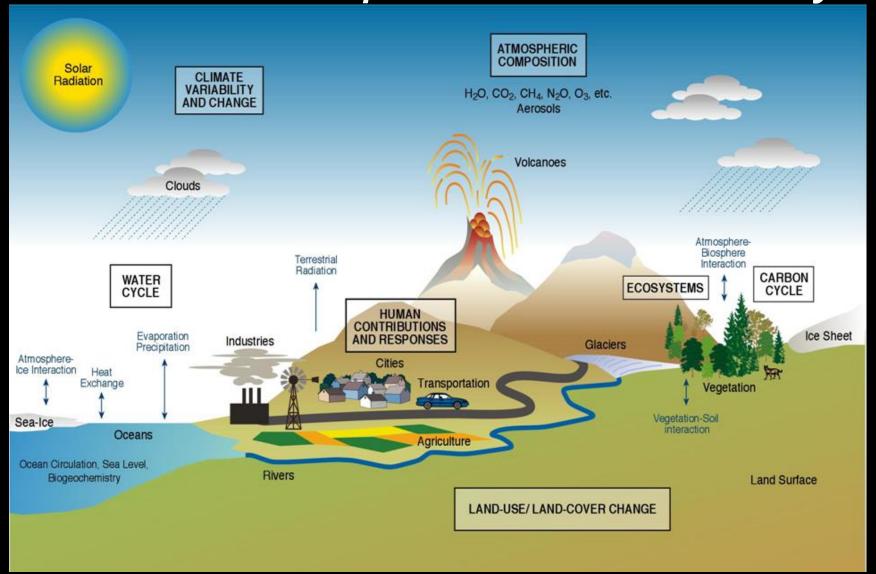






Earth as a Complex Inter-related System



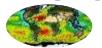
Earth System Science: Requires quantitative understanding of *interactions between processes* in order to define the Earth system – nonlinearities link spatial and temporal scales

NASA Earth Science Division Elements



Flight (incl. Data Systems)

Develops, launches, and operates NASA's fleet of Earthobserving 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.







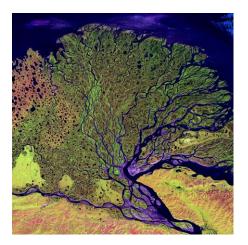
Earth Science Overview

Strategic Objective

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

Major Activities

- Build and operate Earth observing satellite missions, many with international and interagency partners (e.g., NOAA, USGS)
- Conduct and sponsor cutting-edge research
 - Field campaigns and airborne missions to complement satellite measurements
 - Analyses of NASA and non-NASA mission data
 - Modeling
- Make high-quality data products available to broad science, applications, and private sector communities, and to other federal and local government agencies
- Develop and demonstrate applications delivering societal benefit, and build user capacity
- Advance Earth observation technologies, including development and demonstration of science-focused CubeSat/SmallSat instrumentation and constellations







Earth Science

- Completes 15 orbital Program of Record missions/instruments identified and recommended by 2007 Decadal Survey and emphasized in the 2017 Decadal Survey
- Includes robust SmallSat/CubeSat programs for science and technology development
- Implements Decadal-recommended Flight/Technology activities and funds Earth Venture-Continuity program
- Conducts pre-formulation Decadal mission/observing system studies for Designated Observables in preparation for Decadal wedge, opening in FY 2021
- Provides substantial support to National and cross-agency satellite programs and international partnerships, including LandSat
- Expands commercial/private sector integration through SmallSat Constellation Data Buy, commercial hosting in GEO and LEO, Google/Microsoft/Conservation International partners

NASA/ESD Funding/Appropriation

- FY19 (1 Oct 2018 30 Sept 2019) funding appropriated via an Omnibus is at \$1.931B
- Budget supports continuation of a balanced ESD portfolio
 - Funding for all remaining elements of the ongoing Flight Program of Record
 - Continues operations and development of Program of Record
 - Landsat-9 remains on-track for 12/2020 launch; NASA portion of Sustainable Land Imaging Program funded
 - Venture-Class remains fully funded and on-track for planned solicitations and selections
 - Applied Sciences and Earth Science Technology Office programs flat-funded, including InVEST CubeSat validation program
 - Small-satellite Constellation Data Buy Pilot funded
- The budget is consistent with, and partially addresses, the 2017 Decadal Survey recommendations
 - Supports DO study activities, EVC-1 solicitation, and incubation planning
- President's FY20-24 detailed budget proposal released March 11, 2019
 - Proposes FY20 ESD funding at ~\$1.78B
 - Continues to propose termination of PACE and CLARREO-PF

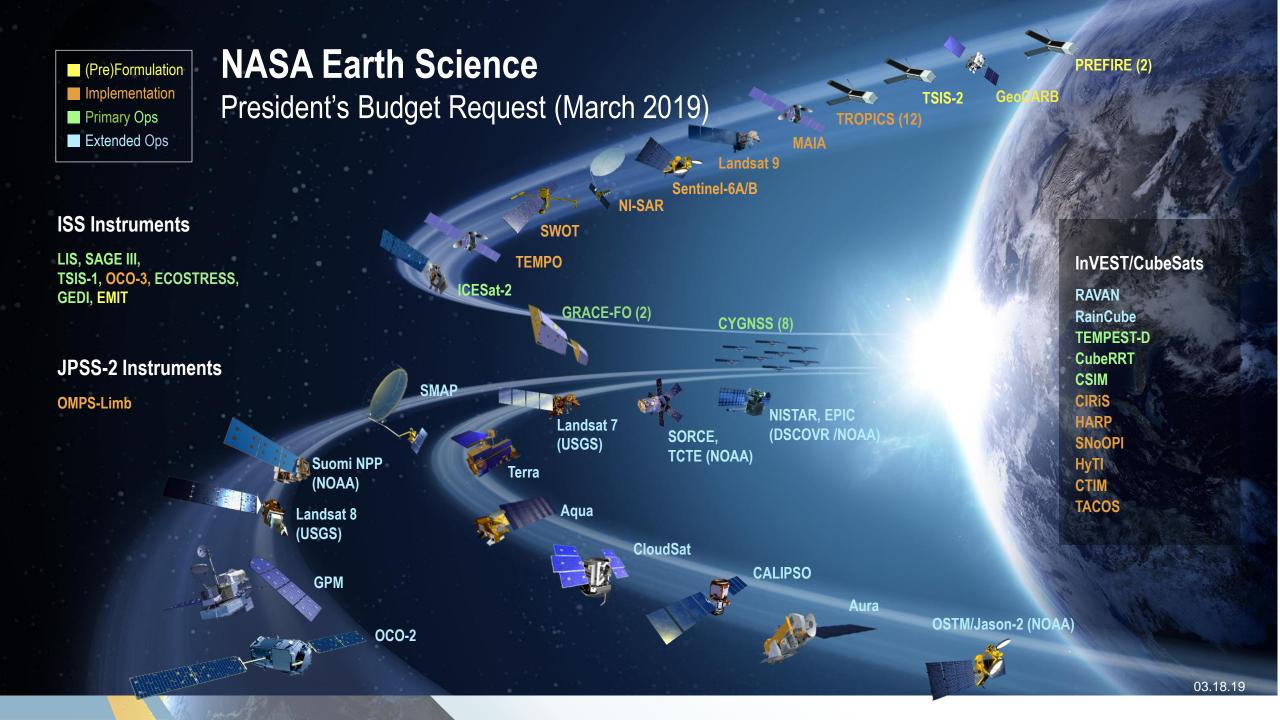
Earth Science Budget Features

What's Changed

- New Decadal Incubation project within ESTO
- Initiated Earth Venture Continuity strand within Venture Class
- 4 new DO studies within Decadal Survey
- TROPICS instrument confirmed as build to storage
- Selection of EMIT and PREFIRE instruments within Venture Class

What's the Same

- Supports recently launched missions GRACE FO, ICESat-2, GEDI; ESD now operating 20 on-orbit missions
- SWOT, NISAR, Sentinel-6, Landsat 9, TEMPO, GeoCarb, and MAIA remain on schedule for launch in budget window
- Maintains regular cadence of Venture Class missions and instruments solicitations
- Healthy research and applied science programs, SmallSat/CubeSat investments, and commercial data buy activities
- As in FY 2019 Presidential Budget Request, terminates PACE and CLARREO Pathfinder



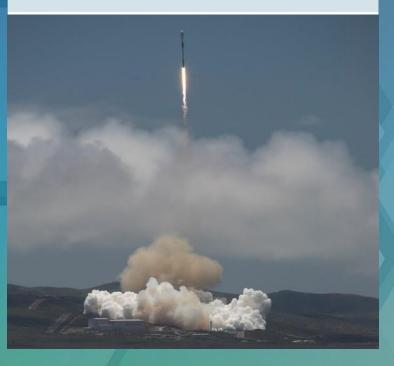
NASA Earth Science OSTM/Jaso **Current Operating Missions** (NOAA) ICESat-2 GRACE-FO (2) **International Collaborations** ISS: LIS, SAGE III, TSIS-1, ECOSTRESS, GEDI InVEST/CubeSats CYGNSS (8) RAVAN RainCube TEMPEST-D Landsat 7 **CubeRRT SMAP** (USGS) **CSIM** Aqua 🔴 🥎 **NISTAR, EPIC Suomi NPP** (DSCOVR / NOAA) (NOAA) SORCE, TCTE (NOAA) Landsat 8 (USGS) Aura I CALIPSO CloudSat | | **OCO-2** 03.18.19

Recent and Near-Term Planned ESD Launches (1 of 2)

TSIS-1: DEC 15, 2017



GRACE-FO: May 22, 2018



ECOSTRESS: June 29, 2018



TSIS-1

GRACE-FO

ECOSTRESS

The Total and Spectral Solar Irradiance Sensor (TSIS-1) is measuring the total amount of sunlight that falls on Earth, and how that light is distributed among the ultraviolet, visible and infrared wavelengths.

