysical information
  - Data availability (latency) and subdistribution rights vs. cost
  - Vendor plans for constellation maintenance/evolution
- Expect on-ramps in the future

Recap: 2017 Earth Science and Applications Decadal Survey

Quick Recap: 2017 Decadal Survey

2017 DECADAL SURVEY


Thriving on Our Changing Planet A Decadal Strategy for Earth Observation from Space

UNEDITED PREPUBLICATION—SUBJECT TO FURTHER EDITORIAL CORRECTION

Thriving on Our Changing Planet:
A Decadal Strategy for Earth Observation from Space

Committee on the Decadal Survey for Earth Science and Applications from Space

Space Studies Board

Division on Engineering and Physical Sciences

A Consensus Study Report of
The National Academies of
SCIENCES · ENGINEERING · MEDICINE

THE NATIONAL ACADEMIES PRESS
Washington, D.C.
www.nap.edu

UNEDITED PREPUBLICATION-SUBJECT TO FURTHER EDITORIAL CORRECTION

- Publicly released January 5, 2018
- Supports the ESD (and international) *Program of Record*
- Prioritizes *observations* rather than specific missions
- Emphasis on *competition* as cost-control method
- Explicitly allows *implementation flexibility*
- Explicitly encourages *international partnerships*
- Endorses *existing balances* in ESD portfolio

ESAS 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**

Updates on Designated Observables (DO) Studies

Designated Observables Summary as Described in the Decadal Survey

Observable	Science/Applications Summary	Candidate Measurement Approach	ESAS maximum cost
Aerosols	**Aerosol properties, aerosol vertical profiles, and cloud properties** to understand their effects on climate and air quality	Backscatter lidar and multichannel/multi-angle/polarization imaging radiometer flown together on the same platform	CATE Cap $800M
Clouds, Convection, And Precipitation	**Coupled cloud-precipitation state and dynamics** for monitoring global hydrological cycle and understanding contributing processes including cloud feedback	Radar(s), with multi-frequency passive microwave and sub-mm radiometer	CATE Cap $800M
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	Est Cap $300M
Surface Biology and 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	CATE Cap $650M
Surface Deformation and Change	**Earth surface dynamics** from earthquakes and landslides to ice sheets and permafrost	Interferometric Synthetic Aperture Radar (InSAR) with ionospheric correction	Est Cap $500M

DO Studies

- The studies are examining approaches for:
  - Incorporating non-traditional architectures (e.g., commercial solutions, partial solutions, smallsat constellation solutions, etc.),
  - the possible use of other sampling platforms (e.g., aircraft, suborbital, etc.),
  - innovative development approaches including how design of a spacecraft without knowing instrument interfaces - or vice versa
  - new technologies

- Each study will also assess the impacts of the designated observables on applications for society and decision-making

Surface Biology and Geology (SBG) Study:
Updates, Next Steps, and Opportunities for Engagement

ESD Lead – Woody Turner (woody.turner@nasa.gov)

- Updates and Next Steps:
  - Four Research and Applications (R&A) Working Groups established for *Algorithms, Applications, Cal-Val,* and *Modeling*
  - Architecture studies and R&A Traceability Matrix underway at Centers
- Opportunities for Engagement:
  - February/March 2019 – Development of public website to share SBG information
  - Early Summer 2019 – Planning SBG All Hands Meeting in DC area

Aerosols, Clouds, Convection and Precipitation (ACCP) Study: Updates, Next Steps, and Opportunities for Engagement

ESD Lead – Hal Maring (hal.maring@nasa.gov)

- Updates and Next Steps:
  - SATM (Science/Application Traceability Matrix) under development
  - Preparation for Architecture construction and collaborative design underway
- Opportunities for Engagement:
  - Website in development
  - February – March: Iterations on draft SATM with ACCP community & Science Community Cohort
  - March - RFI release (for instrument concept specs)
  - April 2-4 – Community Workshop in Pasadena

Surface Deformation and Change (SDC) Study: Updates, Next Steps, and Opportunities for Engagement

ESD Lead – Gerald Bawden (gerald.w.bawden@nasa.gov)

- Updates and Next Steps:
  - SATM (Science/Application Traceability Matrix) under development
  - Began modifying the NISAR Performance Tool to support SDC capabilities
  - Draft of Research & Applications work charter and work plan developed
  - Initiated SAR constellation performance modeling
- Opportunities for Engagement
  - Website in development
  - Apr 28-May 1: SDC Research and Applications Workshop, Pasadena
  - May 20-22: SAR Technology Workshop, Pasadena
  - Sep 26-28: Second Research and Applications Workshop, TBD (LaRC or GSFC)

