



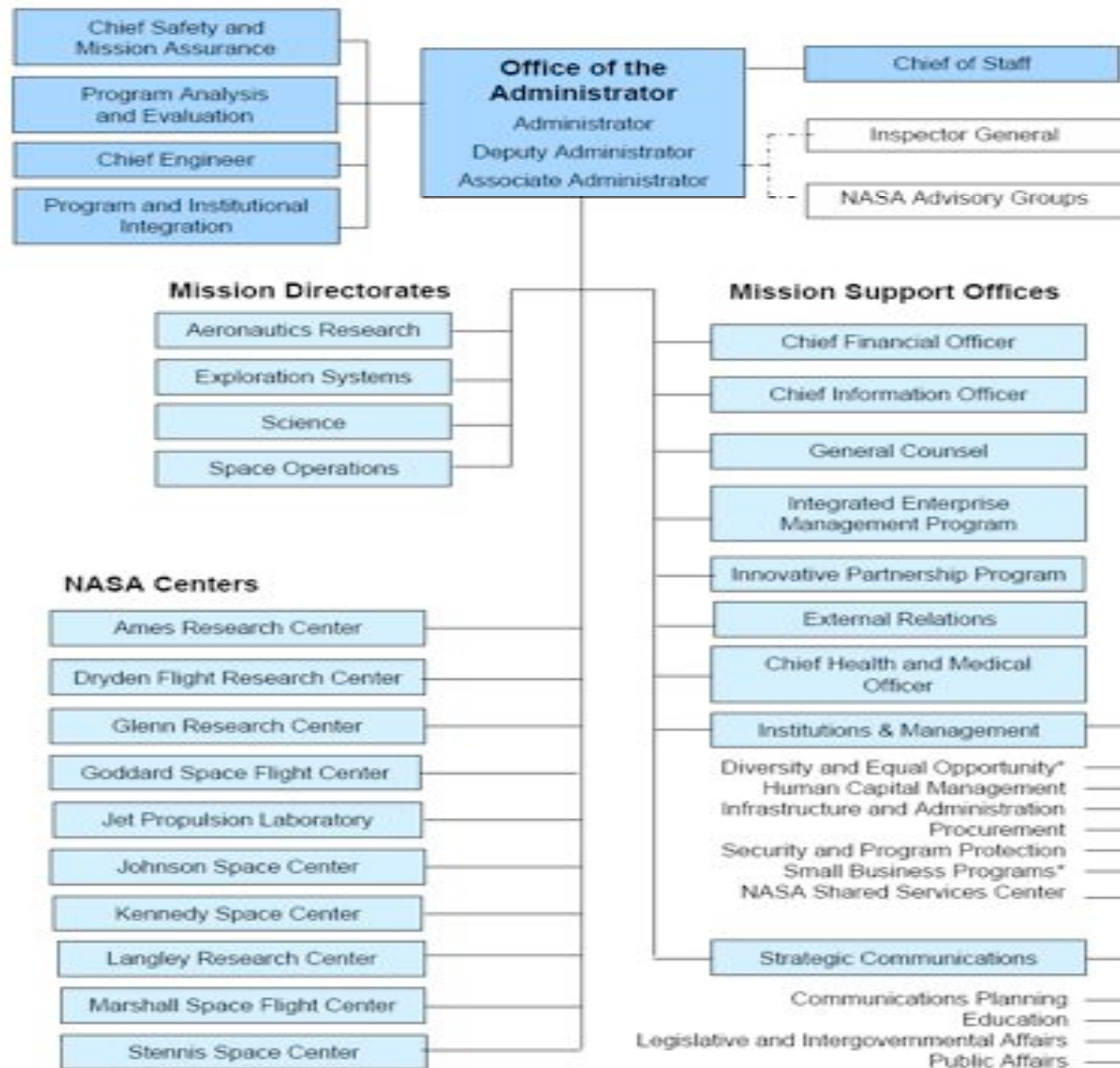
## Program Update for NASA Ocean Biology & Biogeochemistry