Obtaining high resolution global models of Earth's gravity field, including how it varies over time

Providing insight into plant-water dynamics & how ecosystems change with climate via high spatiotemporal resolution thermal infrared radiometer measurements of evapotranspiration (ET)

Recent and Near-Term Planned ESD Launches (2 of 2)

ICESat-2: Sep 15, 2018



GEDI: Dec 5, 2018



OCO-3



ICESat-2 Quantifying 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

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.

Major Recent Accomplishments FY18-19

- Earth Science Decadal Survey, "Thriving on Our Changing Planet," received January 2018
- Launched Gravity Recovery And Climate Experiment (GRACE)-Follow On mission on May 2018 and ICESat -2 in September 2018
- Launched two instruments to ISS
 - ECOSTRESS June 2018
 - GEDI November 2018
- Launched four CubeSat missions
 - TEMPEST-D July 2018
 - CubeRRT July 2018
 - RainCube July 2018
 - CSIM-FD December 2018
- Two Earth Venture Instruments selected in 2018: Polar Radiant Energy in the Far Infrared Experiment (PREFIRE) and Earth Surface Mineral Dust Source Investigation (EMIT)
- Landsat-9, NASA and USGS partnership, November 2021 reflects the agency baseline commitment made at the Key Decision Point-C review December 2017; on track to launch December 2020
- Conducted 14 oceanic and terrestrial airborne field campaigns in four continents
- NASA and USAID awarded a new SERVIR Amazonia hub serving South America

Planned Accomplishments FY19-20

- Implementation of Earth Venture Continuity recommendation from the Decadal Survey through the first selection
- Selection of Earth Venture Instrument-5 project in late FY 2019, Earth Venture Continuity-1 project in early FY 2020
- Initiation of Earth Venture Sub-Orbital-3 campaigns through out FY 2019 and FY 2020
- Complete System Integration Reviews (SIRs) for Landsat 9, SWOT, Sentinel-6A and NISAR
- Launch four InVEST CubeSats: HARP (3U), CIRiS (6U), CTIM (6U) and HyTI (6U) in FY 2020
- NASA to select the next Health & Air Quality Applied Sciences Team with rapid result projects in collaboration with businesses and state and local governments
- NASA/USAID SERVIR Amazonia Hub to have its first full year of activities and operation

NASA Portfolio Balance

Earth Science research: maintain at 22-26% of the budget Includes 18% for openly competed research and analysis Includes approximately 3% each for computing and administration

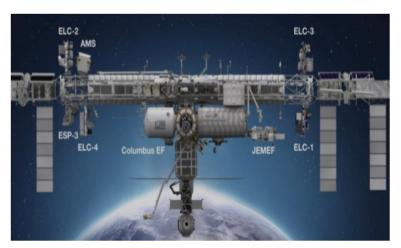
Applications program: maintain at 2-3% of the budget

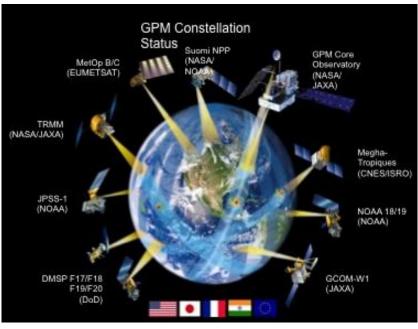
Technology program: increase from its current 3% to about 5%

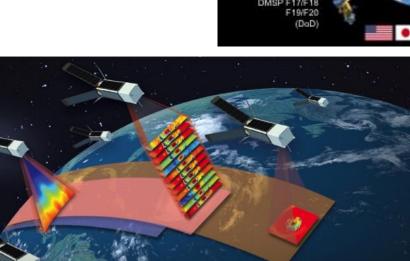
Flight programs, including Venture: *maintain* at 50-60% of the budget

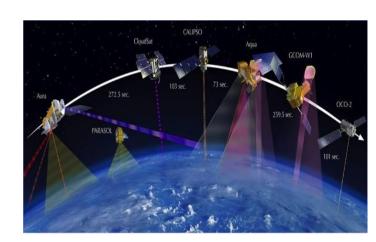
Mission Operations: *maintain* at 8-12% of the budget

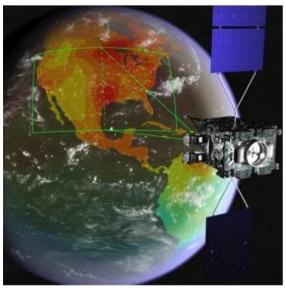
NASA Observing System INNOVATIONS











Earth Science Division's Venture Opportunities

EVS

Sustained Sub-Orbital Investigations (~4 years)

EVM

Complete, selfcontained, small missions (~4 years)

EVI

Full function, facility-class instruments Missions of Opportunity (MoO)

(~3 year)*

EVC (New)

Full Missions or Missions of Opportunity (MoO) for measurement continuity

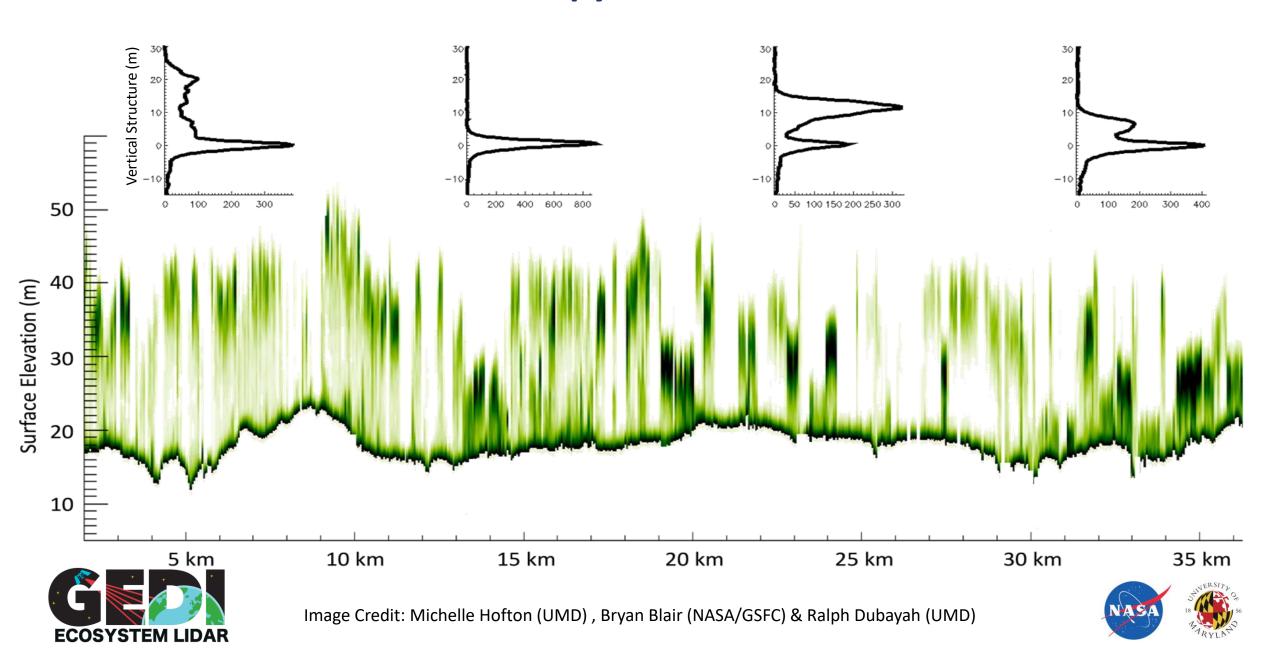
(~3 years)

| 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 |

* Previously ~18 months; now alternating with EVC

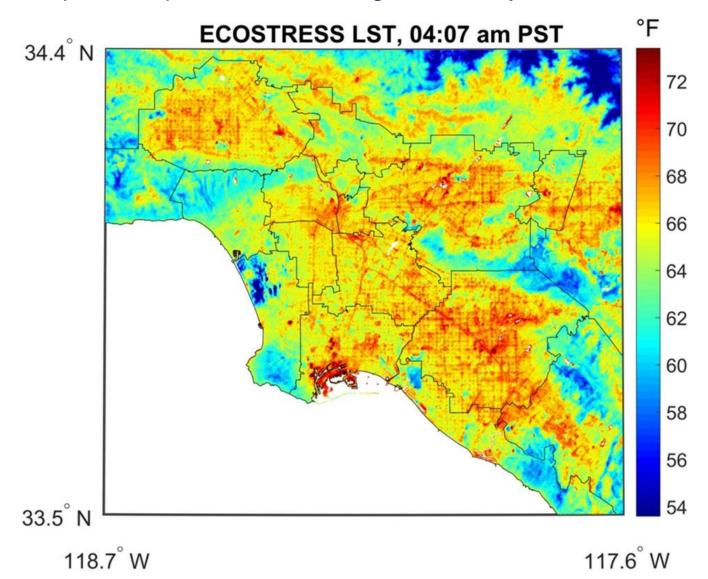
Open solicitation - In Review Completed solicitation

