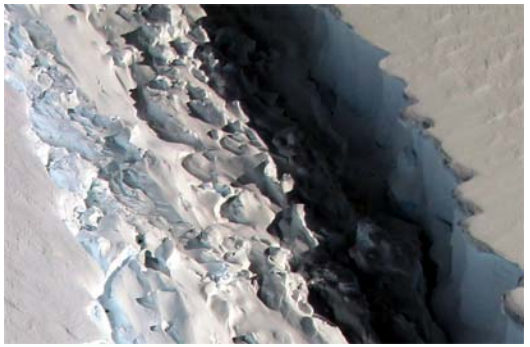
SCIENCE






Decadal Survey Briefing to Earth Science Stakeholders

Earth Science Division, NASA HQ

September 6, 2018

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 you 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

- Appropriation Status
- ESD Flight Program Status and Plans
- 2017 Decadal Survey ESD's Interpretation Recap
- Framework for implementing Earth Venture Continuity (EVC)
- Framework for implementing Earth Science Explorers (ESE)
- Incubator Program (Preliminary)
- Framework for implementing Designated Observables (DO)
- Non-Federal Community Involvement
- International Involvement
- Questions

NASA/ESD Appropriation: FY18, FY19

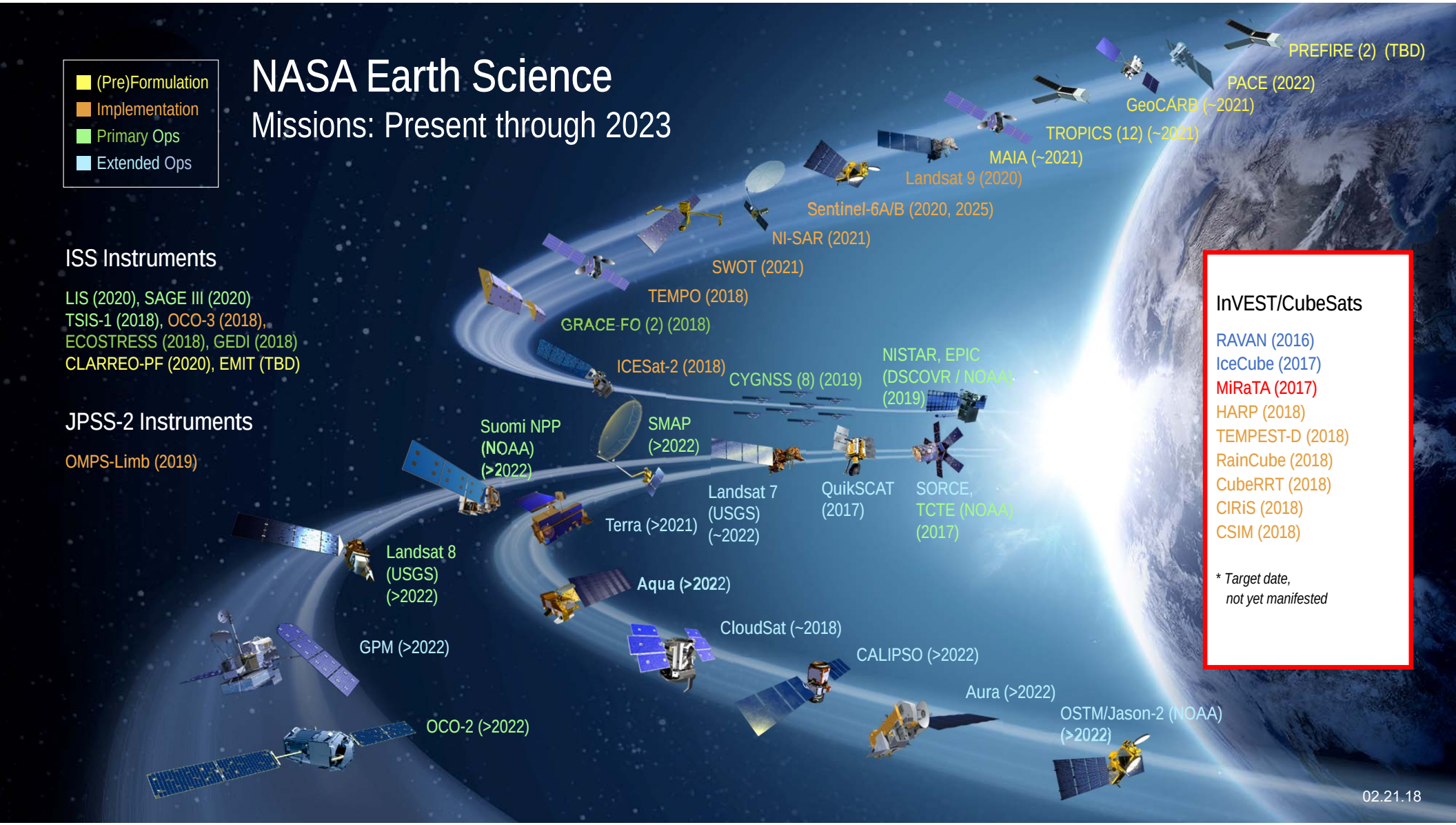
- FY18 (1 Oct 2017 – 30 Sept 2018) funding – appropriated via an Omnibus – is at the FY16/FY17 level (~$1.92B)

