NASAA HQ Update

Ken Jucks, Aura Program Scientist
Earth Science Division, Science Mission Directorate

31 August 2015
Current NASA missions

- SMAP
- QuikSCAT
- Suomi NPP
- Jason 2
- Landsat 8
- GF

The image shows a globe with various satellites and missions orbiting around it, indicating the current NASA missions.
SLI-TBD Formulation in 2015

RBI
OMPS-Limb
[[TSIS-2]]
[[Future Altimetry]]

JPSS-2 (NOAA)

TEMPO
GRACE-FO (2)

PACE
SWOT

NI-SAR

CYGNSS

ICESat-2

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

SMAP

SORCE

TRMM

QuikSCAT

EO-1

Suomi NPP (NOAA)

Landsat-8 (USGS)

Aqua

CloudSat

CALIPSO

GRACE (2)

OSTM/Jason 2 (NOAA)

GPM

Aura

OCO-2
3 ESD-developed EO missions launched since 2/2014
2 ISS-developed EO instruments launched (2014, 2015)
11+ more ESD EO launches before 2022
Overall FY2016 Budget Summary

• ESD budget increases significantly

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<th>FY15</th>
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• 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)
The Senior Review and Aura...
## Missions reviewed for extension in 2015

### Original Call

**Missions Included:**
- Extended missions invited to propose: Aqua, Aura, CALIPSO, *CloudSat*, GRACE*, OSTM, *QuikSCAT*, SORCE*, Terra (*missions with unsustainable budgets*)
- Missions completing prime operations & new to the Senior Review process: Aquarius

**Missions NOT included**
- Missions in prime that will not be included in the 2015 Senior Review: GPM, SNPP, OCO-2
  - when their prime ops end, they will be granted extension to the next senior review in the PPBE guidance, to be confirmed at the End of Prime Mission Review.
- **Extended missions in operation NOT invited for further extension, due to scheduled decommissioning:** EO-1, TRMM
- Missions failed since 2013 Senior Review: Jason-1, ACRIMSAT

### Changes

**QuikSCAT:**
- The mission declined to propose for further extension, citing:
  - Successful transfer of calibration standard to ISS RapidScat;
  - Community survey of potential scientific applications of QuikSCAT data in the non-spinning mode indicated that QuikSCAT could provide no unique or significant contribution.

**EO-1:**
- HQ explicitly informed EO-1 (and TRMM) on Dec 14, 2014 that they would be excluded.
- In February, the mission team unofficially proposed extension as a lunar calibration lab & requested reconsideration of their exclusion based on both the lab proposal and continuing data value at the projected MLT. Mar 23 briefing was scheduled to consider the request.
- Mar 30, ESD amended the Call Letter to include EO-1.
Senior Review Panel Instructions

- **Science Panel**: Evaluate and rank the scientific merit of the proposed mission extensions in the context of ESD science goals, objectives and research focus areas described in the NASA Science Plan.
  - Intrinsic scientific value of the data record and data continuity
  - Data Product Maturity & **Quality Trend**
  - Relevance to NASA Science Goals
  - Secondary Factors (considering results from the sub-panels):
    - Contribution to National Needs
    - Technical Status of mission & cost effectiveness

- **National Interests Sub-Panel**: Assess the contributions of the missions, sensors, and core data products to “applied and operational uses” that serve national interests, including: operational uses, public services, business and economic uses, military operations, government management, policy making, non-governmental organizations’ uses, etc.

- **Technical Sub-Panel**: Review hardware status and performance and reliability projections, and assess adequacy of mission operations plans to maintain performance.

- **Cost Sub-Panel**: Review funding request and assess reasonableness compared to historical costs.
Science Panel Membership

- Science Panel:

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Previous Panel(s)</th>
<th>Discipline</th>
<th>Lead Reviewer</th>
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<td>Dessler, Andrew</td>
<td>Texas A&amp;M</td>
<td>2011</td>
<td>Climate/Atmos Chemistry</td>
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<td>Jaegle, Lyatt</td>
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<td>Microwave remote sensing</td>
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<td>Liu, Guosheng</td>
<td>Florida State University</td>
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<td>Meteorology</td>
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- Technical Sub-Panel: LaRC Science Support Office, Waldo Rodriguez, Chair
- Cost Analysis: SMD Resources Division, Voleak Roeum, Chair
### 2013 Senior Review Findings