GEDI – Forest Canopy Profile and Waveforms

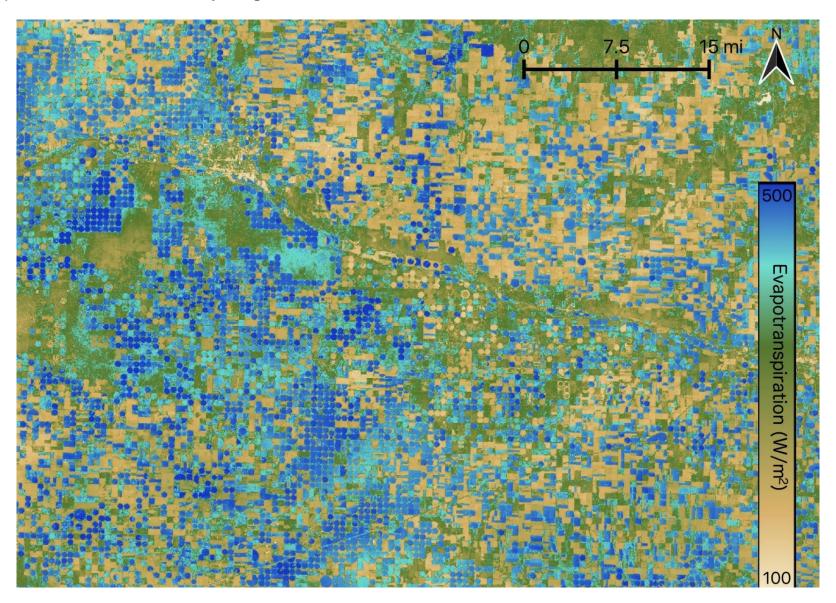


ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS)

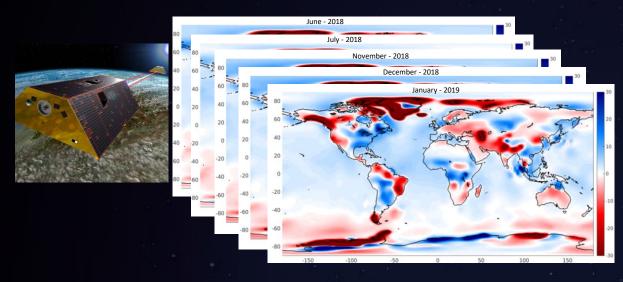
Surface-temperature patterns in Los Angeles County.



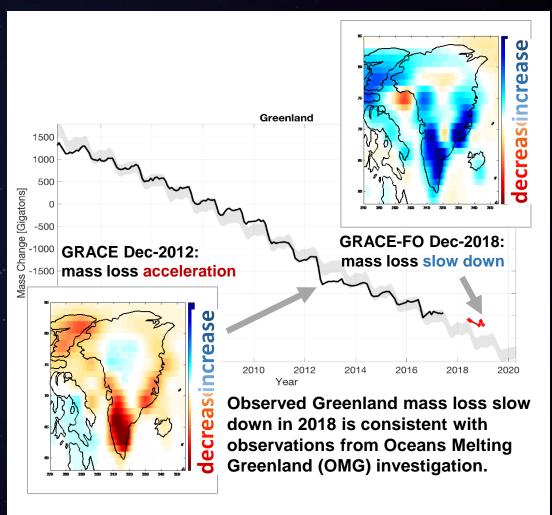
Evapotranspiration over Garden City, Kansas USA | Center pivot irrigation dominates the landscape with circular patterns distributed across this Kansas community. Blue circles and squares indicate recently irrigated fields.

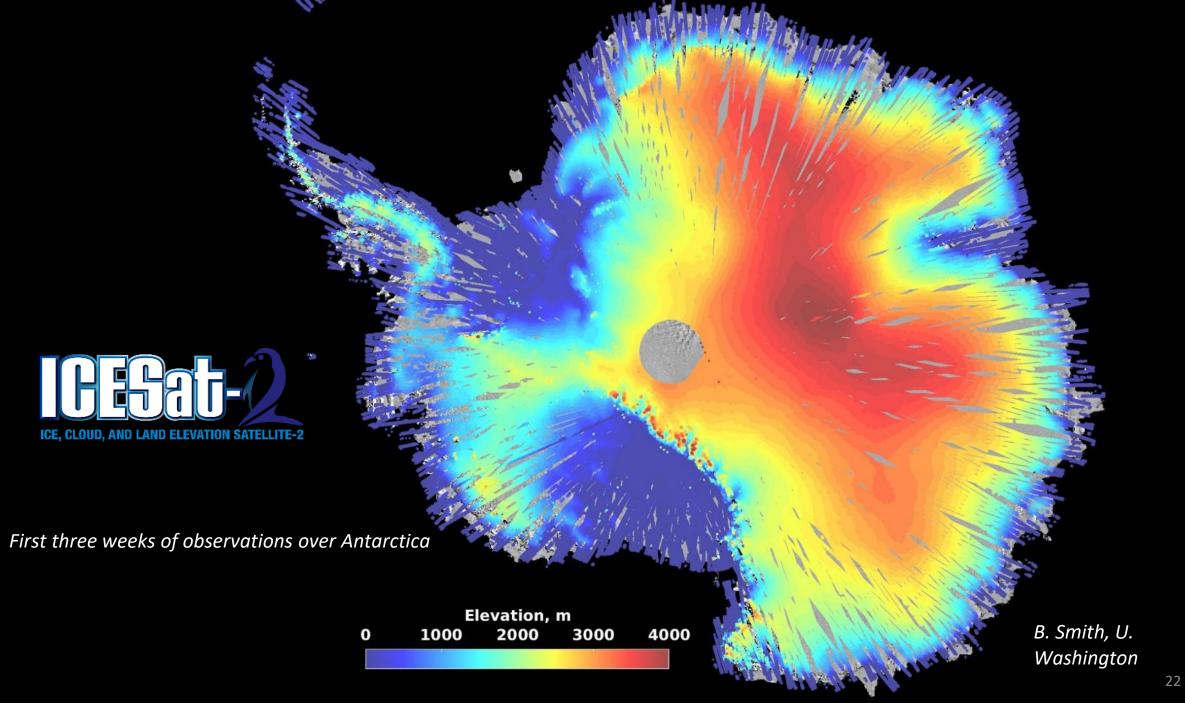


GRACE Follow-On

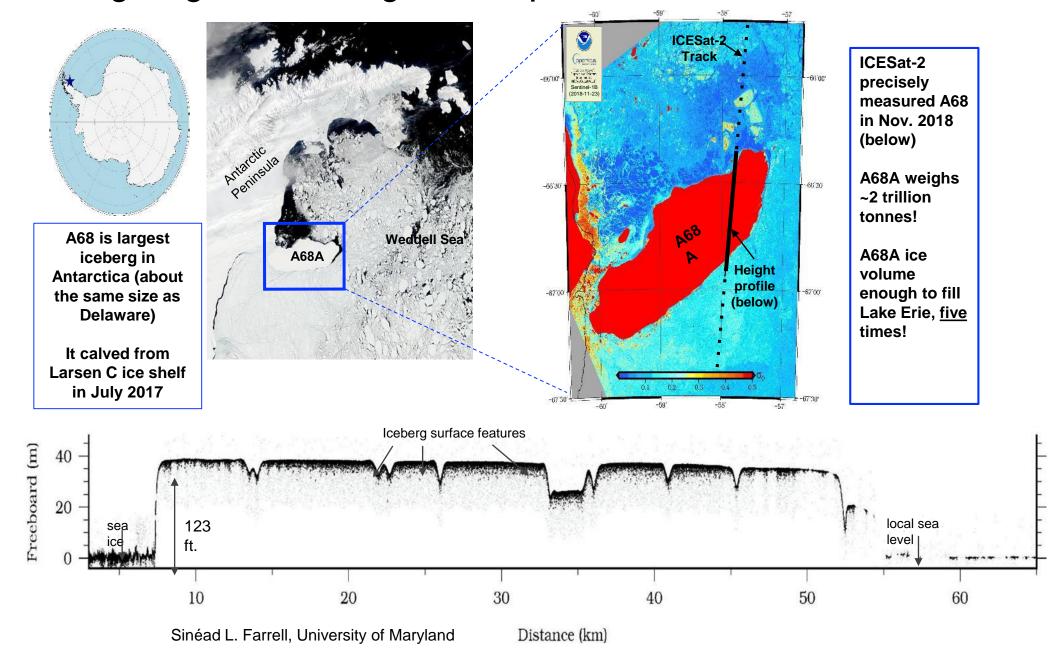


- Formal transition to science phase on Jan. 28, 2019
- Collecting monthly science data, demonstrating continuity with 15-year record from GRACE
- Initial results are providing new insights
- GRACE-FO performance meets the Level 1 science and technology requirements