*Advance Planning/ROSES/Budget*

Paula Bontempi  
NASA Headquarters  
11-13 April 2007

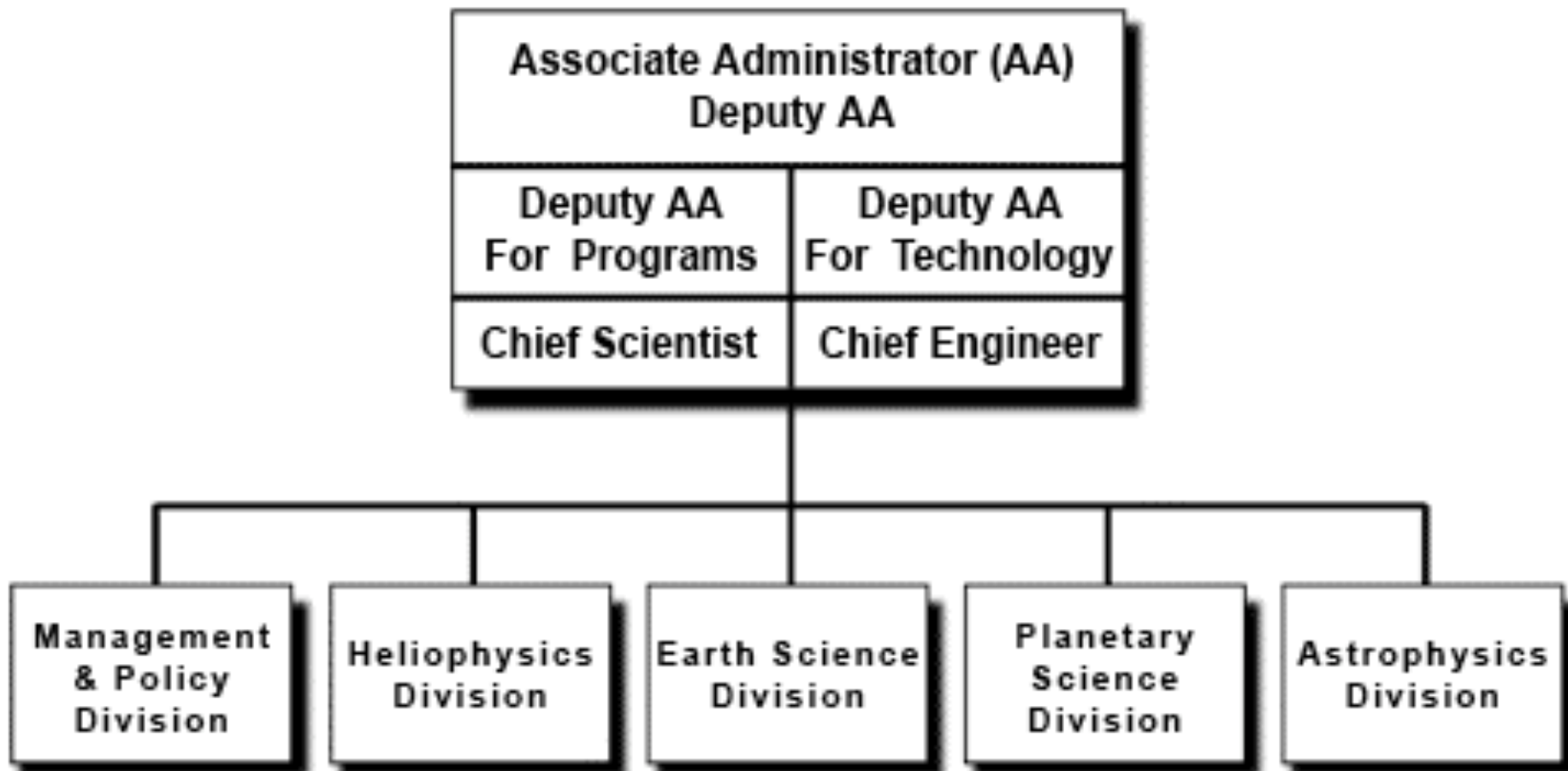
Thank you.

# National Aeronautics and Space Administration



\* In accordance with law, the offices of Diversity and Equal Opportunity and Small and Disadvantaged Business Utilization maintain reporting relationships to the Deputy Administrator and Administrator.

# Science Mission Directorate



-AA is Alan Stern

- Chief Scientist : John Mather

- Deputy Chief Scientist – Space – Andy Cheng

- Deputy Chief Scientist – Earth – Jack Kaye (acting)

- Deputy for Ethics and Process

- Deputy for R&A



# NASA's Ocean Biology and Biogeochemistry Program Challenges

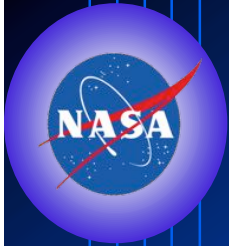
- i) shift in NASA priorities to 'pioneer the future in space exploration, scientific discovery and aeronautics research', eliminating a key phrase in previous Vision '*To understand and protect our home planet*'; to explore the universe and search for life; to inspire the next generation of explorers ... as only NASA can'