Mass Change (MC) Study: Updates, Next Steps, and Opportunities for Engagement

ESD Lead –Lucia Tsaoussi (lucia.s.tsaoussi@nasa.gov)

- Updates and Next Steps:
  - Science and Applications Traceability Matrix baseline in development
  - Candidate architectures will be developed and assessed following SATM baselining
  - Current phase also focused on identifying capabilities and creating value framework
  - Discussions underway with ESA for joint MC studies and future collaboration
- Opportunities for Engagement:
  - Website in development

Industry Engagement in DO Studies

DO Industry Engagement - Summary

- ESD is committed to engaging with industry in support of the DOs
- Four categories of industry engagement will be pursued in the coming months

	Description	Supported Activity	Date of solicitation
Category 1	Cross-cutting expertise in specific areas	All of the DOs	NLT April 2019
Category 2	Support to HQ	HQ Decadal Strategy	NLT April 2019
Category 3	Technology Demonstrations	Specific to each DO	Beginning summer 2019 (TBC)
Category 4	Applications Support	All of the DOs	NLT May 2019

Category 1 – Crosscutting support to DOs

- NLT April 2019, ESD will issue a solicitation in support of the DO Architecture Studies in cross-cutting areas (i.e. capabilities that could apply to multiple DOs) where industry has unique expertise:
  - Small-Sat/CubeSat Constellations (one contract)
  - Payload hosting on Commercial Satellites (one contract)
  - Ground System Architectures (one contract)
  - Data Processing/Data Storage/Cloud Computing (one contract)
  - Market Research on out-of-the-box enabling commercial technologies (one contract)
  - Research identifying and engaging non-traditional stakeholders and partnerships, such as philanthropies, and foundations (one contract)

- One-year period of performance with options to renew on an annual basis

Category 2 – Support to ESD

- NLT April 2019, ESD will issue a solicitation for general decadal support to the ESD HQ team.
- Solicitation targeted to contractors that are not competing for hardware later in the process.
- The selected contractor will support HQ in the decadal activities at NASA HQ, such as development and assessment of strategies, future activities, requirements development, etc.

- One support contract will be solicited
- 3-year period of performance

Category 3 – Technology Demos

- ESD is prepared to fund industry technology demonstrations in support of the DO studies OUTSIDE of the current study funding.
- This is expected to be somewhat akin to the SLI technology demonstrations.
- The solicitations will be managed by ESTO.
- ESD is requesting suggestions for necessary technology demonstrations from the DO study teams by May 31, 2019.
- Initial solicitations are anticipated beginning summer 2019 (TBC).

- Multiple selections are anticipated

Category 4 – Crosscutting Applications Support

- ESD is willing to fund industry to help in the assessment of Applications Communities in support of the DO studies OUTSIDE of the current study funding.
- This industry support is to *complement* the DO team in identifying new users, preparing the Community Assessment Report (CAR), and on-going engagement with non-research users.
  - This is NOT an effort to "contract out" the CAR; Teams are expected to work in tandem with the contractor.
- ESD is requesting suggestions from the DO study teams by the end of March 2019
- Solicitation will be issued ~ May 2019

- One support contract will be solicited

Earth Venture Continuity-1 (EVC-1)

Earth Venture Continuity-1 (EVC-1) – schedule

- Solicitation was released on December 19, 2018
  - https://nspires.nasaprs.com
  - Solicitation #: NNH17ZDA004O-EVC1

- Schedule has been updated following the government shutdown:
  - Pre-proposal WebEx/Teleconference: February 28, 2019
  - Mandatory Notices of Intent (NOI) due: April 26, 2019, 11:59 PM EDT
  - Last Date for submission of Questions: July 12, 2019, 11:59 pm EDT
  - Proposals are due: July 26, 2019, 11:59 PM EDT
    - Due Date for Receipt of Electronic Proposals in NSPIRES: July 26, 2019, 11:59 pm EDT
    - Due Date for Receipt of Proposal CD-ROMs: July 31, 2019, 4:30 pm EDT

