



**NASA Science Mission Directorate
Earth Science Division**

NASA, Greenhouse Gases, and the Decadal Survey
Ken Jucks, NASA Program Manager Upper Atmosphere
Research Program; Program Scientist for Aura, **OCO-2, OCO-3,**
CLARREO, ASCENDS, ATTREX/CARVE (EVS-1), ACT-America
(EVS-2), CMS



What are NASA's current GHG satellite plans?

If it works, keep it going!

- As long as OCO-2 is producing scientifically useful data, NASA will continue its operations.
 - This will require the OCO-2 project to submit a “Senior Review Proposal” to continue (more next Page)

If it's built, try to fly it!

- OCO-3 is now in “Implementation”, meaning NASA has committed to a budget to fly it. Current plan is on ISS with launch date ~October 2018.



What is Senior Review?

Each mission has a defined length of “Prime Mission” which is the length of time required to obtain sufficient data to meet the science objectives of the mission.

The primary budget for each mission includes the Mission Operation and Data Analysis (MO/DA) for this prime mission operation period.

In order to obtain the budget to continue operation after this time period, each mission must propose to continue operation.

This is done through the Senior Review, where each mission states its case that it is providing sufficiently high quality science data to warrant continued operation.

Proposals are reviewed by a panel of scientists. The vast majority of proposals are rated sufficiently high to continue operation for the next 2 years.



Current NASA missions





SLI-TBD
Formulation in 2015

JPSS-2 (NOAA)

RBI
OMPS-Limb

[[TSIS-2]]

[[Future Altimetry]]

- Formulation
- Implementation
- Primary Ops
- Extended Ops

NI-SAR

PACE

SWOT

TEMPO

GRACE-FO (2)

ICESat-2

CYGNSS

RapidScat, CATS,
LIS, SAGE III (on ISS)

SMAP

SORCE

TRMM

QuikSCAT

[[TCTE]]

EO-1

Landsat-7
(USGS)

Terra

Aquarius

Suomi NPP
(NOAA)

Aqua

Landsat-8
(USGS)

CloudSat

GPM

CALIPSO

Aura

OCO-2

GRACE (2)

OSTM/Jason 2
(NOAA)

“Carbon Cycle” missions: A NASA Emphasis!

Besides OCO-2, OCO-3, there are:

- GEDI (JUST about to enter Phase C),
- ECOSTRESS (in Phase C),
- LandSat continuity (for USGS, in “planning”)
- PACE (STILL in pre-Phase A)