# NASA's Strategic Goals: 2006 - 2016



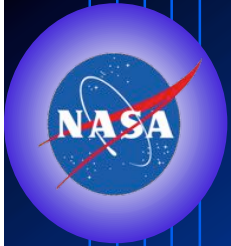
- **Strategic Goal 3 (6 total):** Develop a balanced overall program of science, exploration, and aeronautics consistent with the redirection of the human spaceflight program to focus on exploration.
  - **Sub-goal 3A (7 total):** Use Earth-orbiting satellites to study global change and enable better predictions of climate, weather, and natural hazards
    - 2006 - Launch Cloudsat and CALIPSO
    - 2008 – Glory (aerosol properties, Sun's influence on climate)
    - 2008 – NPP (CDRs of key measurements, new weather instruments)
    - 2008 – Ocean Surface Topography Mission (next gen. ocean alt.)
    - 2008 – Orbiting Carbon Observatory (OCO – global distribution of CO<sub>2</sub>) and Aquarius (2009 – global sea surface salinity)
    - ~ 2010 – Global Precipitation Measurement (GPM – TRMM f. o.)
    - NASA & USGS – Landsat-type data follow-on



# Scenarios for the Future: Looking Beyond 2016

- Earth Science
  - satellites that operate in sentinel orbits; constellations of smart satellites as parts of an integrated, interactive “sensorweb” observing system
  - Future sensorweb systems detect environmental phenomena automatically
  - Sensorweb would link to “modelwebs” of prediction systems to turn data into useful products for environmental characterization and prediction.

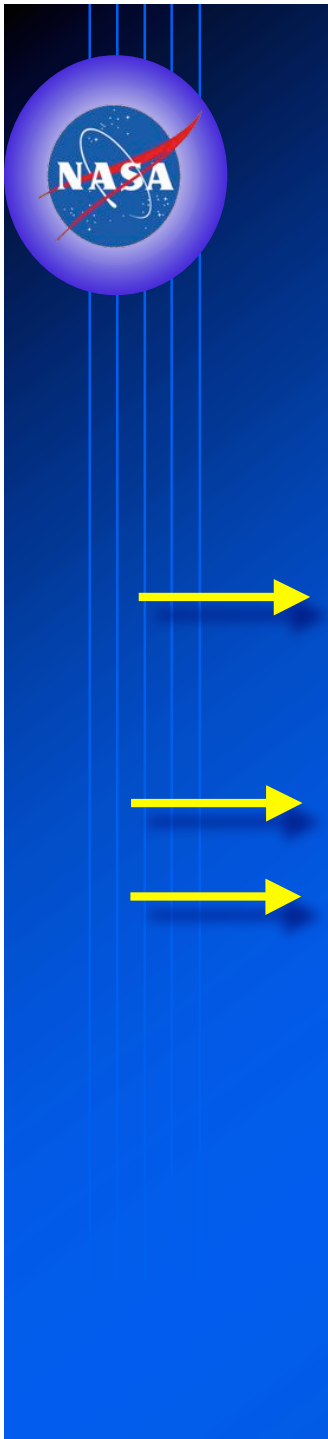




# NASA's Ocean Biology and Biogeochemistry Program Challenges

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respectively. Missions are listed in order of decreasing cost from each mission. Detailed descriptions of the missions are given in Part II, and Part III provides the foundation for selection.

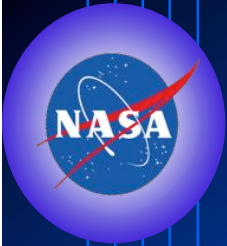
Decadal Survey Mission	Mission Description	Orbit	Instruments	Rough Cost Estimate
<b>Timeframe 2010 – 2013, Missions listed by cost</b>				
CLARREO (NASA portion)	Solar and Earth radiation, spectrally resolved forcing and response of the climate system	LEO, Precessing	Absolute, spectrally-resolved interferometer	\$200 M
SMAP	Soil moisture and freeze/thaw for weather and water cycle processes	LEO, SSO	L-band radar L-band radiometer	\$300 M
ICESat-II	Ice sheet height changes for climate change diagnosis	LEO, Non-SSO	Laser altimeter	\$300 M
DESDynI	Surface and ice sheet deformation for understanding natural hazards and climate; vegetation structure for ecosystem health	LEO, SSO	L-band InSAR Laser altimeter	\$700 M
<b>Timeframe: 2013 – 2016, Missions listed by cost</b>				
HypIRI	Land surface composition for agriculture and mineral characterization; vegetation types for ecosystem health	LEO, SSO	Hyperspectral spectrometer	\$300 M
ASCENDS	Day/night, all-latitude, all-season CO <sub>2</sub> column integrals for climate emissions	LEO, SSO	Multifrequency laser	\$400 M
SWOT	Ocean, lake, and river water levels for ocean and inland water dynamics	LEO, SSO	Ka-band wide swath radar C-band radar	\$450 M
GEO-CAPE	Atmospheric gas columns for air quality forecasts; ocean color for coastal ecosystem health and climate emissions	GEO	High and low spatial resolution hyperspectral imagers	\$550 M
ACE	Aerosol and cloud profiles for climate and water cycle; ocean color for open ocean biogeochemistry	LEO, SSO	Backscatter lidar Multiangle polarimeter Doppler radar	\$800 M
<b>Timeframe: 2016 -2020, Missions listed by cost</b>				
LIST	Land surface topography for landslide hazards and water runoff	LEO, SSO	Laser altimeter	\$300 M
PATH	High frequency, all-weather temperature and humidity soundings for weather forecasting and SST <sup>a</sup>	GEO	MW array spectrometer	\$450 M
GRACE-II	High temporal resolution gravity fields for tracking large-scale water movement	LEO, SSO	Microwave or laser ranging system	\$450 M
SCLP	Snow accumulation for fresh water availability	LEO, SSO	Ku and X-band radars K and Ka-band radiometers	\$500 M
GACM	Ozone and related gases for intercontinental air quality and stratospheric ozone layer prediction	LEO, SSO	UV spectrometer IR spectrometer Microwave limb sounder	\$600 M
3D-Winds (Demo)	Tropospheric winds for weather forecasting and pollution transport	LEO, SSO	Doppler lidar	\$650 M