- Continues operations and development of FY17 Program of Record (including DSCOVR EPIC/NISTAR, PACE, CLARREO-PF, OCO-3 (to launch as manifested by February 2019)

- House Appropriations Committee marked up the FY19 NASA/ESD budget in April, 2018
  - Original text had ESD authorized at $1.45B in FY19
  - Amendment to increase ESD appropriation to $1.92B passed by a vote of 27-5 !!

- Senate Appropriations marked up the FY19 budget in May
  - $1.925B in FY19
  - However, this *includes* restoration of OCO-3, DSCOVR ops, PACE, CLARREO-PF

- The Earth Science Division funding is substantial and is expected to remain at a high level for FY19 and beyond


(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 (2018),
ECOSTRESS (2018), GEDI (2018)
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)
GRACE-FO (2) (2018)
ICESat-2 (2018)
CYGNSS (8) (2019)
NISTAR, EPIC
(DSCOVR / NOAA)
(2019)
Suomi NPP
(NOAA)
(>2022)
SMAP
(>2022)
Landsat 7
(USGS)
(~2022)
QuikSCAT
(2017)
SORCE,
TCTE (NOAA)
(2017)
Terra (>2021)
Landsat 8
(USGS)
(>2022)
Aqua (>2022)
CloudSat (~2018)
GPM (>2022)
CALIPSO (>2022)
Aura (>2022)
OSTM/Jason-2 (NOAA)
(>2022)
OCO-2 (>2022)
InVEST/CubeSats
RAVAN (2016)
IceCube (2017)
MiRaTA (2017)
HARP (2018)
TEMPEST-D (2018)
RainCube (2018)
CubeRRT (2018)
CIRiS (2018)
CSIM (2018)
* Target date,
not yet manifested
02.21.18

RECENT and UPCOMING NOTABLE FLIGHT PROGRAM EVENTS

- 2017 Senior Review recommended continuation of most on-orbit missions
- QuikSCAT to be decommissioned Aug-Sep 2018
- TES instrument on Aura discontinued (low availability resulting from hardware issues)
- RBI discontinued by NASA for technical, cost, schedule issues; work underway to develop an affordable and capable replacement for launch in JPSS-3 timeframe (2026)
- CATS (ISS) mission ended owing to instrument failure
- GRACE mission ended after 15 years
- Jason-2/OSTM moved to lower orbit (IMU redundancy/temperature issues) – continues to provide near-real-time and geodetic measurements
- CloudSat moved to safe orbit below A-Train (loss of hardware redundancy) – continues to potentially provide high-quality science data
- Calipso decision to join CloudSat in graveyard orbit for synergistic science
- TSIS-1 instrument successfully launched to ISS and operating
- NOAA's JPSS-1 mission successfully launched and operating
- ICECube, MIRATA CubeSats launched (MIRATA failed once on-orbit); MicroMAS-2 CubeSat successful on JPSS-1 launch
- TEMPEST-D, RainCube, CubeRRT, successfully launched on OA-9, May 21, 2018 to ISS, deployed 13 July 2018
- GRACE-FO successfully launched May 22, 2018
- ECOSTRESS successfully launched 29 June 2018, installed (5 July), operating on ISS