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</table>

- Science scores based on intrinsic science value of dataset, relevance to ESD science goals, and maturity/quality trend of the data products.
- Utility scores based on intrinsic value of data products, frequency and timeliness of use.
- Technical Risks were based on: Redundancy, Age, Design(e.g. mechanical components), Heritage (long-lived predecessor), power and propellant margins, performance to date.
- Cost Risks were based on: historical costs, internal consistency, funding and staffing profiles by organization and task, and uncosted carryover projections.
Mission ‘Ranking’

- Ranking was done after the panel discussions, to verify assessments, explore similarities and differences from the discussions.
### Recommended Budget for Extended Missions

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<td>25,316</td>
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**Total MO&DA Extended Missions**

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### ESD funded all Senior Review findings for 2016-2017
2015 Senior Review: Funded Mission Extensions

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</tbody>
</table>

- **TRMM** has been active from CY 97 to CY 21.
- **QuikSCAT** has been active from CY 00 to CY 21, except for CY 10 to CY 13 where it was declined to propose.
- **Terra** has been active from CY 02 to CY 14.
- **ACRIMSAT** has been active from CY 06 to CY 15.
- **EO-1** has been active from CY 07 to CY 15.
- **Jason 1** has been active from CY 08 to CY 16.
- **GRACE** has been active from CY 12 to CY 19, with a projected re-entry in CY 20.
- **Aqua** has been active from CY 13 to CY 21.
- **SORCE** has been active from CY 14 to CY 18.
- **Aura** has been active from CY 15 to CY 20.
- **CloudSat** has been active from CY 16 to CY 20.
- **CALIPSO** has been active from CY 17 to CY 20.
- **OSTM/Jason 2** has been active from CY 18 to CY 20.
- **Aquarius** has been active from CY 19 to CY 21.
- **Suomi NPP** has been active from CY 20 to CY 21.
- **Landsat-8** has been active from CY 20 to CY 21.
- **GPM** has been active from CY 20 to CY 21.
- **OCO-2** has been active from CY 20 to CY 21.
- **SMAP** has been active from CY 20 to CY 21.

**Note:** The diagram indicates the status of each mission from CY 97 to CY 21, with symbols showing the status for each year.
### Aura Senior Review Guidance

- Implement the baseline proposal for extended operations

<table>
<thead>
<tr>
<th>Aura</th>
<th>FY16</th>
<th>FY17</th>
<th>FY18</th>
<th>FY19</th>
<th>FY20</th>
<th>FY21</th>
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<td>Senior Review Target</td>
<td>26,572</td>
<td>26,884</td>
<td>25,891</td>
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<td>25,895</td>
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<td><strong>Uncosted Carryover Reductions</strong></td>
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<td>(3,000)</td>
<td>0</td>
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</tbody>
</table>
What the SR said about Aura...

The Aura spacecraft is healthy and is expected to operate until at least 2022, likely beyond. There is great value in continuing the mission to (1) extend the unique 10-year record of stratospheric composition, variability, and trends as well as the chemical and dynamical processes affecting ozone recovery and polar ozone chemistry; (2) continue to map-out rapidly changing anthropogenic emissions of NO2, SO2, and aerosol products influencing air quality; (3) continue to develop greater vertical sensitivity by combining radiances from separate sensors; (4) use Aura data to further evaluate global chemistry-climate, climate, and air quality models; (5) extend observations of short-term solar variability overlapping with SORCE and providing a bridge to future measurements (GOME-2 TROPOMI); (6) continue the development of new synergetic products combining multiple Aura instruments and instruments from the A-Train; (7) provide continuity and comparison to current and future satellite missions (Suomi NPP, SAGE-III, TROPOMI); and (8) deliver operational products: volcanic monitoring, aviation safety, operational ozone assimilation at NOAA for weather and UV index forecasting, OMI Aerosol Index and NO2 products for air quality forecasting. As such, the Panel concludes that Aura mission be continued as currently baselined.
The competitively selected Aura Science Team is reselected every 3 years.