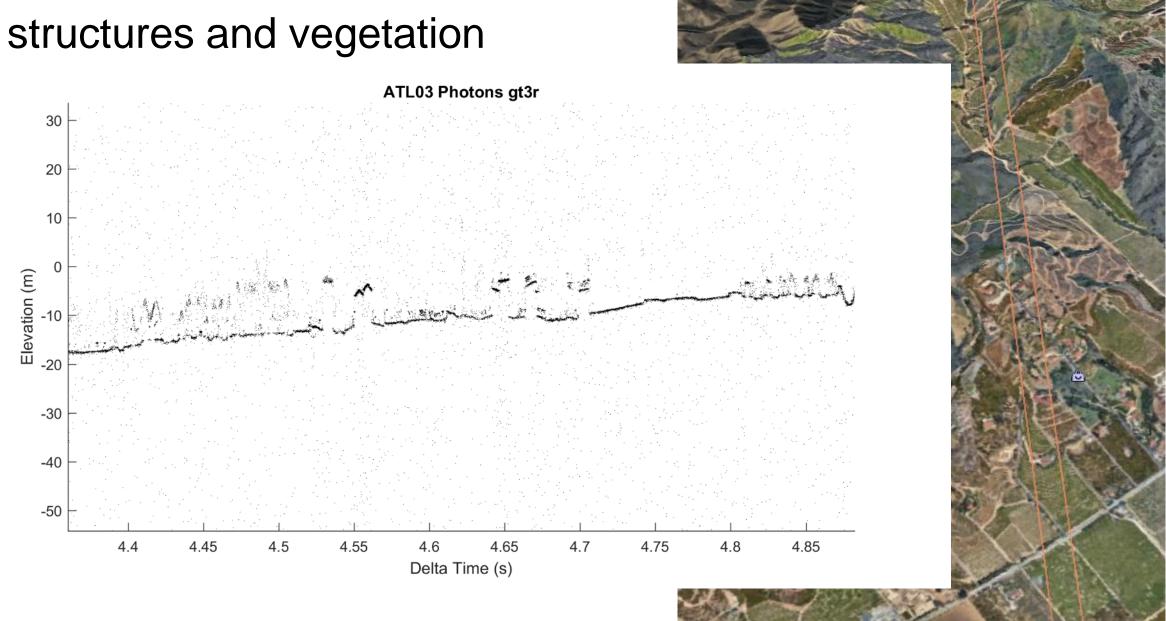




Weighing an Iceberg from Space

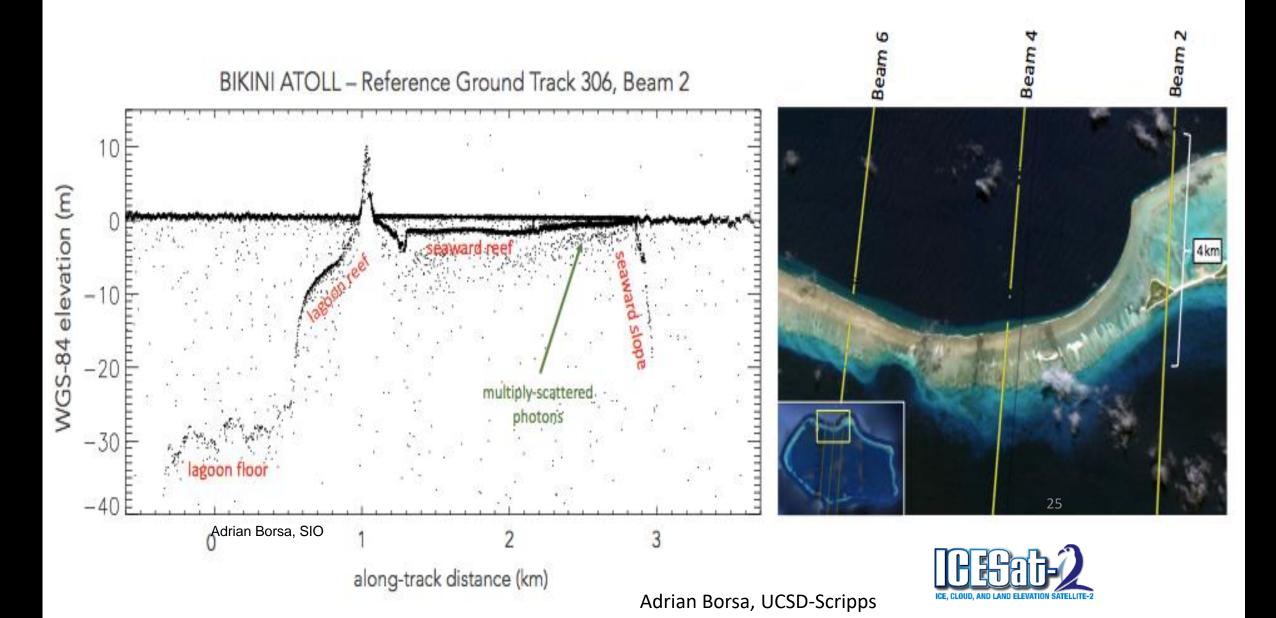


Coast of California- built



Lori Magruder, University of Texas at Austin

Bathymetry - Bikini Atoll



NASA Small-Satellite Programs

ESD is pursuing a rich program of orbital missions using small satellites

- 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 SCIENCE
- 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 **SCIENCE**
- PREFIRE (Polar Radiant Energy in the Far Infrared Experiment): 2-satellite CubeSat constellation to measure Far-IR emissions primarily from the Arctic SCIENCE
- 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 TECHNOLOGY
- 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 ENABLING

Private Sector Small-Satellite Constellation Pilot

Present ESD funding opportunities for use of Small-Satellites and resulting data

Earth Venture–Mission and –Instrument programs: Science-driven, PI-led, cost/schedule constrained, competitively selected, frequently solicited (every 4 years for EVM, every 18 months for EVI); proposals using small-sats have been selected for both EVM and EVI

InVEST: Competitively selected spaceborne technology validations that *must use* small-sats or cubesats; 3-year solicitation cadence, frequent launch opportunities using NASA CSLI and VCLS

R&A and Applications ROSES calls: R&A and Applied Sciences competitive research calls are data-source agnostic – use of measurements and information from small-satellite systems/constellations is welcomed if their scientific and applications value to the research is justified in the proposal

Earth Observations from Private Sector Small Satellite Constellations Pilot: Data buys of 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; pilot buys in 2018

Private Sector Small-Satellite Constellation Pilot - Update

Have signed contracts with three companies to buy *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

May provide a cost-effective means to augment and complement the suite of Earth Observations

Have identified a broad set of ESD-funded researchers who will be supported to 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

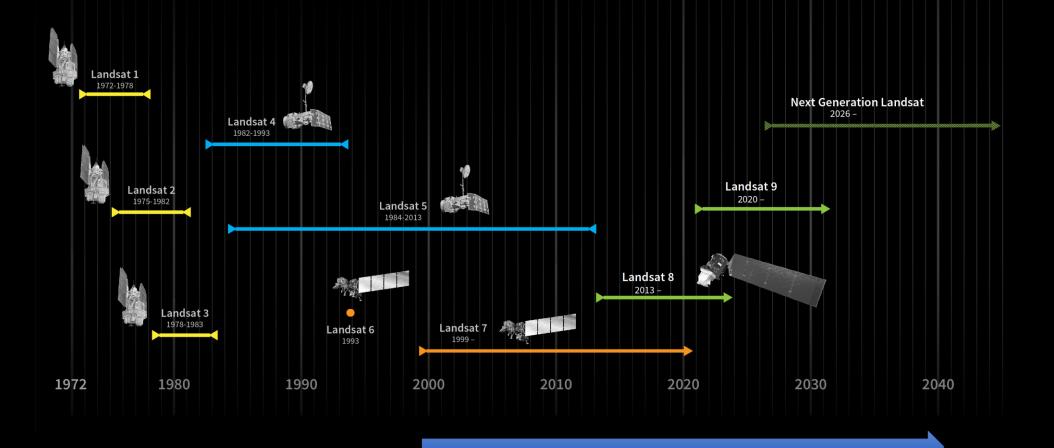
Written reports to ESD (not scientific papers)

Quality of geophysical information

Data availability (latency) and subdistribution rights vs. cost

Vendor plans for constellation maintenance/evolution

BUILDING ON THE LANDSAT LEGACY



NASA-USGS Interagency Partnership

- NASA: Space Segment and Launch
- USGS: Operations & Data Processing/Distribution

Earth System Science Carbon Cycle and Ecosystems Climate Variability and Change Atmospheric Composition Earth Surface and Interior Water & Energy Cycle Weather

R&A Selected Highlights

Field Work

2019 - Cloud and Aerosol Monsoonal Processes Exp't (near Philippines); Firex-AQ (Idaho, Kansas, California/with NOAA);
 HyspIRI (Europe), Operation Ice Bridge (Arctic, Antarctic), ABoVE (Alaska/NW Canada), DAWN/HALO test flights (CA)

New Competed Science Programs (many ROSES calls)