- OCO-3 completion and delivery to storage Aug, 2018 for launch by February, 2019 (PSR June 13, 2018)
- CSIM CubeSats/SmallSats, HARP manifested for launch in 2018
- ICESat-2 on-track for launch September 15, 2018
- GEDI delivery accelerated to allow launch as early as November, 2018
- EVI-4 selections: EMIT (hyperspectral aerosol mineralogy/composition) and PREFIRE (Arctic Far-IR emissions from dual CubeSats)

Recent ESD Launches

TSIS-1: DEC 15, 2017

GRACE-FO: May 22, 2018

ECOSTRESS: June 29, 2018

TSIS-1	*The Total and Spectral Solar Irradiance Sensor (TSIS-1) will measure the total amount of sunlight that falls on Earth, and how that light is distributed among the ultraviolet, visible and infrared wavelengths.*
GRACE-FO	*Obtain high resolution global models of Earth's gravity field, including how it varies over time*
ECOSTRESS	*Provide insight into plant-water dynamics & how ecosystems change with climate via high spatiotemporal resolution thermal infrared radiometer measurements of evapotranspiration (ET)*

Planned for Launch in 2018/19

ICESat-2	GEDI	OCO-3
		
September 2018	November 2018	February 2019

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*

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.*

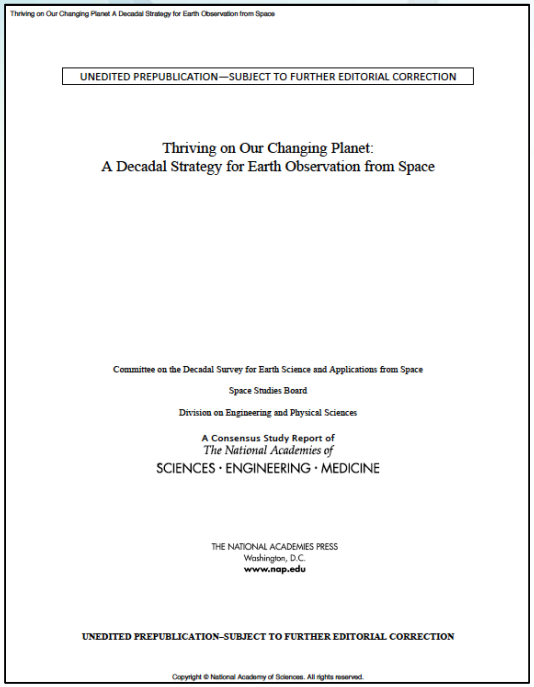
Private Sector Small-Satellite Constellation Pilot - Update

- Pursuing 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
- Attempting to make awards ASAP