Incubation Program Strategy

Incubation as Described in the DS

- A new program element, focused on investment for priority observation capabilities needing advancement prior to cost-effective implementation, including an innovation fund
  - Suggested funding $20M/year ~~including innovation fund~~
  - ~~Innovation fund to respond to emerging needs described as unexpected opportunities that occur on sub-decadal time scales~~
- Support maturation of mission, instrument, technology, and/or measurement concepts to address specific high priority science (for 2027-2037 decade) of the 3 targeted observable areas:
  - ~~Atmospheric Winds (AW), also listed under ESE~~ under ESE only
  - Planetary Boundary Layer (PBL), and
  - Surface Topography and Vegetation (ST&V)
- The Incubation investment should achieve sufficient risk reduction to achieve readiness for space flight during the next decade
- Plans for Incubation Program implementation continue to mature

Incubation Observables Summary from DS

Observable	Science/Applications Summary	Candidate Measurement Approach	Measurement Requirements
Planetary Boundary Layer (PBL)	**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	• From High resolution and diurnally resolved 2D/3D measurements of PBL - 200 m vertical resolution for 3D variables (Temperature, Humidity and Horizontal wind vector) with 2-3 hourly temporal resolution and 20 km horizontal resolution
Surface Topography and Vegetation (ST&V)	**High-resolution global topography** including bare surface land topography ice topography, vegetation structure, and shallow water bathymetry	Radar; or lidar*	• Contiguous 5m sampling with 0.1m vertical accuracy from space • Contiguous 1m sampling with 0.1m vertical accuracy from aircraft • With seasonal repeat

* **Notable that both observables list a multi-function lidar for candidate measurement approach**

Incubation Program: ESD's Analysis

- The PBL and ST&V measurement requirements are at very different levels of understanding:
- PBL - Determine needed measurements over land (including ice) and oceans that are not covered by Designated Observables (DOs), selected Targeted Observables (TOs) and Program of Record (POR).
  - Prepare models to assimilate PBL measurements to support the Earth System models
  - Determine spatial/temporal resolution and accuracy characteristics
  - Determine optimal combination of remote sensing (space and suborbital platforms) and in-situ measurements

- ST&V - Characteristics are better understood
  - Determine cost effective combination of active and passive sensors (observing system) to make the measurements, considering all available assets, platforms and emerging technologies

Assessing the needs of each TO

Phase 1 – Assemble a science team for each TO

Phase 2 – Decide on activities

- Example activities could be:
  - Modeling, OSSEs (to improve understanding of measurement needs)
    - Exploitation of existing data sets to improve models
    - Identifying new data sets (from field campaigns and possible augmentation of ground networks…)
  - Inventory assessment of relevant mature and evolving emerging technologies and measurement capabilities
  - Observing systems studies – combining alternate observation platforms (ground and suborbital) and existing data sets (commercially or from POR assets), with or without satellite observations
  - Targeted technology investments including qualification efforts
  - Suborbital campaigns for concept demonstrations/validations

Incubation Program Solicitation Plans (1/2)

- **Incubation Solicitation** in FY19, FY20 funds, release ~ Early Spring 2019
  - Solicitation (ROSES) competes science team membership for each TO (PBL, ST&V)
    - Team membership is competed through solicitation, where Individuals propose areas of investigation, and can self nominate for Team Lead Position**. Expectation is for some team members to have expertise in instrumentation.**
    - **Anticipate opportunities for community engagement, such as town halls (i.e. at AGU, AMS in FY20) and workshops that would be open beyond team membership**
  - Objective of teams would be to define desires, needs and capabilities
    - Main deliverable – white paper summarizing present state - understanding of science and candidate measurement approaches, current capabilities, desired future state of relevant technology, analysis of field campaign data, role of modeling, and recommending future activity areas (Modeling, OSSEs, field campaigns, emerging technology developments, etc.**) to be used as a basis for next solicitation**.
    - Period of performance up to 1 year with an interim and final report, and final presentation**, after which team disbands.**

Incubation Program Solicitation Plans (2/2)

- **Solicitation Cadence**:
  - First Solicitation is for Science Teams – Up to one year studies, where **teams disband after conclusion**
  - Subsequent solicitations are for activities and will be released every 2-3 years for duration of up to 3 years each
  - Solicitations have two parts: one for PBL and the other for ST&V, with each part tailored to the corresponding TO - proposers can tackle one or both.
  - Each new solicitation will consider evolving needs/aspects of each TO
- **Management**:
  - Management would follow current R&A or ESTO reporting requirements, depending on which area the work best aligns (Research or Technology)