 Selected next round of Earth Venture Suborbital (5 campaigns, most for 5 years), next round of MEaSUREs data set preparation tasks (5 years), competed science teams for PMM, CYGNSS, SAGE III, DSCOVR, open solicitation for ECOSTRESS; selected new round of US Participating Investigators for US scientist engagement in foreign missions

Modeling and Data Assimilation

- All-sky microwave radiances from the GPM GMI instrument were introduced into the 4D assimilation system, resulting in improved analyses in and around cloudy regions
- NOAA-20 data (CrIS, ATMS, and OMPS) introduced into the GEOS analyses
- GEOS model is transitioning to include a new scale-aware representation of physical processes alongside the FV3 dynamical core
- GEOS CF (Composition Forecasting) is going live in March 2019, producing daily 25-km resolution analyses and forecasts for air quality etc.
- GEOS S2S system has been used to demonstrate for the first time the benefits of Aquarius and SMAP Sea-Surface
 Salinity observations on seasonal predictions of El Nino (this will transition to the next upgrade to the production version of
 GEOS S2S (in about 9 months)

Enabling Capabilities

- Advanced next-generation space geodesy network: installed new 12m Very Long Baseline Interferometry (VLBI) antenna at McDonald Observatory (TX); completed first dome for next-generation laser ranging stations
- Built the third modular computing facility at ARC and expanded SMD's supercomputing capacity to 19.5 pflops; expanded capacity at NCCS to 6.7 pflops.
- Completed the installation and dedication of two GOES Rebroadcast receiving antennas for GOES-16 and 17. Began serving GOES geostationary observation data to NASA Earth science research community.

Applied Sciences Program: Selected Highlights-2019

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

New projects commence in all four applications areas. New efforts for greater replication of applications.

Missions & Applications

New efforts to engage applications communities early in satellite mission planning to further increase utility.

Communications

Full-scale implementation of new comms. plan with blend of technical, narrative, and personal stories.

Harvest

Food Security and Agriculture Consortium led by UMd to advance uses of Earth obs for humanitarian pursuits, domestic economy, and resilience in food systems globally and in the U.S.

Impact Assessments

VALUABLES Consortium conducting economic studies on Earth science; also arranging venues for Earth scientists wanting to learn about policy and economic terms/methods.

SERVIR





New Amazonia regional hub for South America is planned to open in Spring.

Solicitation for 3rd SERVIR Applied Science Team with start in Oct. 2019.

ARSET Trainings

New professional-level hands-on trainings on remote sensing for risk assessment, disaster scenarios, and Black Marble VIIRS Nighttime Data.

DEVELOP

New collaboration with Lenfest Ocean Program for projects on marine and coastal management issues.

Earth Science Technology

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. Future solicitations planned in FY20, and FY23

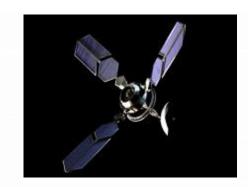
In-Space Validation of Earth Science Technologies (InVEST)

On-orbit technology validation and risk reduction for small instruments and instrument systems.. Four projects selected in FY18. Future solicitations planned in FY21 and FY24

Instrument Incubator Program (IIP)

Earth remote sensing instrument development from concept through breadboard and demonstration

17 projects awarded in FY17. Future solicitations planned in FY19, FY22, and FY25



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

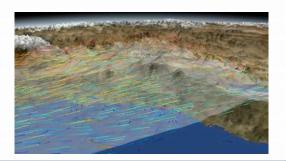
22 projects awarded in FY17. Future solicitations planned in FY19, FY21, FY23, and FY25



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

Future solicitations planned in FY19 and FY21



2017 DECADAL SURVEY



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

2017 Decadal Survey Snapshot

- Publicly released January 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 "Incubator Program" between Technology, R&A, and Flight to mature specific technologies for important – but presently immature – measurements (preparation for next Decadal)

Designated Observables Summary

| 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 |

ESD Strategic Decisions and Progress to-date on DS Response (1)

- Initiated Communications Plan to keep all communities involved/informed
 - Weekly interactions with ESD Program Scientists/PEs/Managers
 - Monthly all-Center web-ex/telecons (initiated April)' 4-monthly open community web-ex/telecons (initiated 10 May)
 - ESD DS Web Site for 2-way information exchange
- Defined and accelerated implementation of Earth Venture Continuity competed strand
 - 1-year on-orbit demonstration of affordable measurement approach
 - Interleaved with EV-Instrument EVI or EVC solicitation every 18 months
 - Explicit EVC program objectives and proposal review criteria established
 - First EVC solicitation released December 2018 (targeted for radiation budget sensor/RBI replacement); will have extraordinary 5-year lifetime target
 - ~\$150M total cost constraint; NASA-owned RBI hardware made available to proposers as GFE

ESD Strategic Decisions and Progress to-date on DS Response (2)

Initiated 4 **Designated Observable** studies in early FY19 that are expected to result in missions/observing systems to address the DO priorities - combined Aerosol/Clouds, Convection, And Precipitation; Mass change; Surface Biology and Geology (SBG); and Surface Deformation and Change (SDC)

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

ESD has established an acquisition strategy for the DO Mission/Observing System

- Partnerships strongly encouraged
- Cost constraint (not cap) for each observing system informed by DS

ESD Strategic Decisions and Progress to-date on DS Response (3)

- Incubator Program will be implemented in two stages
 - Stage 1 solicitation will be released in FY19 and awarded in FY20 to assemble a science team that will develop activities to be pursued in Stage 2 for the Planetary Boundary Layer (PBL), and Surface Topography and Vegetation (ST&V) Targeted Observables (TO)
 - Up to one year studies, where teams disband after conclusion
 - Stage 2 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
- Earth Science Explorer strategy development is still on-going and its implementation will be delayed to later in the decade

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 <u>not</u> 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

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



ESD Top Level Approach to EVC

ESD will use EVC to demonstrate a technique/approach for making long-term measurements with the appropriate characteristics (a "continuity demonstration")

Criteria for selecting an EVC project:

Capability of the instrument/characteristics of the data

Cost of future copies

Accommodability

Producibility

Ease of technology infusion (optional)

Payload Classification will be Class C or D, as stated in the AO for a specific solicitation

EVC will NOT address continuity beyond the demonstration

Minimum demonstration period is 1 year beyond on-orbit commissioning

Additional on-orbit acquisition will not be under the cost cap

Interleaved with EV-Instrument - EVI or EVC solicitation every 18 months

~\$150M total cost constraint

The ESD objective will be to fly 3 EVC missions in the decade

Earth Venture Continuity-1 (EVC-1)

EVC-1 is a targeted solicitation for making continuity measurements of Earth radiation budget science

PI Managed Cost Cap is \$150M

EVC-1 allows for three types of proposals:

Focused Mission of Opportunity (FMO) - JPSS: The PI is responsible for developing and delivering an instrument that is compatible with NOAA requirements for flight on a JPSS spacecraft. The instrument and all associated project costs (project management, systems engineering, etc.) and the one year of operations are included under the PI-Managed Cost Cap. NASA will identify the accommodations costs in coordination with the JPSS program, and will fund accommodations to integrate the payload to the JPSS spacecraft outside of the Cost Cap.

FMO - Hosted Payload: The PI is responsible for the instrument, ground system, and hosting arrangement, and the one year of operations. The instrument, ground system, and all associated project development costs (project management, systems engineering, etc.) and the one year of operations are included under the PI-Managed Cost Cap. NASA will fund accommodations to integrate the payload to the host outside of the Cost Cap. However, the specific hosting options and associated costs, as well as the appropriate partner costs, must be identified in the proposal.

Small Complete Mission (SCM): The PI is responsible for providing the observing system hardware, ground system, and all associated project development costs (project management, systems engineering, etc.) and the one year of operations under the PI-Managed Cost Cap. In addition, the PI must identify arrangements and costs for access to space, including all necessary launch services, in the proposal. However, costs associated with access to space will be covered by NASA outside the Cost Cap.

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

Solicitation was released in 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