<sup>a</sup> Cloud-independent, high temporal resolution, lower accuracy SST to complement, not replace, global operational



# NASA's Ocean Biology and Biogeochemistry Program Challenges

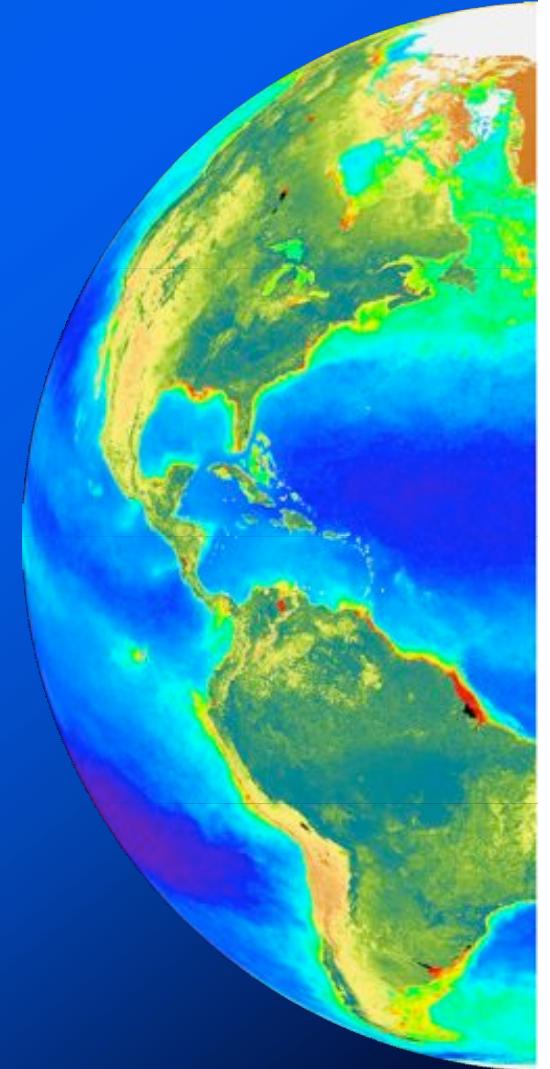
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- iii) Integration of the **Congressionally-mandated NASA Science Plan** with the NRC Decadal Survey
  - NASA Authorization Act for 2005 (S.1281) - (d) SCIENCE.— (1) IN GENERAL.—The Administrator shall develop a plan to guide the science programs of NASA through 2016.



# NASA Earth Science Research Questions

Research: How is the Earth changing and what are the consequences for life on Earth?