2017 Decadal Survey ESD's Interpretation Recap

2017 Decadal Survey Snapshot

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

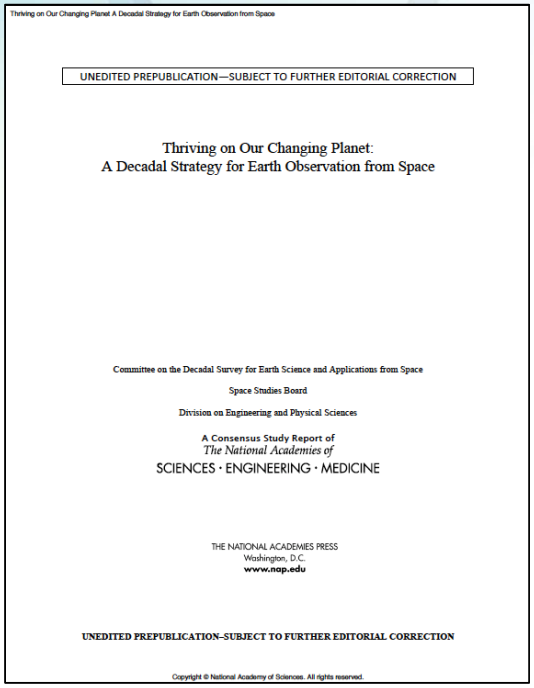
THE NATIONAL ACADEMIES PRESS
Washington, D.C.
www.nap.edu

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

2017 Decadal Survey Snapshot (cont.)

2017 DECADAL SURVEY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UNEDITED PREPUBLICATION–SUBJECT TO FURTHER EDITORIAL CORRECTION

- 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)*
- Calls for "cost-capping" essentially all missions
- 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)
- *ESD is conducting 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.*
  - Decadal new mission budget wedge opens only in late FY21

Framework for implementing Earth Venture Continuity (EVC)

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
- 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

Targeted Solicitation: EVC-1

- Defined and accelerated implementation of Earth Venture Continuity competed strand targeted for radiation budget sensor/RBI replacement
- Preparing EVC solicitation for release Dec 2018 (draft AO for comment during Fall, 2018); EVC-1 will allow flight on JPSS-3; will have extraordinary 5-year lifetime target
- NASA-owned RBI hardware made available to proposers as GFE

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

Incubator Program (preliminary)

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~~
  - 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**

Framework for implementing Earth Science Explorers (ESE)

ESE Observables Summary (from DS)

Observable	Science/Applications Summary	Candidate Measurement Approach
Greenhouse Gases	**CO2 and methane fluxes and trends,** global and regional with quantification of point sources and identification of sources and sinks	Multispectral short wave IR and thermal IR sounders; or lidar**
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**
Ocean Surface Winds and 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	Doppler scatterometer
Ozone and Trace Gases	**Vertical profiles of ozone and trace gases** (including water vapor, CO, NO2, methane, and N2O) globally and with high spatial resolution	UV/Vis/IR microwave limb/nadir sounding and UV/Vis/IR solar/stellar occultation
Snow Depth and Snow Water Equivalent	**Snow depth and snow water equivalent** including high spatial resolution in mountain areas	Snow depth and snow water equivalent including high spatial resolution in mountain areas
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 and forest degradation	Lidar**
Atmospheric Winds*	**3D winds in troposphere/PBL** for transport of pollutants/carbon/aerosol and water vapor, wind energy, cloud dynamics and convection, and largescale circulation	Active sensing (lidar, radar, scatterometer); passive imagery or radiometry-based atmos. motion vectors (AMVs) tracking; or lidar**

*Atmospheric Winds is listed as BOTH an ESE Observable ~~and Incubation Observable~~

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

ESE Decisions

- Atmospheric Winds is eligible for DS Explorers focus list - removed from Incubator list
- ESE will use a two-step AO process, similar to mission solicitations in other SMD Divisions
  - $350M cost-capped (including launch services) observing systems/missions to be solicited
  - 9-14 month Phase A prior to down-select
  - First solicitation will likely allow proposals for any observable from the DS Explorers list
  - Subsequent ESE solicitations will likely restrict primary observable foci based on previous selections
  - ESD will encourage solicitations that address more than one ESE Observable and that support other aspects of the DS-recommended ESD portfolio
- The first ESE solicitation will be planned for release no earlier than FY20, pending budget developments
- New Earth System Explorers Program Office to be established
- Budget constraints may make it unlikely that Earth Science Explorer will be initiated until late in the decade.