Future Solicitations

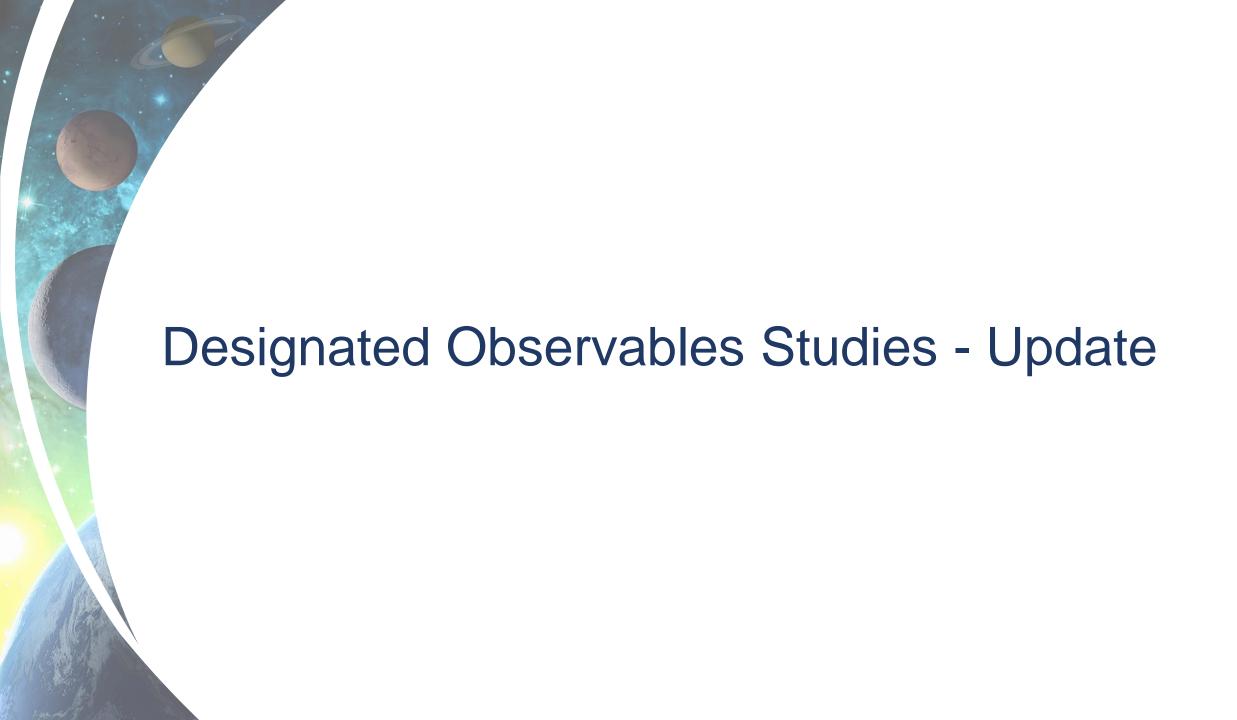
Future EVC solicitations may:

Target a single observation for a given imperative (similar to EVC-1)

Target a set of observations (e.g. solar irradiance, ozone, and CO2)

ESD will maintain the flexibility to pursue either of the above options, but it is expected that most will be single observation targeted

However, once we know what we want to do with the next EVC, ESD will alert the community to our intentions



ESD Points of Contact <u>once Studies</u> are Underway (PE, PS, and PA)

| Study | Program Executive | Program Scientist | Program Applications Lead |
|-------|--|--|--|
| A-CCP | Tahani Amer (Alternate: Steve Neeck) | Hal Maring (Alternates: Gail Skofronick-Jackson, Barry Lefer) | John Haynes (Alternate: David Green) |
| SBG | Dave Jarrett (Alternate: Marissa Herron) | Woody Turner (Alternate: Ben Phillips) | Woody Turner (Alternate: Brad Doorn) |
| SDC | Charles Webb (Alternate: Kevin Murphy) | Gerald Bawden (Alternate: Hank Margolis) | David Green |
| MC | Mitra Dutta (Alternate: Bruce Tagg) | Lucia Tsaoussi (Alternate: Jared Entin) | Brad Doorn |



Aerosol – Cloud, Convection and Precipitation (A-CCP) Designated Observable Study Plan

Objectives

Refine Science Traceability Matrices (STM) from ACE and add STMs for aerosol air quality, convection and precipitation

Engage NASA center, university, US government agencies, commercial and international partners

Use refined STMs as the scientific basis to design, develop and assess viable candidate architectures for making necessary observations utilizing satellite remote sensing, airborne measurements and surface-based sensors

Scope/Implementation

- Phase 1 Develop Science Value Framework
- Phase 2 Refine and Develop STMs
- Phase 3 Develop A-CCP DO Architecture(s) including documentation for Mission Concept Review
- **Phase 4** Preparation of Final Study Report

Participants

- Vickie Moran, Study Coordinator (GSFC)
- Tammy Brown, Deputy Study Coordinator (GSFC)
- Chip Trepte, Deputy Study Coordinator (LaRC)
- Deborah Vane, Deputy Study Coordinator (JPL)
- Study Leads—Jody Terek (MSFC), Ryan Stephan (GRC), Ryan Spackman (ARC)
- HQ Hal Maring, Felix Seidel, Gail Skofronick Jackson, Barry Lefer, Tahani Amer, John Haynes
- Hoped for International Partners CNES, JAXA, ESA, SRON, etc.

Study Structure

HQ initiated a request for a Study Team and Plan to address the Aerosol (A) and Cloud-Convection Precipitation (CCP) Designed Observables (DO) called out in the 2017 Earth Science Decadal Survey (DS).

Study Plan was submitted in July 2018 for a NASA HQ-sponsored, multi-center (GSFC, LaRC, JPL, MSFC, ARC, and GRC), 3-year pre-formulation study commencing Oct. 1, 2018.

The Study Team relies heavily on representatives from Academia on the Science Community Cohort (SCC) which provide independent review and consultation on the Science Value for each OS.

The Study Team also relies heavily on expertise on the Science Impact Team (SIT) and Applications Impact Team (AIT) to review and assess overall Science and Applications Value.

The Study Team has had extensive outreach to the international community and will be conducting a Community Workshop 1-5 April to get International and Industry input and identify Potential International Partnerships; bilats with CNES, JAXA, CSA, DLR.

A-CCP DO SATM Status and Traceability To Decadal Survey

The A-CCP Goals have direct traceability to 2017 DS Most Important and Very Important Goals

The team is making excellent progress in developing the SATM which has been released for input and consultation with Academia, International Community, and Industry with face to face discussions planned at the Community Workshop on 1-5 April 2019

| Overarching A-CCP Goal | A+CCP | А | CCP | 2017 DS Most Important Very Important | Goals |
|--|-------|---|-----|---|--|
| | | | | C-2a, C-2g, W-1a, W-2a | G1 <u>Cloud Feedbacks</u> Reduce the uncertainty in low- and high-cloud climate feedbacks by advancing our ability to predict the properties of low and high clouds. |
| Understand the processing of | | | | C-2g, C-5c, H-1b, W-1a, W-2a, W-4a | G2 Storm Dynamics Improve our physical understanding and model representations of cloud, precipitation and dynamical processes within storms. |
| water and aerosol through the atmosphere and develop the societal applications enabled from this understanding. | | | | H-1b, W-1a, W-3a, S-4a | G3 Falling Snow Quantify the rate of falling snow at middle to high latitudes to advance understanding of its role in cryosphere-climate feedbacks. |
| | | | | <u>W-1a, W-5a,</u> <u>C-5a</u> | G4 <u>Aerosol Processes</u> Reduce uncertainty in key processes that link aerosols to weather, climate and air quality related impacts. |
| | | - | | C-2h, C-5c | G5 <u>Aerosol Radiative Forcing</u> Reduce the uncertainty in Direct (D) and Indirect (I) aerosol-related radiative forcing of the climate system. |

Goal only fully realizable via combined mission.

A or CCP makes meaningful contribution to goal

| * | Study Team Accomplishments | |
|---|---|---------------------|
| | ✓SATM Rev A Review With SMT | 13-14 Feb 2019 |
| | A & CCP Goals & Objectives Combined | |
| | ✓SATM Rev A Release To International Community/Industry & SCC for Input | 19 Feb 2019 |
| | ✓Architecture Construction Workshop (ACWS) Planning Kick-Off | 4 Mar 2019 |
| | ✓SATM Rev B Release To International Community/Industry & SCC for Input Geophysical Variables | 4 Mar 2019 |
| | ✓SET Kick-Off Mission Traceability Matrix (MTM) Development | 6 Mar 2019 |
| | ✓Request for Information (RFI) Released for Observables | 19 Mar 2019 |
| | Near Term Plan Forward | |
| | SATM Rev C Release To Community & SCC for Input | 25 Mar 2019 |
| | Threshold Geophysical Variables and Desired Capabilities | |
| | Community Workshop With International & Industry Participation | 1-5 Apr 2019 |
| | (including bilats with CNES, JAXA, CSA, DLR) | |
| | SATM Rev D Release Reflecting Comments from SCC and Community | 19 Apr 2019 |
| | RFI Responses Received | 19 Apr 2019 |
| | Questions/Dialog with RFI Respondents & Libraries Finalized for ACWS #1 With JPL Team X | 19 Apr – 8 May 2019 |
| | Final Preparation for ACWS #1—Large/Medium Observatories | 9-10 May 2019 |
| | Finalize Mission Traceability Matrix (MTM) for ACWS #1 | |
| | Library Evaluated Against Threshold Desired Capabilities | |
| | Architecture Finalization for ACWS #1 | |
| | ACWS #1 With JPL Team X | 14-16 May 2019 |

Longer Term Plan Forward

| Final Preparation for ACWS #2—SmallSat Constellations Finalize MTM for ACWS #2 Library Evaluated Against Threshold Desired Capabilities Architecture Finalization for ACWS #2 | Early June 2019 |
|---|-----------------------|
| ACWS #2 @ JPL | 18-20 June 2019 |
| Incorporate Lessons Learned Into SATM, MTM, and Library | Late June 2019 |
| Present Refined SATM and Threshold Science Objectives to A-CCP HQ | Early July 2019 |
| Program Scientist (PS) | |
| Put SATM Under CM (Requiring SMT Change Approval) | Mid July 2019 |
| Architecture Refinement (With GSFC Mission Design Lab (MDL)) | 5-9 Aug 2019 |
| Qualitative Ranking of Science Value & Programmatics of All Architectures | Mid Aug 2019 |
| Review with HQ and Down-Select for Center Design Center (CDC) | Mid Aug 2019 |
| Design Refinements | |
| Refinement of Instruments (With GSFC Instrument Design Lab (IDL)) | 19-23 Aug 2019 |
| CDC #1 (GSFC) | 16-20 Sept 2019 |
| CDC #2 (GSFC) | 7-11 Oct 2019 |
| Sub-Orbital Workshop | Fall 2019 |
| Other CDCs TBS (@ LaRC, MSFC, GRC) | TBS Through July 2020 |

Longer Term Plan Forward

Value Framework Assessments After Each CDC

Independent Costing

HQ Reviews Observing Systems

Draft Final Report Submitted to HQ

Final Report & Presentations

Oct 2019-Oct 2020

Nov 2019-Nov 2020

Nov 2020-Dec 2020

July 2021

Sept 2021



Mass Change (MC) Designated Observables Study Plan

Objectives & Study Scope

Identify and characterize a diverse set of high value MC observing architectures responsive to Decadal Survey, preserving the fundamental approach that MC is observed through gravitational forces acting on the space craft(s).