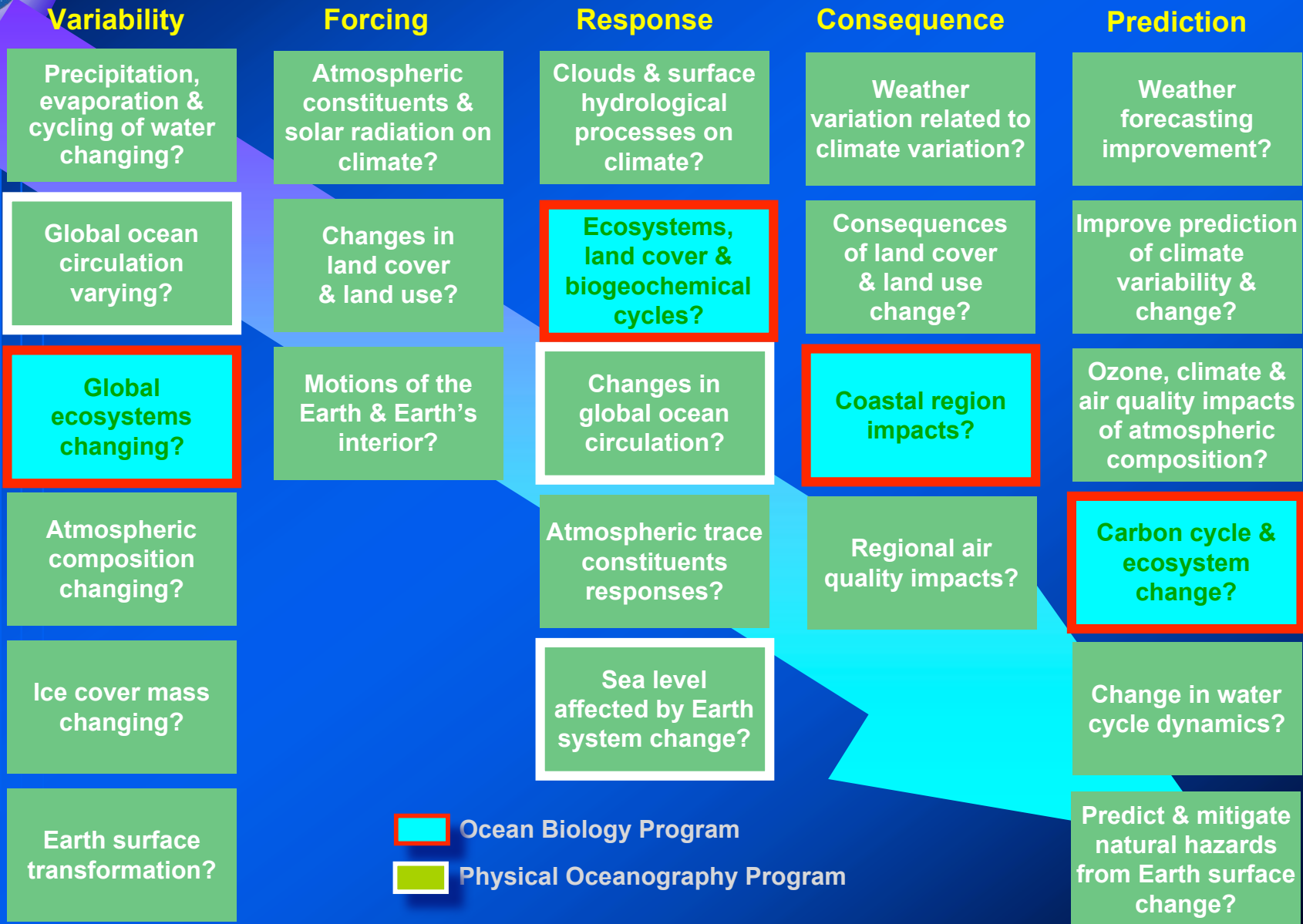
- How is the global Earth system *changing*?
- What are the primary *forcings* of the Earth system?
- How does the Earth system *respond* to natural and human-induced changes?
- What are the *consequences* of changes in the Earth system for human civilization?
- How well can we *predict* future changes in the Earth system?





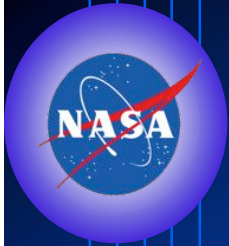
# Ocean Science Program Derives from Earth Science Research Strategy

ES Science Questions and Ocean Program Involvement



 Ocean Biology Program

 Physical Oceanography Program



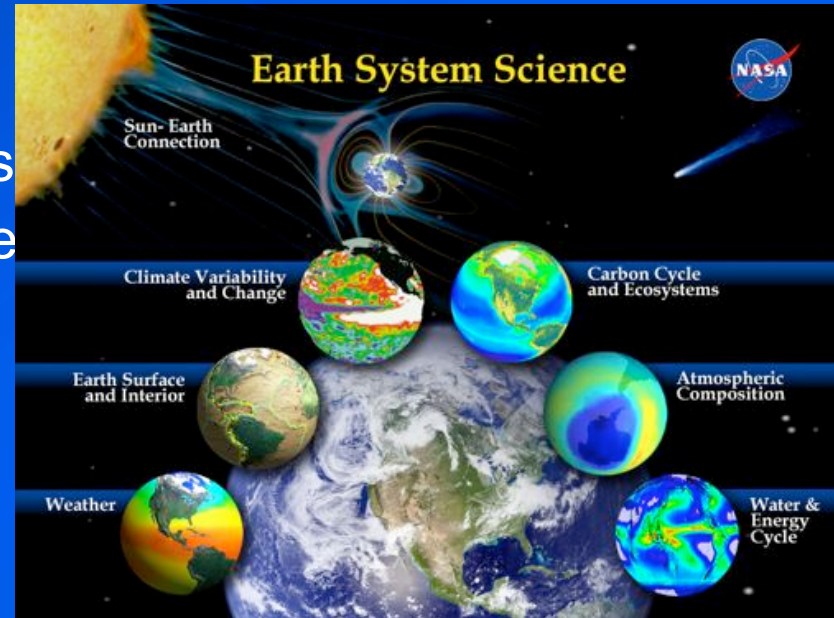
# NASA Earth Science Research Programs / Science Focus Areas

