National Aeronautics and Space Administration

NASA Earth Science

LCLUC Science Meeting

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March 31, 2009

The Earth System Science Endeavor

- The Earth is an integral, complex system
  - Many processes, with varying time and spatial scales
  - Quantitatively describing the ***interactions between processes*** is key

- ***Measurements*** must span all important variables, and all important scales

- ***Research*** leads to greater understanding, which is codified in numerical models – ***prediction***

- Societal benefits result when ***understanding*** is combined with ***measurements*** to generate ***useful information products***

NASA's APPROACH

- Spaceborne measurements feature global coverage, high spatial resolution, and frequent revisit
  - Indirect measurements must be validated
  - Stability and accuracy are essential for trend detection
  - Multiple missions needed for proper sampling

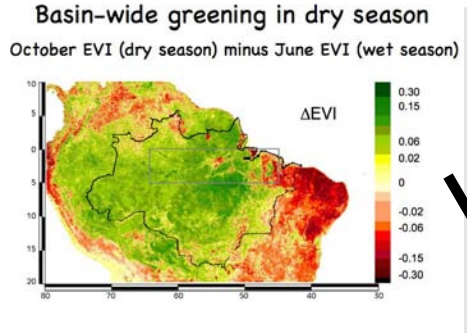
- A comprehensive ***suite*** of missions and instruments is required to measure all important quantities

- Inter- and cross-disciplinary ***research and applications programs*** are needed to (among other things):
  - Synthesize complementary measurements from multiple missions
  - Advance the use of spaceborne measurements by non-mission scientists and other stakeholders

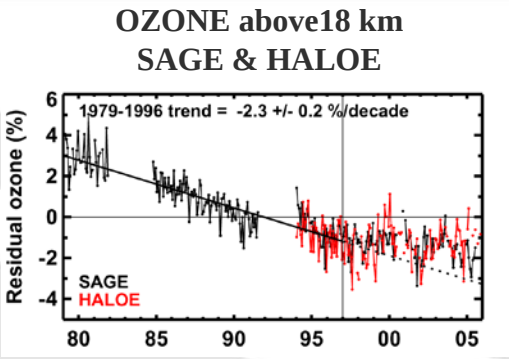
Earth Science Division Overview

- Overarching goal: to advance Earth System science, including climate studies, through spaceborne data acquisition, **research and analysis, and predictive modeling**
- Six major activities:
  - Building and operating Earth observing satellite missions, many with international and interagency partners
  - Making high-quality data products available to the broad science community
  - **Conducting and sponsoring cutting-edge research in 6 thematic focus areas**
    - Field campaigns to complement satellite measurements
    - Analyses of non-NASA mission data
    - Modeling
  - Applied Science
  - Developing technologies to improve Earth observation capabilities
  - Education and Public Outreach