Candidate Mission Architectures will maintain continuity of measurements for research and applications, and/or explore:

- Ground water and water storage mass change
- Land ice contributions to sea level rise
- Ocean mass change & heat content (when combined w/altimetry)
- Glacial isostatic adjustment
- Earthquake mass movement.
- Operational applications (drought, hazards, agriculture, etc.)

Current Team Activities - Team Meeting held March 14, 2019

- Identify issues with SATM, work off GRACE-FO STM (also being developed) and utilize for baseline performance capabilities
- Establish traceability of capabilities on observables (Science/Applications products), instruments and mission.
- Organize the development and work for the Applications Community Assessment report (CAR) major theme water resources, hydrology across multiple sectors.
- Establish value framework for architecture assessment/evaluation
- Develop candidate architectures in detail
- TBD MC Study dedicated public website and community engagement

SDC POCs

- PS: Lucia Tsaoussi, Jared Entin (alt)
- PE: Mitra Dutta
- PAL: Brad Doorn
- Study Coordinator: Bernie Bienstock (JPL)

Timeline & Milestones

Early October 2018 - Study initiation / Center & HQ team joint telecon

Oct 2018 – Phase 1 – Develop Candidate Architectures: Engage user communities to define requirements and establish capabilities, and create value framework

- Science & Applications Traceability Matrix Focus (March 2019)
- MC A team Study (June 2019) (A-team meeting May 1-2, 2019 @JPL)
- MC Status Brief to HQ (August 2019)
- Candidate architectures selected (September 2019)

Oct 2019 – Phase 2 – Assessment of Candidate Architectures: Evaluate science and applications value, down-select to top candidates for detailed evaluations

June 2020 - Phase 3 - Architecture Design of top candidate(s)

Jan 2021 – Phase 4 – Develop final report and Preparation of Mission Concept Review

Sept 2021 – Delivery of final report and end of Study

Mass Change (MC) Study - Example SATM draft

Objectives for SATM

- Solid Earth: earthquake mass movement and Glacial Isostatic Adjustment (GIA)
- Global Hydrological Cycles and water Resources: ground water and water mass storage
- Some objectives connected to MC can only be inferred with auxiliary info and models
- Some ambiguities in objectives lead to range of capability
- Climate Variability: Land-ice mass change, ocean mass change

Solid Earth SATM

- At a minimum, a threshold mission that meets GRACE measurement capabilities for Solid Earth target observables is needed.
- Continuity measurements with GRACE is particularly important for documenting the ongoing postseismic respond to the > 18 great earthquakes that occurred in the GRACE, now GRACE-FO, time period.
- The response of the solid Earth to ice mass change ("GIA") occurs on a variety of temporal (1 10⁴ years) and spatial scales and varies from region to region. At a minimum, GIA needs to be estimated at the same spatial and temporal scale as the ice mass change observations to reduce uncertainty in estimates of mass balance.

| 2017 Decadal Survey Objectives (from Appendix B) | | | | | | | T | Table C.1 Mass Change: Science & Applications Summary by Panel, "Solid Earth" (ESI) S1 Earthquake Mass Movement | |
|--|--|-------------------------------|------------|-------------|--|--|--------------------------------|--|--|
| S-1b Measure and forecast interseismic, preseismic, coseismic, and postseismic activity over tectonically active areas on time scales ranging from hours to decades S-4a Quantify global, decadal landscape change produced by <u>abrupt events</u> and by continuous reshaping of Earth's surface from surface processes, tectonics, and societal activity | | | | | | S1 Ear | | | |
| | | | | | | "Gravity change associated with large earthquakes" (> 8.0, GRACE), next slides | | | |
| J | | | | | | Glacial Isostatic Adjustment ed at same spatial scale as ice change obs. | | | |
| S-5a Determine the effects of convection within Earth's interiorthe interaction between mantle convection and plate motion Qua | | | | | | Quasi- | static/long-term gravity field | | |
| -6b Measure all significant fluxes in a | and out of the g | roundwater s | system acr | oss the red | charge area | | | oundwater and water storage mass change (se- presentation) | |
| | | Desire | d Capabil | lity | | | | | |
| Earthquake Mass Movement Geophysical Variables | Range , Range -Rate, Range Accele r. | Precisi on Accura cy | | Resolution | on | Observables | | Notes | |
| Minimum (GRACE Observed) | • | | | | | | | | |
| Coseismic | | | | | | Gravity anomaly (1-18 μGal), month multi-arc (L1B) range-rate, range- acceleration | nly L2, | Low-latency L1B product used for testing alternate early seismic source models (Mau example) | |
| Post-seismic | | | | | | > 0.5 μGal/yr , also some componer seismic moment tensor significant | nts of | Need long-term continuity as the solid Earth will response on times scales of days to decades to great earthquakes | |
| | | | | | | Possible Tohoku ex (tensor of gravit | | Other great earthquakes are being examine | |

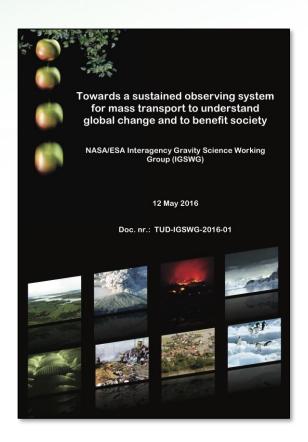
Mass Change (MC) - value framework development

Two Key guiding existing documents - geophysical observables and their utility are well-defined within these two international assessments of mass change science, applications, and future missions:

Towards a sustained observing system for mass transport to understand global change and to benefit society NASA/ESA Working group IGSWG

Science and User Needs for Observing Global Mass Transport to Understand Global Change and to Benefit Society

Roland Pail, Rory Bingham, Carla Braitenberg, Henryk Dobslaw, Annette Eicker, Andreas Guntner, Martin Horwath, Eric Ivins, Laurent Longuevergne, Isabelle Panet, Bert Wouters, IUGG Expert Panel Received: 10 June 2015 / Accepted: 16 October 2015 / Published online: 27 October 2015 Springer Science+Business Media Dordrecht 2015

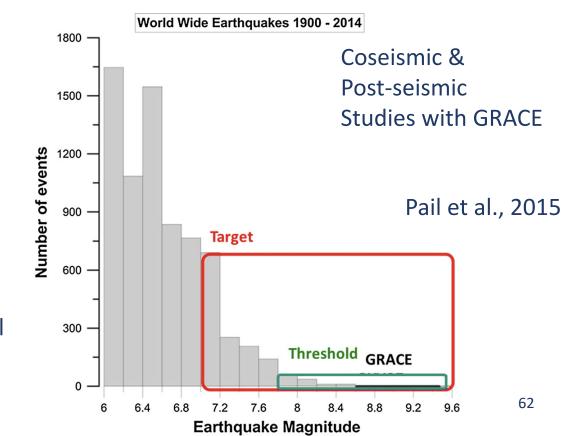


Geophysical observables:

- Hydrology
- Cryosphere
- Ocean
- Solid Earth

Observable temporal scales:

- Long-term trends
- Monthly to interannual
- Short-term daily to weekly





Surface Biology and Geology (SBG) Designated Observable Study Plan

Objectives

Establish research and applications questions for SBG looking to the Decadal Survey and prior HyspIRI questions

Engage SBG end users and stakeholders in the above process

Use a science and applications traceability framework to derive observing system desired capabilities from questions

Explore domestic and international partnerships Develop, assess, and design candidate architectures

Scope/Implementation

- Phase 1 Development of Candidate Architectures
- Phase 2 Assessment of Potential Architectures for Costeffective SBG Observations
- Phase 3 Design of Recommended SBG Architecture and Preparation of Mission Concept Review Material
- Phase 4 Preparation of End of Study Report

Timeline

- August 2018 Final HyspIRI Workshop/Initial SBG Workshop
- September 2018 HyspIRI Final Report
- October 2018 Initiate SBG Study Plan Funding
- December 2018 Parallel and connected activities of the Research and Applications, Architecture Formulation, and Cost Estimation technical teams
- January 2019 to September 2021 Assessment of candidate architectures and design of SBG observing system concept
- December 2021(?) Final Report, Mission Concept Review