Framework for implementing Designated Observables (DO)

Designated Observables Summary (from DS)

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 Mission/Observing System Implementation

- Each DO Mission/Observing System will be directed to a Center
- Each Mission/Observing System will be cost-constrained, informed by DS
- Payloads will be competed by HQ
- Satellite bus expected to be procured
- Partnerships strongly encouraged
- Contributions of each mission/observing system to other ESD science objectives strongly encouraged
- SBG or some combination of Aerosol/CCP will be first DO mission/observing system to be initiated

Designated Observables Guidance Summary

- ESD requested multi-center study plans to perform studies associated with the following cost-constrained DOs:
  - SBG: <$650M, full NASA cost for implementation (including launch services and core science)
  - Aerosols: <$800M, full NASA cost …
  - CCP: <$800M, full NASA cost …
  - Combined Aerosols and CCP study to address missions/observing systems approaches that can be implemented for <$1,600M, full NASA cost …
  - SDC: <$500M, full NASA cost …
  - MC: <$300M, full NASA cost …
- Study plans were submitted for ACCP (Combined), SBG, SDC and MC (4 total)
- The SBG, Aerosols, CCP and Combined Aerosols/CCP studies are expected to result in the initiation (KDP-A) of at most 2 projects in the FY21/22 timeframe approximately as follows:
  - DO#1 - 10/2021
  - DO#2 - 4/2022
- Other projects resulting from the DO studies are expected to be initiated (KDP-A) no earlier than FY24.

Guidance for DO Study Plans

- The studies will examine 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
  - new technologies
- Each study will perform a (qualitative or quantitative) assessment of the impacts of the designated observables on society, including the actual decisions or policies potentially affected

Multi-Center Study Plans: Points of Contact

- Points of Contact for each Study Plan during iterations:
  - ESD POC is the Evaluation Team Lead
    - Evaluation Team Leads are responsible for communicating/coordinating with Evaluation team members and ESD leadership
  - Center Team POC is the Study Coordinator identified in the Plan
    - Study Coordinators are responsible for communicating/coordinating with study personnel and management at Centers

- Points of Contact for each Study once iterations are complete:
  - Once studies are underway, the ESD Points of Contact for the duration of the study will be the PE, PS, and PA assigned to each Study

Points of Contact during Study Plan Iterations:

Study Plan	ESD Evaluation Team Lead	Centers' Study Coordinator
A-CCP	Hal Maring (Alternates: Barry Lefer, Gail Skofronick-Jackson)	William Cutlip (GSFC)
SBG	Woody Turner (Alternate: Ben Phillips)	Jamie Nastal (JPL)
SDC	Gerald Bawden (Alternate: Hank Margolis)	Paul Rosen (JPL)
MC	Lucia Tsaoussi (Alternate: Jared Entin)	Bernard Bienstock (JPL)

ESD Points of Contact once Studies are Underway (PE, PS, and PA)

Study	Program Executive	Program Scientist	Program Applications Lead
A-CCP	Mitra Dutta	Hal Maring (Alternates: Gail Skofronick-Jackson, Barry Lefer)	TBD
SBG	Dave Jarrett	Woody Turner (Alternate: Ben Phillips)	TBD
SDC	Richard Slonaker	Gerald Bawden Alternate: Hank Margolis)	TBD
MC	Mayra Montrose	Lucia Tsaoussi (Alternate: Jared Entin)	TBD

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

Timeline

- September 2018 – Start Development of Science Value Framework
- October 2018 – Initiate Science Group work on STMs
- January 2019 – Complete STMs
- January/February 2019 – Meeting of Full A-CCP Study Team
- March 2019 – Blue Sky Study
- April/May 2019 – Start Architecture Studies
- Early 2022 – Final Report, Mission Concept Review

Participants

- HQ – Maring, Jackson, Lefer, Dutta, Edwards, Haynes
- Study Coordinators – Cutlip (GSFC), Vane (JPL), Trepte (LaRC)
- NASA Centers - GSFC, JPL, LaRC, MSFC, ARC, GRC
- Other Expected US Participants NOAA, EPA, Universities, Commercial
- Hoped for International Partners – CNES, JAXA, ESA, SRON, …