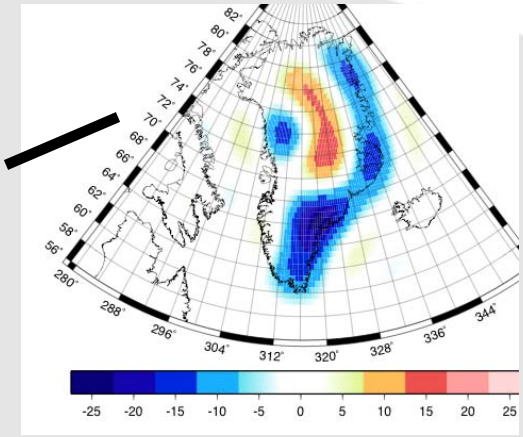
Earth **SCIENCE** Division Focus Areas



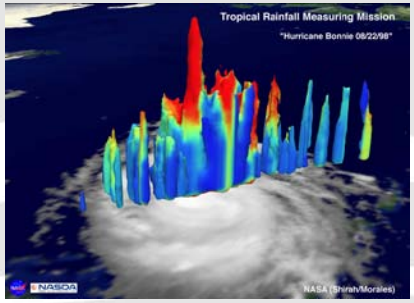
Atmospheric Composition



Carbon Cycle and Ecosystems

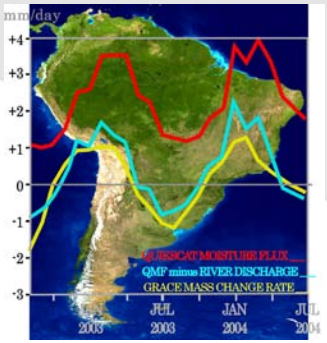


Climate Variability and Change

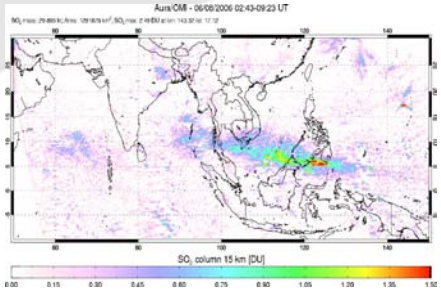


Weather

Water and Energy Cycle



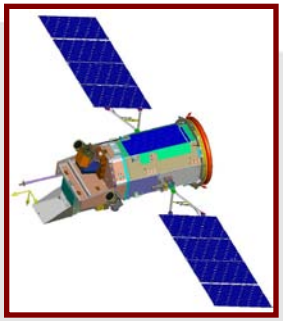
Earth Surface and Interior



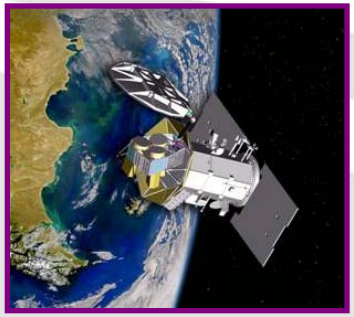
NASA Operating Research Missions (15)