International Engagement

International Engagement

- ESD has conducted focused Decadal Survey telecons/meetings with international partners
  - JAXA, CNES, DLR, ESA, EUMETSAT, CSA
  - Further discussions with the broader international community are expected
- Discussions have begun 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

What's next

- ESD Leadership Team is continuing to address additional DS topics
- Stakeholder Community Forum (4th in the series) – JULY 11, 1:00-3:00 EDT, via telecom and Webex
  - See https://science.nasa.gov/earth-science/decadal-survey-community-forum for details
- Check the ESD Decadal Survey web page to:
  - Find meeting schedules and details
  - Ask questions and see answers as they become available
  - Review information in previous sets of charts
  - https://science.nasa.gov/earth-science/decadal-surveys

Attendance/Questions

- Please email your name to ensure you will be informed of future Community Forums
- During this presentation please email your questions.

TO: Amy.A.Treat@nasa.gov

Backup

Summary of Top Science and Applications Priorities*

* Complete set of Questions and Objectives in Table 3.3

Science & Applications Topic	Science & Applications Questions addressed by **MOST IMPORTANT** Objectives
Coupling of the Water and Energy Cycles	**(H-1)** How is the water cycle changing? Are changes in evapotranspiration and precipitation accelerating, with greater rates of evapotranspiration and thereby precipitation, and how are these changes expressed in the space-time distribution of rainfall, snowfall, evapotranspiration, and the frequency and magnitude of extremes such as droughts and floods? **(H-2)** How do anthropogenic changes in climate, land use, water use, and water storage interact and modify the water and energy cycles locally, regionally and globally and what are the short- and long-term consequences?
Ecosystem Change	**(E-1)** What are the structure, function, and biodiversity of Earth's ecosystems, and how and why are they changing in time and space? **(E-2)** What are the fluxes (of carbon, water, nutrients, and energy) *between* ecosystems and the atmosphere, the ocean and the solid Earth, and how and why are they changing? **(E-3)** What are the fluxes (of carbon, water, nutrients, and energy) *within* ecosystems, and how and why are they changing?
Extending & Improving Weather and Air Quality Forecasts	**(W-1)** What planetary boundary layer (PBL) processes are integral to the air-surface (land, ocean and sea ice) exchanges of energy, momentum and mass, and how do these impact weather forecasts and air quality simulations? **(W-2)** How can environmental predictions of weather and air quality be extended to seamlessly forecast Earth System conditions at lead times of 1 week to 2 months? **(W-4)** Why do convective storms, heavy precipitation, and clouds occur exactly when and where they do? **(W-5)** What processes determine the spatio-temporal structure of important air pollutants and their concomitant adverse impact on human health, agriculture, and ecosystems?
Reducing Climate Uncertainty & Informing Societal Response	**(C-2)** How can we reduce the uncertainty in the amount of future warming of the Earth as a function of fossil fuel emissions, improve our ability to predict local and regional climate response to natural and anthropogenic forcings, and reduce the uncertainty in global climate sensitivity that drives uncertainty in future economic impacts and mitigation/adaptation strategies?
Sea Level Rise	**(C-1)** How much will sea level rise, globally and regionally, over the next decade and beyond, and what will be the role of ice sheets and ocean heat storage? **(S-3)** How will local sea level change along coastlines around the world in the next decade to century?
Surface Dynamics, Geological Hazards	**(S-1)** How can large-scale geological hazards be accurately forecasted and eventually predicted in a socially relevant timeframe?

Recap: ESD Implementation of 2017 Decadal Survey

- **ESD is conducting these focused community forums (for ~18 months) to translate the recommendations into an executable program and, for Flight, a portfolio of specific, realistic, launch-ordered missions and solicitations.**
- ESAS(2017) calls for "cost-capping" essentially all missions
- Earth Venture Continuity (EVC) Measurements: an addition to the existing Venture-class program. EVC-1 is in preparation
- Designated observables (DOs) for mandatory acquisition: four multi-center DO Studies are underway (*Surface Biology & Geology;* Combined *Aerosols / Clouds, Convection, & Precipitation; Surface Deformation & Change; Mass Change)*
- New competed Earth System Explorer (ESE) flight line with $350M cost constraint, 3 observables to be chosen by ESD from among 6 identified in ESAS(2017) -
- Incubator Program between Technology, R&A, and Flight to mature specific technologies for important – but presently immature – measurements – framework in development as preparation for next Decadal
- Decadal Survey new mission budget wedge begins to open in late FY21