The most recent set of proposals were due September 2013, and selections were made in December 2013.

68 proposals were received, and 27 were selected.

A total of $5M/year is currently available on that budget line.

The next Aura ST solicitation will be in ROSES16, combined with ACMAP, with proposal due somewhere near September (TBD).
Other related NASA activity
Earth Venture Suborbital -2

**Atmospheric Tomography Experiment (ATom) – Harvard University (Steve Wofsy)**

This investigation will study the impact of human-produced air pollution on certain greenhouse gases and aerosols. Airborne instruments will look at how atmospheric chemistry is transformed by various air pollutants and at the impact on methane and ozone which affect climate. Flights aboard NASA's DC-8 will originate from the Armstrong Flight Research Center in Palmdale, California, fly north to the western Arctic, south to the South Pacific, east to the Atlantic, north to Greenland, and return to California across central North America.

**North Atlantic Aerosols and Marine Ecosystems Study (NAAMES) – Oregon State U. (Mike Behrenfeld)**

This investigation will improve predictions of how ocean ecosystems would change with ocean warming. The mission will study the annual life cycle of phytoplankton and the impact small airborne particles derived from marine organisms have on climate in the North Atlantic. The large annual phytoplankton bloom in this region may influence the Earth’s energy budget. Research flights by NASA’s C-130 aircraft from Wallops Flight Facility, Virginia, will be coordinated with a University-National Oceanographic Laboratory System (UNOLS) research vessel.

**Atmospheric Carbon and Transport – America – Penn State University (Kenneth Davis)**

This investigation will quantify the sources of regional carbon dioxide, methane and other gases, and document how weather systems transport these gases in the atmosphere. The research goal is to improve identification and predictions of carbon dioxide and methane sources and sinks using spaceborne, airborne and ground-based data over the eastern United States. Research flights will use NASA’s C-130 from Wallops and the UC-12 from Langley Research Center in Hampton, Virginia.

**ObseRvations of Aerosols Above Clouds and Their IntEracTionS (ORACES) – ARC (Jens Redemann)**

ORACES will probe how smoke particles from massive biomass burning in Africa influences cloud cover over the Atlantic. Particles from this seasonal burning that are lofted into the mid-troposphere and transported westward over the southeast Atlantic interact with permanent stratocumulus “climate radiators,” which are critical to the regional and global climate system. NASA aircraft, including a Wallops P-3 and an Armstrong ER-2, will be used to conduct the investigation flying out of Walvis Bay, Namibia.

**Oceans Melting Greenland (OMG) – JPL (Josh Willis)**

The objective of OMG is to investigate the role of warmer saltier Atlantic subsurface waters in Greenland glacier melting. The study will help pave the way for improved estimates of future sea level rise by observing changes in glacier melting where ice contacts seawater. Measurements of the ocean bottom as well as seawater properties around Greenland will be taken from ships and the air using several aircraft including a NASA S-3 from Glenn Research Center in Cleveland, Ohio, and Gulfstream III from Armstrong.

EVS-1 (DISCOVER-AQ, ATTREX) is in it’s last year of observations, in a no-cost extension.
**Venture Class Selections/Solicitations**

<table>
<thead>
<tr>
<th>Mission</th>
<th>Mission Type</th>
<th>Solicitation Release</th>
<th>Proposal Selection</th>
<th>Major Milestone</th>
<th>Total Funding*</th>
</tr>
</thead>
<tbody>
<tr>
<td>EVI-3</td>
<td>Instrument Only</td>
<td>Q2 FY2015</td>
<td>Q2 FY2016</td>
<td>Delivery NLT 2020</td>
<td>$130M</td>
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<tr>
<td>EVI-4</td>
<td>Instrument Only</td>
<td>Q4 FY2016</td>
<td>Q4 FY2017</td>
<td>Delivery NLT 2021</td>
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<td>EVI-5</td>
<td>Instrument Only</td>
<td>Q2 FY2018</td>
<td>Q2 FY2019</td>
<td>Delivery NLT 2023</td>
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<td>EVI-6</td>
<td>Instrument Only</td>
<td>Q4 FY2019</td>
<td>Q4 FY2020</td>
<td>Delivery NLT 2024</td>
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<tr>
<td>EVI-7</td>
<td>Instrument Only</td>
<td>Q2 FY2021</td>
<td>Q2 FY2022</td>
<td>Delivery NLT 2025</td>
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<tr>
<td>EVM-2</td>
<td>Full Orbital</td>
<td>Q3 FY2015</td>
<td>Q3 FY2016</td>
<td>Launch ~2021</td>
<td>$165M</td>
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<tr>
<td>EVM-3</td>
<td>Full Orbital</td>
<td>Q3 FY2019</td>
<td>Q3 FY2020</td>
<td>Launch ~2025</td>
<td>$179M</td>
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<tr>
<td>EVS-2</td>
<td>Suborbital</td>
<td>Q4 FY2013</td>
<td>Q1 FY2015</td>
<td>2016-2020</td>
<td>$162M</td>
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<tr>
<td>EVS-3</td>
<td>Suborbital</td>
<td>Q4 FY2017</td>
<td>Q4 FY2018</td>
<td>2019-2023</td>
<td>$176M</td>
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Most recent Selection