Missions in Formulation and Implementation

OCO
2/23/2009
Atmos CO_2

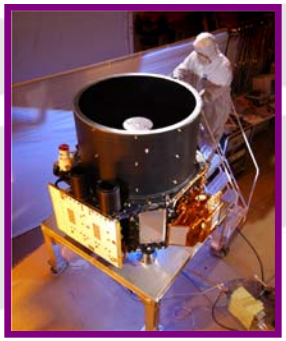


GLORY
1/2010
Aerosols,
Solar Irrad



AQUARIUS
5/2010
Ocean Salinity

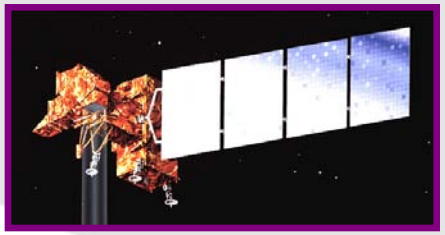
NPP
~1-6/2011
EOS Continuity



ICESat-II
2014-2015
Ice Topog

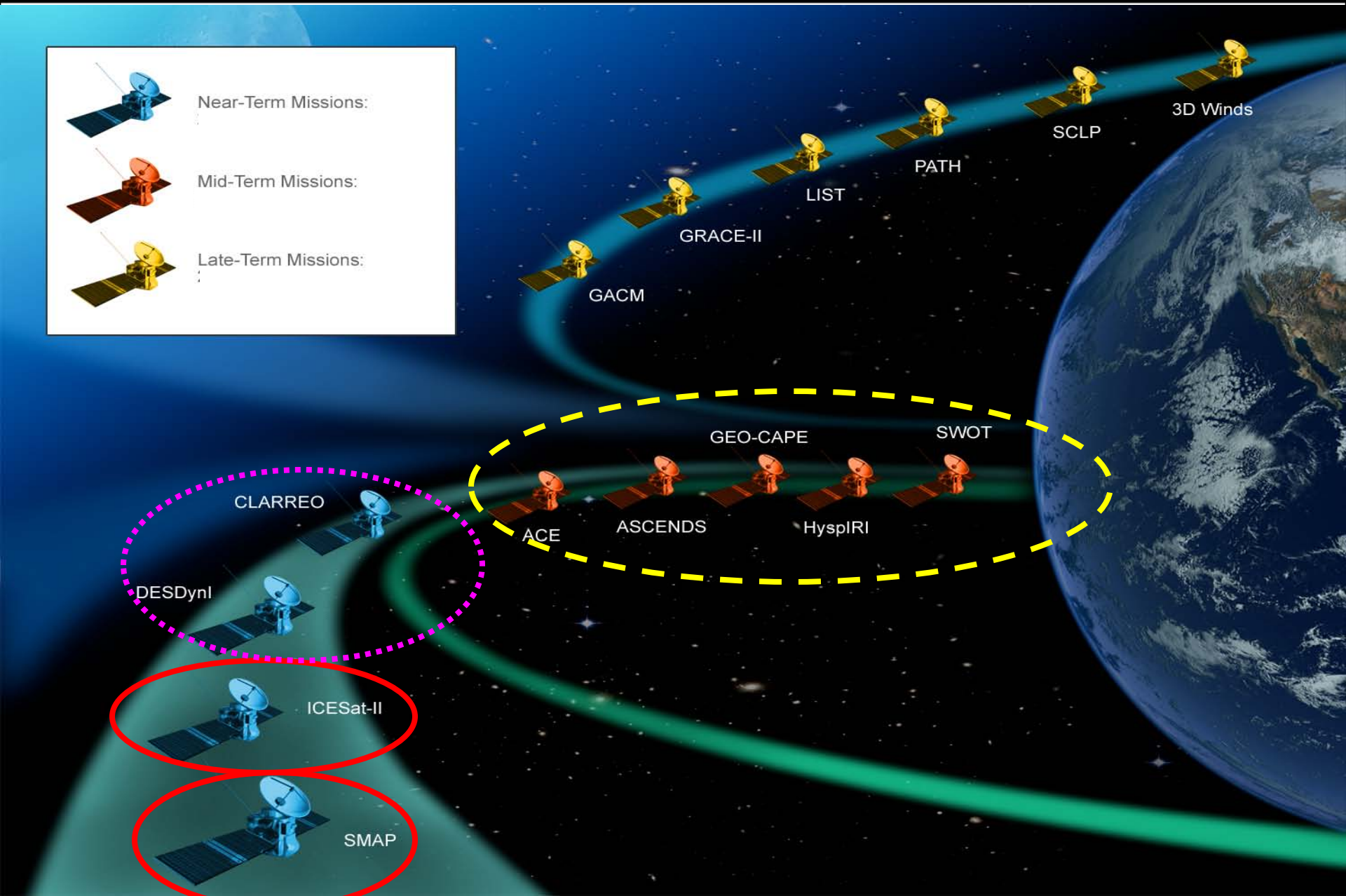
SMAP
2013
Soil Moist+Freeze/Thaw

GPM
7/2013, 11/2014
Global Precip



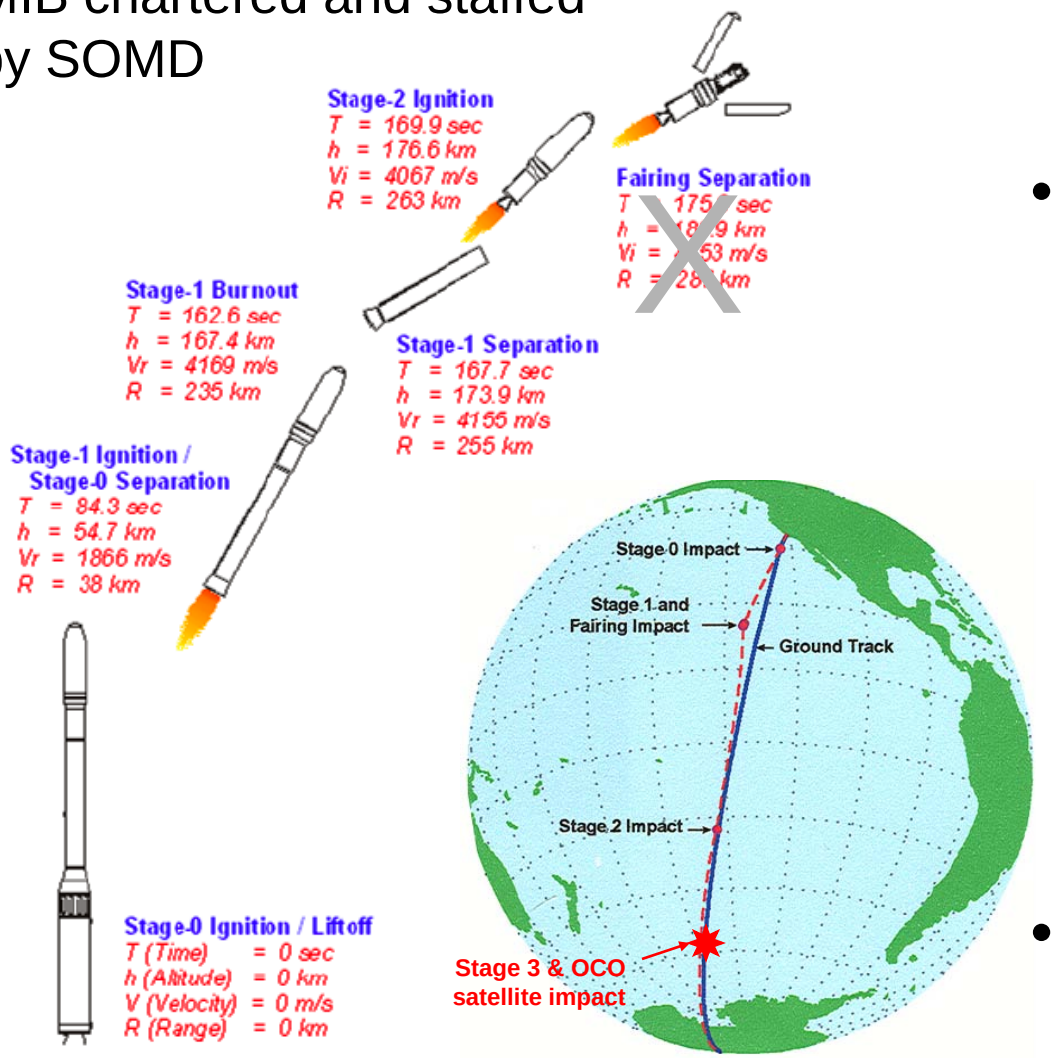
LDCM
12/2012
Land Imaging

Decadal Survey Missions Next Generation



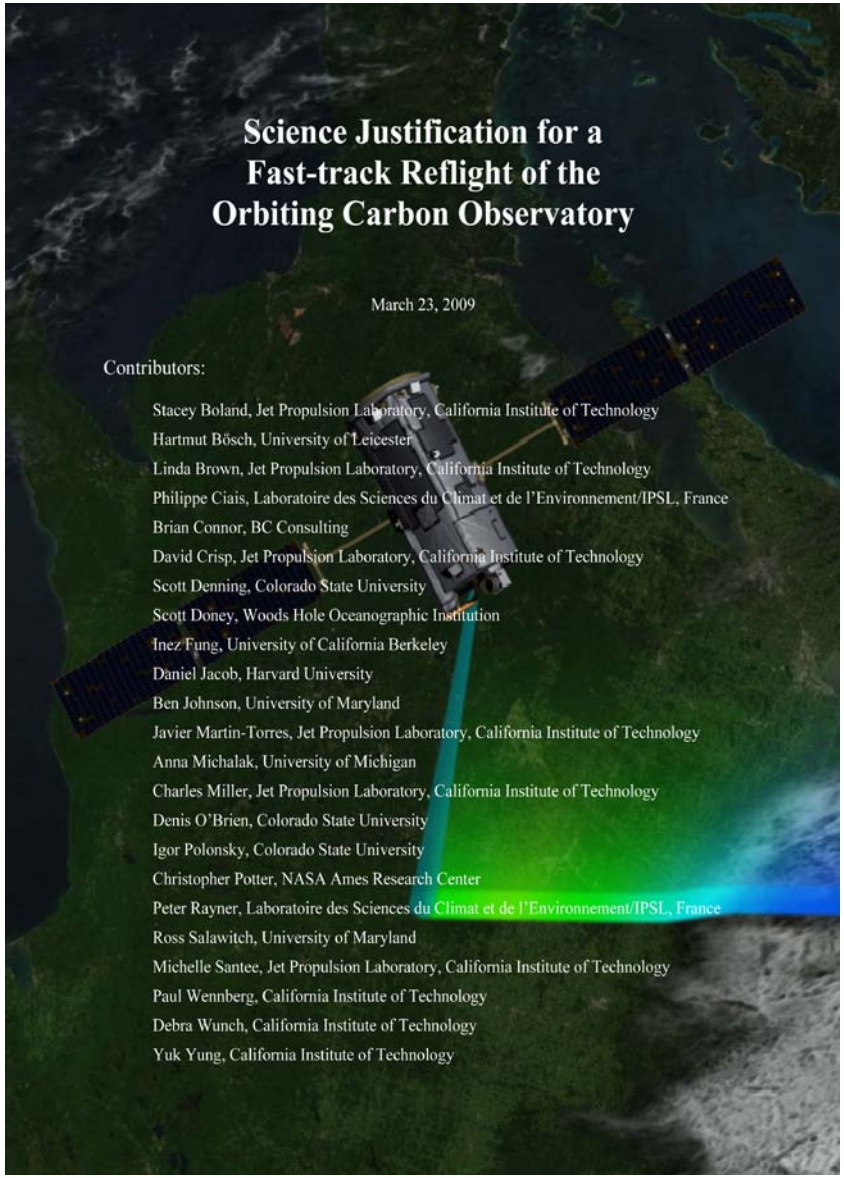