Participants

- HQ Turner, Phillips, Bontempi, Jarrett, Doorn SBG Leads
- Study Coordinator JPL/Jamie Nastal
- GSFC, ARC, LaRC, MSFC study partners
- USGS, USDA, NOAA, SI, etc. Government Participants
- Academia
- Industry
- ESA, SRON, IAVCEI, etc. International Participants



November-December 2018 – Four Research and Applications (R&A) Working Groups established for *Algorithms, Applications, Cal-Val,* and *Modeling* with these WG coleads meeting together as the R&A Steering Committee; in parallel with R&A activities, Architecture studies get underway at Centers

Regular calls by SBG Leadership, R&A Steering Committee, and R&A Working Groups January 17, 2019 – SBG Partnerships Study Session at JPL

February 8, 2019 – SBG JPL Leadership Stock Taking Meeting with HQ SBG Program Leads, NASA Headquarters

February 27-28, 2019 – A-Team Architecture Session at JPL with inputs, including latest Science and Applications Traceability Matrix, from R&A Working Groups March 13-14, 2019 – R&A Co-Leads Meeting in DC

~March 2019 – Development of public website to share SBG information June 12-14, 2019 – SBG All Hands Meeting, hosted by GSFC in DC area

SBG Update

SHUTDOWN: NASA HQ and Centers (GSFC/ARC/MSFC/LaRC) on furlough status; JPL and Universities working

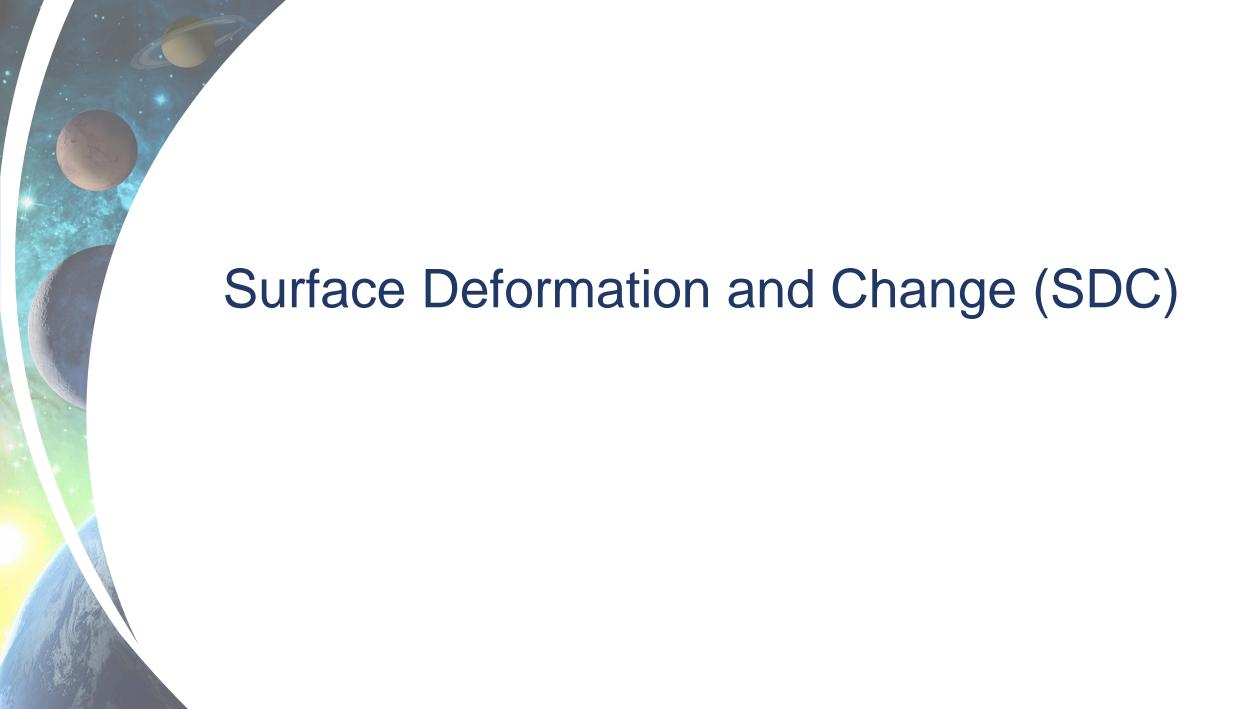
No change expected in timing of the delivery of the SBG study final report and for an MCR in Fall 2021

Participation in 4 SBG Working Groups is growing, with dozens of people in each group

Science and Applications Traceability Matrices have been developed to translate research and applications needs into engineering architecture capabilities

Research and Applications WG activities (Algorithms, Applications, Cal/Val, Modeling) are currently running in parallel with Architecture activities—at this point in the SBG Study (year 1 of 3 years), both activities are casting as wide a net as possible in order to consider as many options as possible

Plans are to begin to narrow these Research and Applications foci and architectural design options in year 2 through a Value Framework process, likely ending up with 3 mission architecture options for NASA to consider in third and final year of the SBG study All potential domestic and international partnerships are currently on the table



Surface Deformation and Change (SDC)

Architecture Study Objectives

Determine cost-effective SAR-based architecture to implement the Decadal Survey's Surface Deformation and Change Observable – SAR phase

Evaluate other Science and Applications that SAR can enable in the trade space – *SAR reflectometry*

Engage emerging best and new practices in industry to maximize engagement and exploitation of commercial sector capabilities and interests, including smallsat constellations

Explore international partnerships to leverage capability and reduce cost.

SDC Leadership

- PS: Gerald Bawden, Hank Margolis (alt)
- PE: Charles Webb, Kevin Murphy (alt)
- PA: David Green
- Study Coordinator: Paul Rosen (JPL)

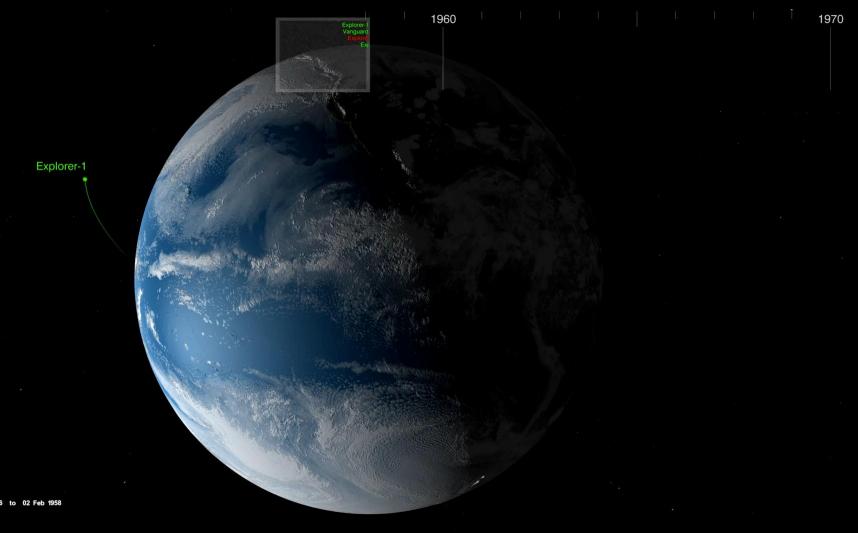
Architecture Study Approach

- SDC will utilize tools developed for NISAR (specifically a set of Performance Tools). This will not only improve the architecture study assessment, but will provide assuredness about the study's findings. It also significantly reduces the development time and costs.
- Study will be managed in an environment where all Centers contribute to the overall study needs. If multiple Centers run a similar task, differences in results will be assessed/understood and incorporated into the Study. Provides checks on the process.
- The Science and Applications are rolled together in the analysis.

Surface Deformation and Change Key Activities

| Date | Activity | Purpose | Location |
|-----------------------|--------------------------------------|--|--|
| Nov 15, 2018 | NASA HQ DO Kickoff | Bring all DO teams to common understanding of scope, applications, industry, and other programmatic aspects | Embassy Suites by Hilton, Washington, DC |
| Feb 12-13, 2019 | Center Leads Planning Meeting | Review the Program of Record, establish a common understanding of study objectives, discuss/derive a detailed study plan, including schedule, clarify roles and responsibilities | Jet Propulsion Laboratory, Pasadena, CA |
| Apr 29-May 1, 2019 | SDC Research & Applications Workshop | Assess the research and application value of the Program of Record and identify observation gaps; prioritize the SDC science and applications objectives; update science and applications traceability; Consider ecosystems and other amplitude-based radiometry observables; build community support for the SDC project. | California Institute of Technology, Pasadena, CA |
| May 13-17, 2019 | Living Planet Symposium | Participate in session geared to international collaborations and coordination; brief SDC study and preliminary concepts; meet international players | Milan, Italy |
| May 20-22, 2019 | SAR Technology Workshop | Survey the latest in technology relevant to the next generation of SAR satellites to determine what will be ready and usable in a 5 year time horizon. <i>Held at the Pasadena Space Technology Expo.</i> | Pasadena Convention Center, Pasadena, CA |
| Sep 26-28, 2019 | Second R&A Workshop | Socialize Science and Applications Traceability Matrix with non- NASA stakeholders, who may have additional applications objectives or capabilities needs, and who may wish to participate in the program | Washington D.C. |

Questions?



NASA Earth Observing Satellites since 1958