- **Atmospheric Composition**
  - Atmospheric Composition, Radiation Sciences, Tropospheric Chemistry, Atmospheric Dynamics
- **Carbon Cycle and Ecosystems**
  - Terrestrial Ecology, Land Cover/Land Use Change, Biodiversity, Ocean Biology and Biogeochemistry
- **Climate Variability and Change**
  - Physical Oceanography, Cryospheric Sciences
- **Earth Surface and Interior**
  - Solid Earth and Natural Hazards
- **Water and Energy Cycle**
  - Water Cycle (Terrestrial Hydrology)
- **Weather**
  - Weather



# NASA Earth Science Focus Areas

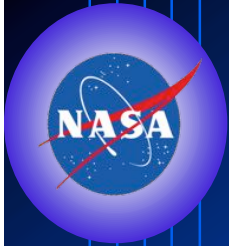
- Atmospheric Composition
- Carbon Cycle and Ecosystems
- Climate Variability and Change
- Earth Surface and Interior
- Water and Energy Cycle
- Weather



- **Approaches and milestones are outlined in the Earth Science Legacy Roadmaps**

*<http://science.hq.nasa.gov/strategy/roadmaps/index.html>*

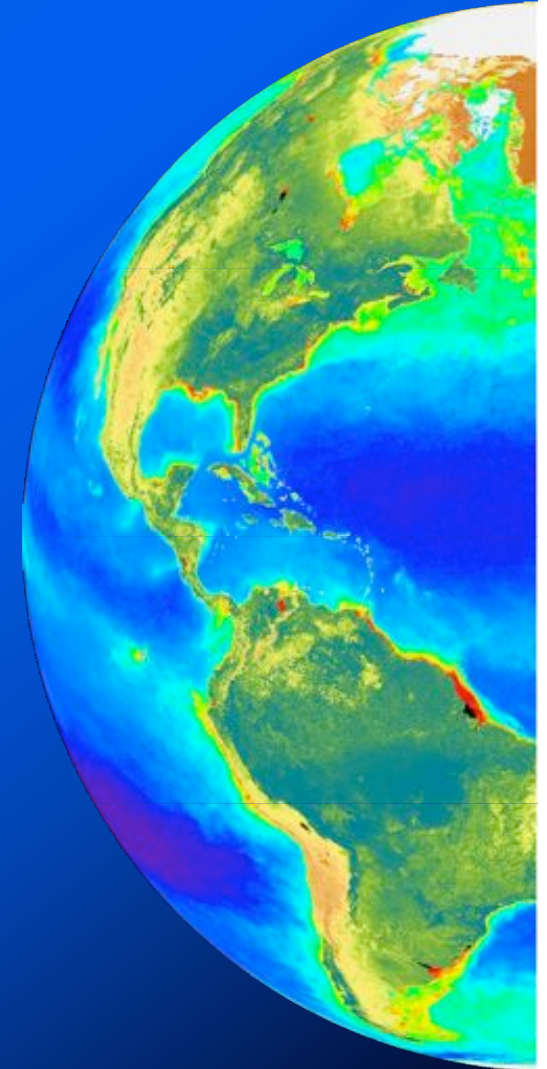
- Suborbital Science
- Modeling, Analysis, and Prediction Program – integration of Focus Area Science
- High-end Computing - Project Columbia

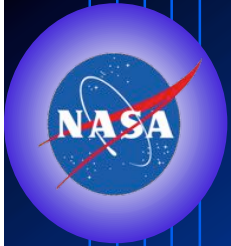


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- How well can we *predict* future changes in the Earth system?
  
- Earth Science is undertaking an advance planning exercise (summer 2007).