OCO Measurement Recovery Activities

MIB chartered and staffed by SOMD



- Carbon measurement recovery assessments underway within ESD
- Evaluations include
  - State of carbon cycle science and assessment of existing or planned satellite observations (JAXA, ESA, others)
  - Potential for OCO reflight with spares and “build to print” as far as possible
  - Possible alternative flight scenarios, including ISS and combined TIRS/OCO free-flyer
- Initial results March 20, iterative development of comprehensive study

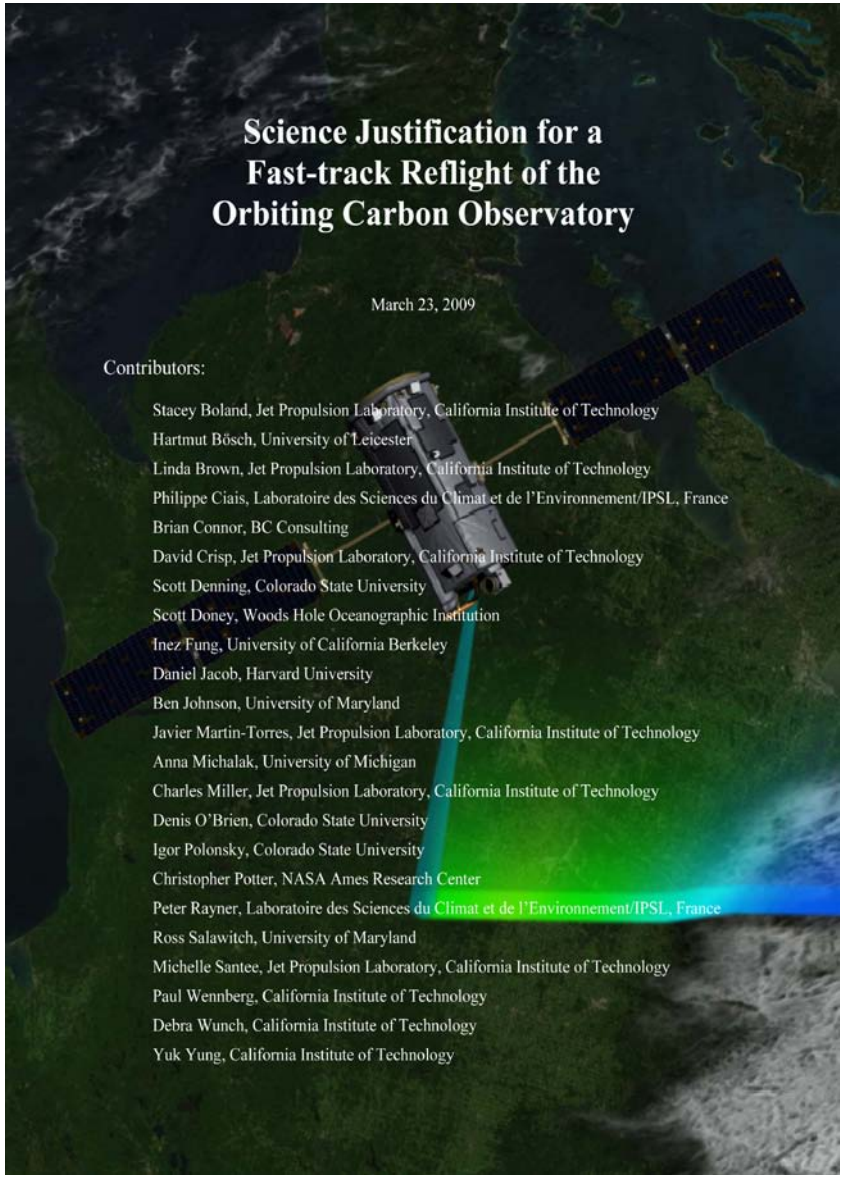
Carbon Cycle Science and OCO-type Measurements



- "I think a strong case can be made that the [Orbiting Carbon Observatory] should be reproduced as soon as possible. Here we are, on the verge of new international agreements, without thinking about how to monitor them. We are neglecting climate as an element of national security. We're not getting the information we need. Where are [climate] changes happening, and where are they going to happen?"
- -Ralph Cicerone, President of the National Academy of Sciences Speaking to Congress, 4 March 2009