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 Cost-effective 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

Surface Deformation and Change (SDC) Designated Observables Study Plan

Objectives

- Determine cost-effective SAR-based architecture to implement the Surface Deformation and Change Observable
- Keep other science and applications that SAR can enable in the trade space
- 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

Scope/Implementation

- Include SAR-based architectures that support broader science/applications observables beyond geodetics in trades
- Phase 1 – Engage user communities to define requirements and 5-6 candidate architectures; establish value framework
- Phase 2 – Evaluate science/applications value; down-select to 2 top candidates for detailed evaluation; down-select to concept
- Phase 3 – Phase A study leading to Mission Concept Review
- Phase 4 – Final Report and MCR prep

Timeline

- October 2018 – Study Kickoff
- October 2019 – Complete Performance Tool Development
- March 2020 – Complete Requirements Definition
- March 2021 – Begin assessment of candidate architectures
- March 2022 – Downselect to concept
- March 2023 – Complete design concept
- October 2023 – Deliver Final Report
- December 2023 – Conduct Mission Concept Review

Participants

- HQ Leads: PS–Bawden, Margolis: PE–Slonaker: PA– Green
- JPL – Study Lead (P. Rosen, Study Coordinator)
- ARC, GSFC, LaRC, MSFC study partners
- USGS, NOAA, NGA government participants
- Academia
- Industry

Mass Change (MC) Designated Observables Study Plan

Objectives

- 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).
- Assess the cost effectiveness of each of the studied architectures.
- Perform sufficient in-depth design of one or two select architectures to enable rapid initiation of a Phase A study

Scope/Implementation

- Examine (1) novel approaches considering emerging capabilities, such as industry spacecraft, launch vehicles, and "data buy" opportunities, and (2) innovative approaches and enabling techniques, such as small satellite buses, constellations using only positioning information, compact, low-power electronic accelerometers and drag compensation systems.
- Candidate Mission Architectures will maintain continuity of measurements and/or explore:
  - Ground water and water storage mass change
  - Land ice contributions to seal level rise
  - Ocean mass change & heat content (when combined w/altimetry)
  - Glacial isostatic adjustment
  - Earthquake mass movement.
  - Operational applications (drought, hazards, agriculture, etc.)

Timeline

- **Oct 2018 – Phase 1 – Develop Candidate Architectures:** Engage user communities to define requirements and establish capabilities, and create value framework
- **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):** Phase A study leading to Mission Concept Review
- **Jan 2021 – Phase 4 – Develop final report and Preparation of Mission Concept Review**
- **Sept 2021 – Delivery of final report and end of Study:** includes required observational capabilities of mission concept that may be used for competitive procurement of mission components.

Participants

- NASA – L. Tsaoussi, MC HQ Lead
- JPL – Study Lead (B. Bienstock, Study Coordinator)
- ARC, GSFC, LaRC study partners
- Academia (U. of Texas, U. South Florida, U. Colorado)
- International (DLR, ESA)
- US government (NOAA, USGS)
- Industry

Non-Governmental/Private Sector Community Involvement

- ESD is encouraging multi-center joint efforts, in partnership with private sector, academia, International and Interagency partners.
- Encouraged to discuss and explore possible observable implementation approaches directly with Centers
- Non-governmental/private sector participation is desired in the multi-center studies. The outcome of the multi-center studies is a study report, NOT the development of mission requirements.
- We want to ensure that participation in the studies does not preclude participation in the missions/observing systems.