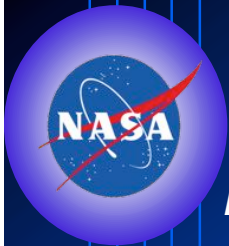




# NASA's Ocean Biology and Biogeochemistry Program Challenges

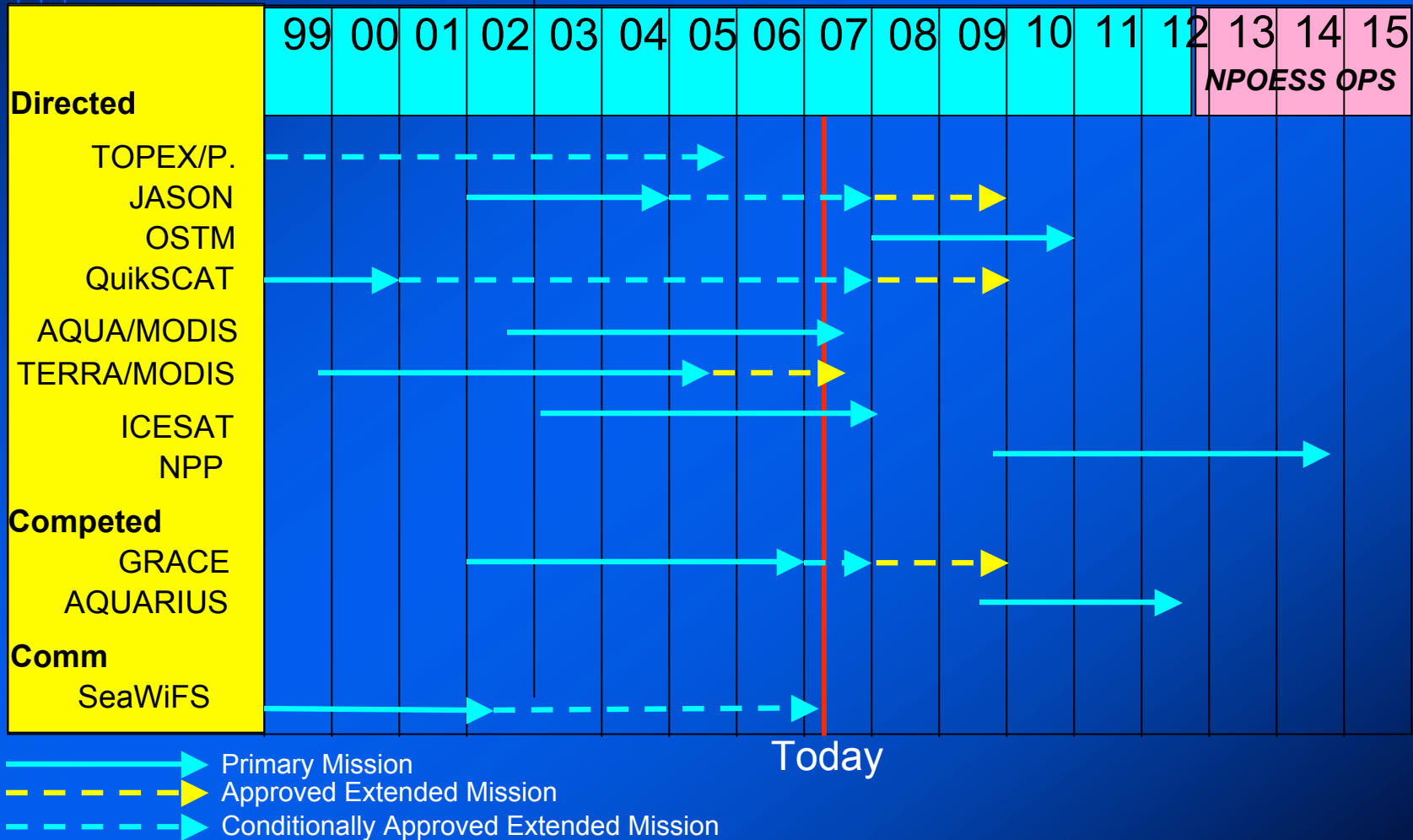
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- iv) **gaps in coverage for key properties** (phytoplankton chlorophyll *a*, primary productivity) after on-orbit missions (SeaWiFS, MODIS). There are no ocean OBB missions in the queue after MODIS for NASA. NPP and NPOESS VIIRS may not provide continuity in systematic observations.

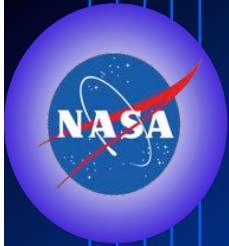




# NASA Current and Approved Oceans and Ice Missions

*Beyond OSTM (2008) and Aquarius (2009), there are no approved NASA oceanographic satellite missions*