Overall FY2016 Budget Summary

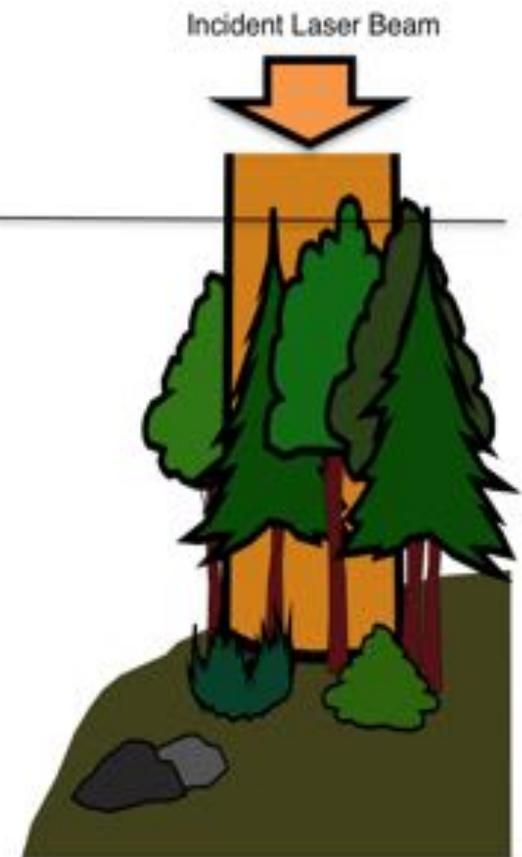
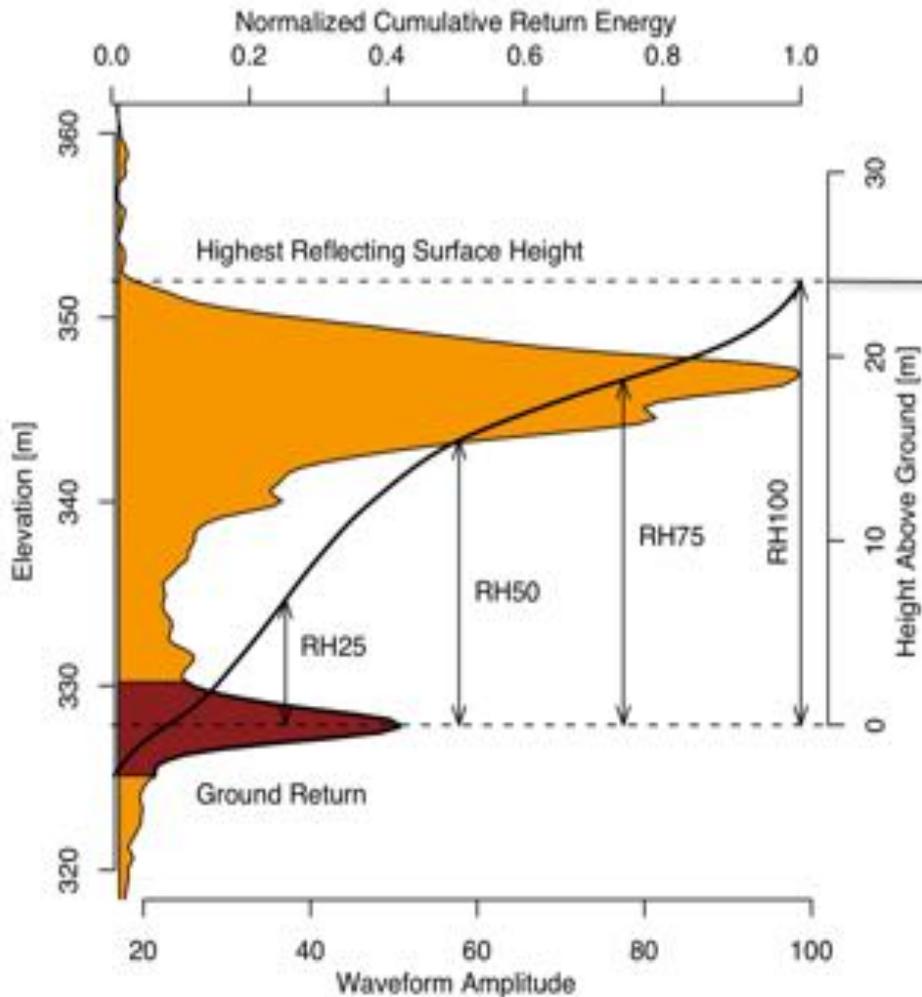
- ESD budget increases significantly

	<u>FY15</u>	<u>FY16</u>	<u>FY17</u>	<u>FY18</u>	<u>FY19</u>	<u>FY20</u>
FY16	1.730	1.894	1.913	1.932	1.952	1.971
FY15		1.762	1.784	1.805	1.829	---

- NASA now has mandate for additional long-term measurements for the nation:
 - Altimetry after Jason-3
 - Solar Irradiance, Ozone Profile, Earth Radiation Budget all starting in FY16
- Sustainable Land Imaging Program (w/USGS; NASA funds flight hardware):
 - TIR-FFD (2019)
 - Upgraded Landsat-9 (2023)
 - Focused technology development to inform designs of Landsat-10+
- Continued development and launch of: SAGE-III/ISS, ECOSTRESS/ISS, GEDI/ISS, CYGNSS, TEMPO, GRACE-FO, ICESat-2, SWOT, NISAR, PACE
- Continue Venture Class on schedule with full funding
- OCO-3 completion and flight to ISS in late 2017
- CLARREO Technology Demonstration instruments on ISS - development and flight in late 2019 (2 instruments, Reflected Solar/HySICS and IR Pathfinder)

GEDI LIDAR

GLOBAL ECOSYSTEM DYNAMICS INVESTIGATION



Where does NASA go from here???

It's all up to the next Decadal Survey!

- Any mission concept from the LAST Decadal Survey that is NOT in Formulation or further is in limbo.
- The only new missions between now and the release of the next DS that will enter formulation would come out of EVM-2 or EVI-4.



Primary Elements of Decadal Survey

- **Assess progress** in addressing the major scientific and application challenges outlined in the 2007 Earth Science Decadal Survey.
- **Develop a prioritized list of top-level science and application objectives** to guide space-based Earth observations over a 10-year period commencing approximately at the start of fiscal year 2018 (October 1, 2017).
- **Identify gaps and opportunities** in the programs of record at NASA, NOAA, and USGS in pursuit of the top-level science and application challenges—including space-based opportunities that provide both sustained and experimental observations.
- **Recommend approaches to facilitate the development of a robust, resilient, and appropriately balanced U.S. program of Earth observations from space.** Consider: Science priorities, implementation costs, new technologies and platforms, interagency partnerships, international partners, and the *in situ* and other complementary programs carried out at NSF, DoE, DoA, DoD.