* Funding for future EVs is approximate and will be adapted depending on previous selections.

**EVS-1:** CARVE, ATTREX, DISCOVER-AQ, AirMOSS, HS-3  
**EVM-1:** CYGNSS (2016 LRD)  
**EVI-1:** TEMPO (2017 Instrument Delivery)  
**EVI-2:** GEDI, ECOSTRESS (2019 Inst. Del.)  
**EVS-2:** AtoM, NAAMES, OMG, ORACLES, ACT-America + CORAL
TEMPO Instrument portion has completed PDR and is now in Phase C earlier this year. CDR was just completed. The selection of a commercial host for the TEMPO instrument has not been made, as potential hosts are not committing to having an appropriate orbit available in the right time frame.
OCO-2 update

- OCO-2 is working well, almost 1 year of operations.
- Level 1 and Level 2 data are now on the GSFC DISC.
- Bias corrected L2 data will be on the DISC very soon.
- All indications are that the mission will operate well into extended mission (2 year prime mission).
- Examples of L2 data on next slide.
Recent slides used by Art Charo of the NAS regarding the next Decadal Survey
• **NASA**: Has a backlog of missions recommended in the inaugural survey and increased responsibility—without commensurate budget increases—starting after the JPSS-1 era for vertical profiles of stratospheric and upper tropospheric ozone, solar irradiance, Earth radiation budget measurements, and altimetry (beyond Jason-3).

• **NOAA**: Stabilizing the weather satellite portfolio and avoiding a potential gap between the NPP spacecraft and the first of the next-generation POES systems, JPSS-1, is a top priority. “Climate”-related instruments moving to NASA.

• **USGS**: Interest in survey focuses on future capabilities, including hyperspectral, for a sustained land-imaging imaging program and options for Landsat follow-ons. However, L-9 is projected to be a near-rebuild of L-8 for launch in 2023. (TIRS on L-8 only has 3-year design life; NASA looking at Class-D TIR free-flyer for 2019 launch.)
Primary Elements of the SOT

• **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.
Other Questions

• Why is this survey different from all other NRC surveys?
  • Systems Approach—Advances require study of the Earth as an integrated system
  • Research driven by user needs
  • Science informs policy
  • Inherently multiagency; R2O and continuity are perennial issues

• How will this survey differ from the inaugural survey?
  • No longer appropriate to recommend based on an aspirational budget
  • Congressionally-mandated independent cost appraisal and technical evaluation (CATE) for big ticket items
  • Likely that the science will be “valued” to avoid having one recommended activity grow at expense of all others
  • Increased opportunities to consider “new space” ideas—new players, smaller and less costly platforms, constellations, hosted payloads etc.
  • Improved consideration of international partners
STATUS

• NRC Approval, May 6, 2015

• Executed contracts from sponsors: hoping for mid-June.
  • First task: appointment of survey leadership, to be followed by rest of steering committee. Panel appointments once survey organization finalized.
  • CESAS working on white paper requests to front-end survey

• 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.

• One-day mini-workshop to discuss survey organization and other top-level issues with survey leads, community representatives, NRC staff and board representatives: late July?

• Final report due ~ 2 years from survey start (backup slide has details).
Questions?