- "…the carbon fluxes over the Southern Ocean are still poorly defined. In addition, we still lack a quantitative understanding of the strength and geographic distribution of carbon fluxes from the terrestrial biosphere. The processes responsible for the dramatic year-to-year variations in the atmospheric CO2 accumulation are also largely unknown. An improved understanding of these sinks, the underlying processes that control their efficiency, and their possible evolution in response to climate change, is essential to enable accurate predictions of future increases in atmospheric CO2 and its impact on the climate [Houghton, 2007; Fung *et al*., 2005; IPCC 2007].

Carbon Cycle Science and OCO-type Measurements



- [U]ncertainty in the projection of climate for the 21st century is driven as much by our inability to quantify the feedback between biogeochemical cycles and climate change as it is by uncertainty in the physical modeling of the cloud and water vapor feedback or economic projections of fossil fuel emission.
- [E]ven for a prescribed fossil fuel emission scenario, current coupled carbon-climate models are unable to predict CO2 levels in 2100 to within 300 ppm, which is equivalent to about 40 years of present anthropogenic CO2 emission levels.

- **No existing or planned near-term satellite sensor will duplicate OCO's unique contributions to Carbon Cycle and Climate Science**
  - **Accuracy/Stabiliy/Precision**
  - **Coverage**
  - **Spatial resolution**
  - **Rapid global repeat**

- ***No near-term carbon recovery mission will be possible without new top-line funds to ESD, or significant delays to ongoing and decadal survey missions***

ESD New Resources

- FY09 Enacted Budget
  - ~$12.5M above President's 2/2008 request (net)
  - Instruction to implement TIRS as rapidly as possible (implied LDCM)
- FY09 "Stimulus" augmentation
  - ~$389M for ESD (net)
  - To be spend in FY09, FY10
  - Tier-1 Decadal Survey, Supercomputing
- Out-year Budget, FY10-14
  - Uncertain at present (clearer in May?)
  - Bush Administration request was decreasing in this time period

Objective/Principles for Augmentation Funds

- Complete and launch the 5 Earth Science missions now under development
  - Glory, Aquarius, NPP, LDCM, GPM
- Develop Decadal Survey missions, as possible
  - Venture-class
  - SMAP, ICESAT-II
  - DESDynI, CLARREO
  - Tier-II mission studies
  - Focused technology development
- Preserve overall program balance
  - R&A, Applied Sciences, Technology
    - Airborne infrastructure and instruments
    - Supercomputing
    - Technology
    - Regional impacts/applications
    - Climate Modeling
    - Education and Public Outreach

OUR RESPONSIBILITY

- What we do in Earth Science is now deemed by the public and national leaders as ***IMPORTANT***, not simply interesting and challenging.
- The nation and the public are looking to us to ***LEAD*** and to ***SUCCEED***.
- We must organize and work so that everything we do supports:
  - Communicating what we are doing, why we are doing it, and what/when the outcome will be;
  - Achieving technical and substantive success in our specific scientific and applications activities; and
  - Clearly articulating what we have discovered or demonstrated, and the implications

BACKUP

The REQUIRED APPROACH

- The NASA/research community must focus on the overall ***program as identified by the Decadal Survey***
  - Multi-mission constellations for synergy
  - Decadal survey priorities and finite resources mean that some communities will not have early missions
  - Mission cost discipline is required – the first missions are not the only missions!
  - Balanced NASA program including Flight, R&A, Applications, Technology

- Build early credibility through technically and programmatically successful missions, focused R&A advances, substantial societal benefits

- Work closely with international partners, NOAA, and USGS to ensure a credible long-term data acquisition system
  - Recognition of maturity differences between weather and climate products, services, user communities
  - Clear, realistic divisions of responsibilities and aspirations

Transition and Long-term Data Acquisition

- ***Earth System science and environmental monitoring and prediction require effective, multi-decadal data acquisition systems. The long-term system is needed to:***
  - Justify initiating new measurements
  - Support and advance science programs for studying climate-scale phenomena
  - Encourage and support applications development through assured data availability
- ***The U.S. must develop a predictable, cost-effective mechanism for civilian long-term data acquisition that encourages technology infusion and that enables climate monitoring, delivery of expanded societal benefits, and advances understanding of the Earth System***