Agency-Specific Tasks

NASA

- Recommend NASA research activities to advance Earth system science and applications by means of a set of prioritized strategic “science targets” for the space-based observation opportunities in the decade 2018-2027. (A science target in this instance comprises a set of science objectives that could be pursued and significantly advanced by means of a space-based observation.) For each science target, the committee will identify a set of objectives and measurement requirements/capabilities for space-based data acquisitions.

If appropriate and usually only for recommendations associated with major investments, the committee will (via a “CATE” process) assemble notional proof-of-concept missions with the recommended capabilities in order to better understand the top-level scientific performance and technical risk options associated with mission development and execution.

- Other NASA tasks include: The committee will pay particular attention to prioritizing and recommending balances among the full suite of Earth system science research, technology development, flight mission development and operation, and applications/capacity building development conducted in the Earth Science Division (ESD) of the Science Mission Directorate.

What Happens to Missions Recommended in the Previous Survey?

TBD, but:

- In developing its recommendations, survey to “include reconsideration of the scientific priorities associated with the named missions from the 2007 decadal survey.”
 - The 2007 survey did not prioritize among the 15 missions for NASA; placement in 1 of 3 time periods (Tiers I, II, III: 2010-13, 2013-2016, 2016-2020) was based on factors including technical readiness; cost; synergy with existing, planned, or recommended missions; and consideration of int’l activities.
- ESD has expressed an interest in having the survey provide guidance on technology investments that will be needed to address recommended science targets.
- Previous surveys have assumed missions in formulation to be considered part of the baseline program of record.

Survey Status

- NRC Approval, May 6, 2015
- Chairs and steering committee have been named, though one co-chair stepped down recently
- 1st round of white papers for science topics were submitted, which helped define committees.
- 2nd round of white papers were due last month (>150 received).
- NASA HQ are not to be part of this process.
- NRC Boards covering atmospheric sciences, polar research, ocean science, hydrology, and the solid Earth will be collaborating partners with the Space Studies Board.
 - Includes membership, execution, staffing, etc.
- Final report due ~ 2 years from survey start (Mid 2017).
- Info @ <http://sites.nationalacademies.org/DEPS/ESAS2017/index.htm>

Decadal Survey Steering Committee

Waleed Abdalati, *Chair*, University of Colorado, Boulder

Steven Battel (NAE), Battel Engineering

Stacey Boland, Jet Propulsion Laboratory

Robert Braun (NAE), Georgia Institute of Technology

Shuyi Chen, University of Miami

William Dietrich (NAS), University of California, Berkeley

Scott Doney, Woods Hole Oceanographic Institution

Christopher Field (NAS), Carnegie Institution for Science

Helen Fricker, Scripps Institution of Oceanography

William Gail, Global Weather Corporation

Sarah Gille, Scripps Institution of Oceanography

Dennis Hartmann (NAS), University of Washington

Daniel Jacob, Harvard University

Anthony Janetos, Boston University

Everette Joseph, University at Albany, SUNY

Molly Macauley, Resources for the Future

Joyce Penner, University of Michigan

Soroosh Sorooshian (NAE), University of California, Irvine

Graeme Stephens (NAE), California Institute of Technology

Byron Tapley (NAE), University of Texas at Austin

W. Stanley Wilson, NOAA/NESDIS (retired)



Decadal Survey Committees

5 committees set up

- Climate Variability and Change: Seasonal to Centennial
- Earth Surface and Interior: Dynamics and Hazards
- Global Hydrological Cycles and Water Resources
- Marine and Terrestrial Ecosystems and Natural Resource Management
- Weather and Air Quality: Minutes to Subseasonal

There are supposed to be “cross-cutting themes” across these committees. What they are is TBD.



Committee Members

Climate Variability and Change: Seasonal to Centennial

- Dr. Carol Anne Clayson (Co-Chair), Woods Hole Oceanographic Institution
- Dr. Arlyn E. Andrews, NOAA Earth System Research Laboratory
- Dr. Lee-Lueng Fu, Jet Propulsion Laboratory
- Dr. Guido Grosse, Alfred-Wegener-Institute for Polar and Marine
- Dr. Randal D. Koster, NASA Goddard Space Flight Center
- Dr. Sonia Kreidenweis, Colorado State University
- Dr. Emilio F. Moran, Michigan State University
- Dr. Venkatachalam Ramaswamy, National Oceanic and Atmospheric Administration
- Dr. Cora E. Randall, University of Colorado
- Dr. Philip J. Rasch, Pacific Northwest National Laboratory
- Dr. Eric J. Rignot, University of California, Irvine
- Dr. Christopher Ruf, University of Michigan
- Dr. Ross J. Salawitch, University of Maryland
- Dr. Amy K. Snover, University of Washington
- Dr. Bruce A. Wielicki, NASA Langley Research Center
- Dr. Gary W. Yohe, Wesleyan University



Committee Members

Earth Surface and Interior: Dynamics and Hazards

- A
- Bunch
- Of
- People
- I
- Don't
- Really
- Know!
- And
- You
- Don't
- Either!