Request for Information

- The DO studies aim to identify and evaluate observing system architectures and approaches that might improve the overall observing systems (increased capability and/or resilience, and/or reduced costs).
- ESD is taking a broad approach to addressing the observation architectures for the DOs. The studies will initially examine and evaluate the costs and benefits of observing system architectures that include a mix of NASA, international, interagency, and/or commercial spaceborne assets and data products, as appropriate.
- The RFI solicits input on *how industry and other non-governmental organizations wish to be involved in the multi-year NASA Designated Observables observing system architecture studies*.
- Offerors interested in participating in the multi-center DO studies are asked to submit short (< 10 pp) statements providing:
  - Ideas on ways they wish to participate in the planning processes/studies associated with implementing the DS recommendations;
  - The level of involvement desired; and
  - Aspects that they can contribute to the studies.
- *The RFI does NOT invite ideas regarding the specific observing systems/solutions that are to come out of the studies*. It rather solicits inputs and ideas on how the private sector and other non-governmental organizations can best *PARTICIPATE in the architecture studies*.
- Informed by the RFI input, NASA ESD intends to issue small contracts with multiple non-government/private sector entities to secure their participation in the studies.
- RFI was posted on September 4, 2018: https://www.fbo.gov/index?s=opportunity&mode=form&tab=core&id=95da1d67e34c9094907c688d1cb2897b

International Engagement

- ESD has conducted focused Decadal Survey telecons/meetings with key international partners
  - ISRO, JAXA, CNES, DLR, ESA, EUMETSAT, CSA
  - Bilateral, HQ-level, face-to-face meetings planned over the next 6 months
  - Some directed international partnerships may originate from ESD/HQ
- Centers are explicitly encouraged to discuss and explore possible observable implementation approaches with international partners
  - Multi-center joint efforts appreciated
  - Keep ESD leadership informed
- ESD will make final partnership determinations and then codify necessary international agreements

What's next

- ESD Leadership Team will continue to develop the framework for Designated Observables and address additional DS topics
- Community Forum (3st in the series) – January 17, 1:00-3:00 EDT, in person 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
  - View records of decisions and other posted material
  - https://science.nasa.gov/earth-science/decadal-surveys

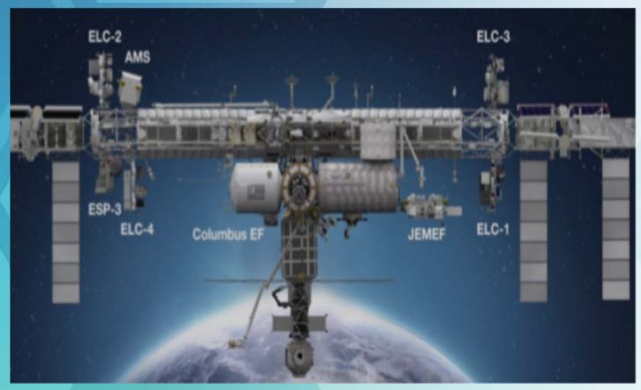
Attendance/Questions

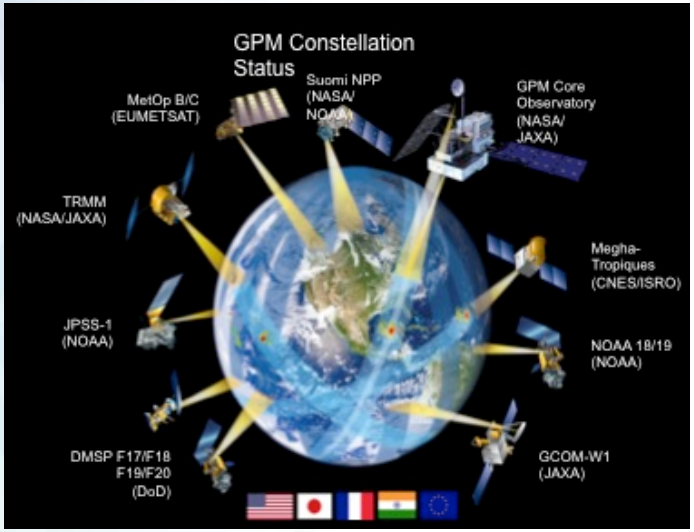
- Please email your name to ensure you will be informed of future Community Forums
- During this presentation please email your questions.