Committee Members

Global Hydrological Cycles and Water Resources

- Dr. Ana P. Barros - (Co-Chair), Duke University
- Dr. Jeff Dozier - (Co-Chair), University of California, Santa Barbara
- Dr. Newsha Ajami, Stanford University
- Dr. John D. Bolten, NASA Goddard Space Flight Center
- Dr. Dara Entekhabi, Massachusetts Institute of Technology
- Dr. Graham E. Fogg, University of California, Davis
- Dr. Efi Foufoula-Georgiou, University of Minnesota
- Dr. David C. Goodrich, U.S. Department of Agriculture
- Dr. Terri S. Hogue, Colorado School of Mines
- Dr. Venkat Lakshmi, University of South Carolina
- Professor Andrea Rinaldo, Ecole Polytechnique Federale de Lausanne
- Dr. Edwin Welles, Deltares
- Dr. Jeffrey S. Kargel, University of Arizona
- Professor Eric F. Wood, Princeton University



Committee Members

Marine and Terrestrial Ecosystems and Natural Resource Management

- Dr. Compton J. Tucker - (Co-Chair), NASA Goddard Space Flight Center
- Dr. James A. Yoder - (Co-Chair), Woods Hole Oceanographic Institution
- Dr. Gregory P. Asner, Carnegie Institution for Science
- Dr. Francisco Chavez, Monterey Bay Aquarium Research Institute
- Dr. Scott Goetz, Woods Hole Research Center (soon N. Arizona)
- Dr. Patrick N. Halpin, Duke University
- Dr. Eric Hochberg, Bermuda Institute of Ocean Sciences
- Dr. Christian J. Johannsen, Purdue University
- Dr. Raphael M. Kudela, University of California, Santa Cruz
- Dr. Gregory W. McCarty, U.S. Department of Agriculture
- Dr. Linda O. Mearns, National Center for Atmospheric Research
- Dr. Mary Jane Perry, University of Maine
- Dr. David A. Siegel, University of California, Santa Barbara
- Dr. David L. Skole, Michigan State University
- Dr. Susan L. Ustin, University of California, Davis
- Dr. Cara Wilson, National Oceanic and Atmospheric Administration



Committee Members

Weather and Air Quality: Minutes to Subseasonal

- Dr. Steven A. Ackerman - (Co-Chair), University of Wisconsin-Madison
- Mr. Richard E. Carbone - (Co-Chair), NCAR
- Dr. Philip E. Ardanuy, INNOVIM, LLC
- Dr. Nancy L. Baker, Naval Research Laboratory
- Dr. Elizabeth A. Barnes, Colorado State University
- Dr. Stanley G. Benjamin, National Oceanic and Atmospheric Administration
- Dr. Mark A. Bourassa, Florida State University
- Dr. Bryan N. Duncan, NASA Goddard Space Flight Center
- Dr. Charles E. Kolb, Aerodyne Research, Inc.
- Dr. Ying-Hwa Kuo, University Corporation for Atmospheric Research
- Dr. W. Paul Menzel, University of Wisconsin-Madison
- Ms. Maria A. Pirone, Harris Corporation
- Dr. Armistead G. Russell, Georgia Institute of Technology
- Ms. Julie A. Thomas, Scripps Institution of Oceanography UCSD
- Dr. Duane Waliser, California Institute of Technology
- Dr. Xubin Zeng, University of Arizona



Open questions regarding NASA's plans

- OCO-2 will most likely pass senior review (assuming they can demonstrate the science value of the mission).
- OCO-3 is NOW officially back in our budget and confirmed for deployment on ISS, currently slated for launch in ~October 2018.
- ASCENDS is uncertain, most likely pending the results from next Decadal Survey.
- Any other GHG related mission will depend on whether the science questions from the Decadal Survey support one.
- Ken's guess is that some form of Earth Venture program will be recommended by the next Decadal Survey.
 - **BUT**...There is little guarantee that this avenue will get YOUR favorite measurement done from space any time soon either.