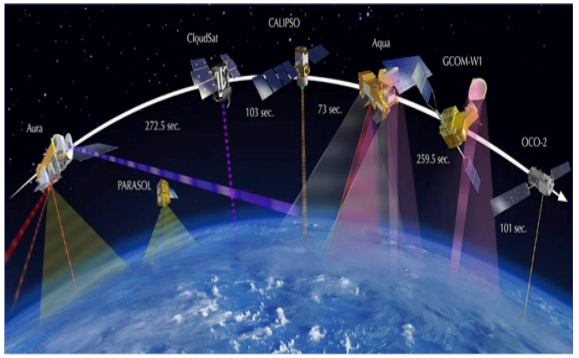
TO: Amy.A.Treat@nasa.gov

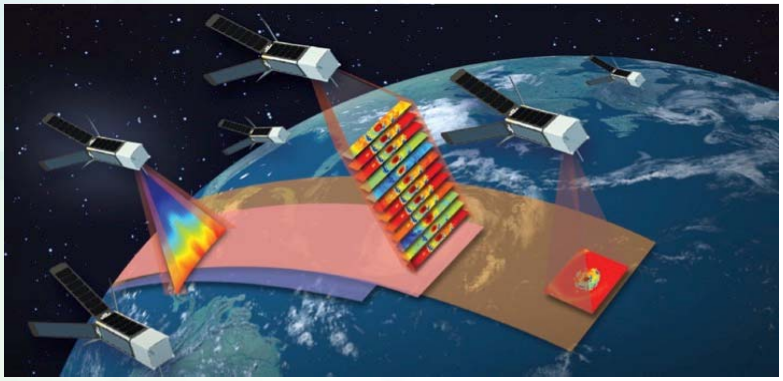
Backup

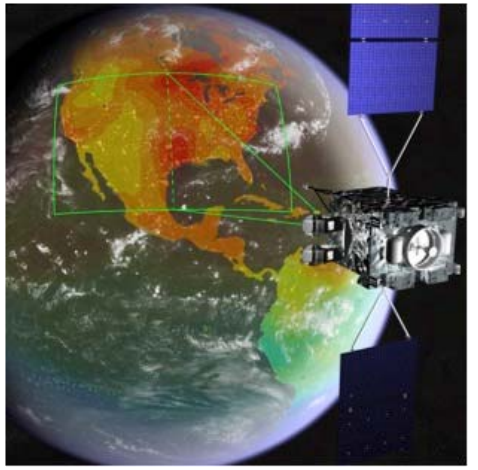
NASA Observing System *INNOVATIONS*



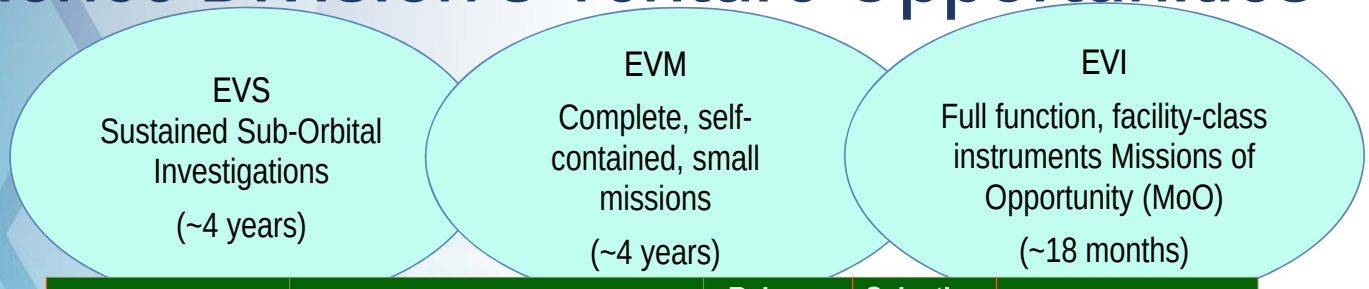








Earth Science Division's Venture Opportunities



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

EMIT, PREFIRE selected for EVI-4

Open solicitation - In Review
Completed solicitation

2017 Earth Science and Applications Decadal Survey Recap

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?

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**