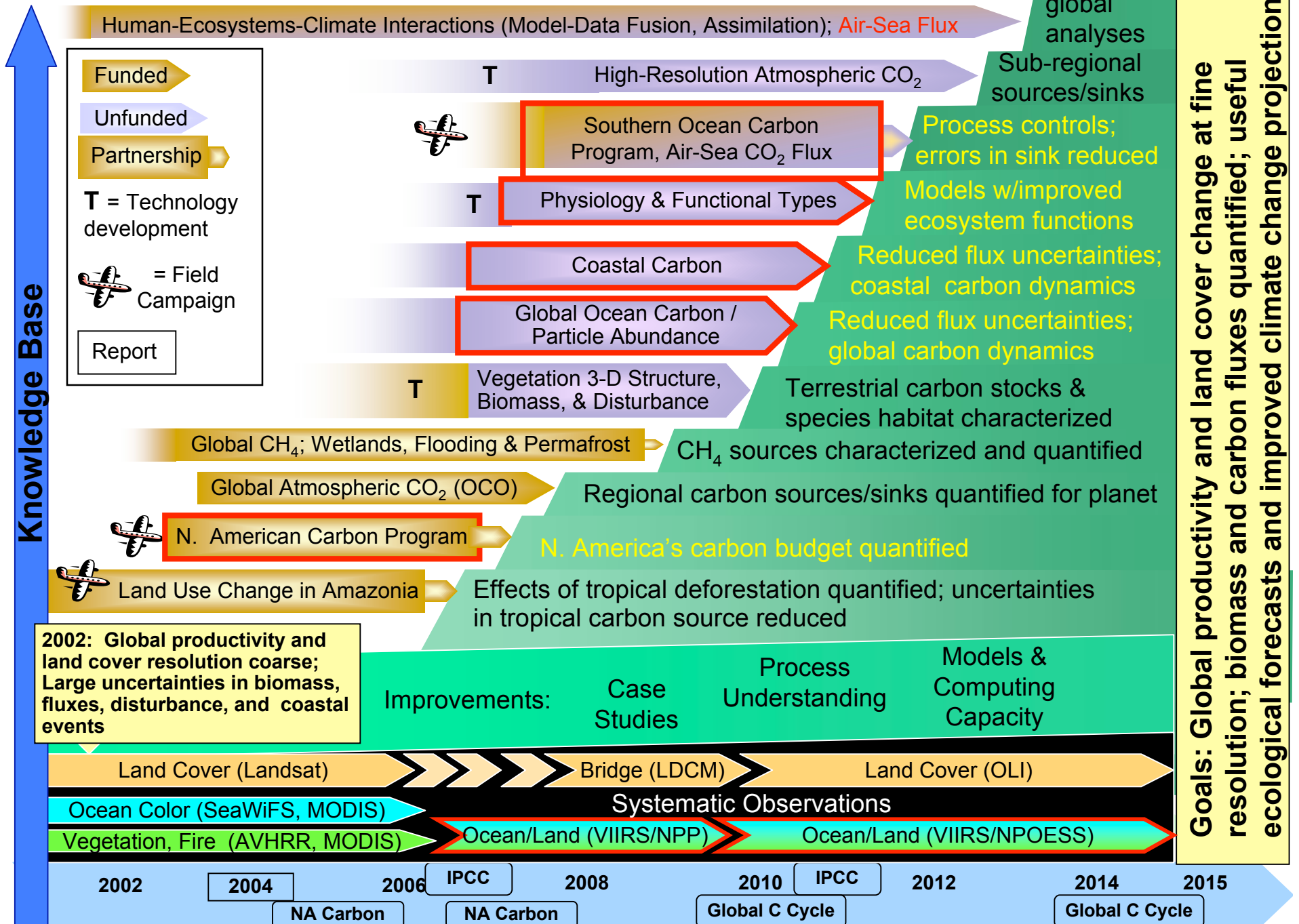




## Agency, Earth Science & NRC Planning

- Legacy Science Focus Area roadmaps available and draft Research Plan (Jan 2005) reviewed by ESSAAC
- Plan to implement missions that are currently in development and formulation
- Utilize SFA Legacy roadmaps to initiate mission concept studies in a preparatory process to respond to decadal survey report
- ESD Roadmap in progress to respond to the Decadal Survey
- Continue to work interagency planning and collaborative programs

# Carbon Cycle and Ecosystems Roadmap

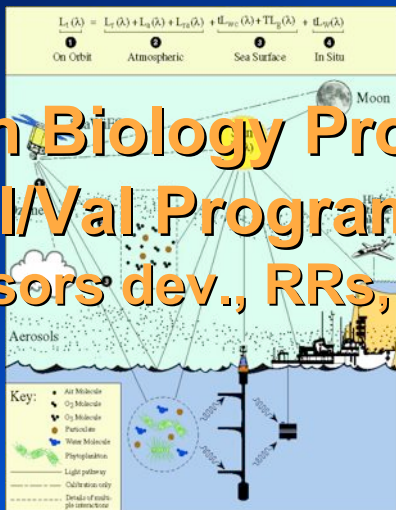




# Carbon Cycle & Ecosystems Focus Area Advance Planning (Management Operations Working Group)

- Engage the broad NASA carbon cycle and ecosystems community to reevaluate NASA directions, goals, approaches, and priorities in carbon cycle and ecosystems research.
- Responsive to and informing Agency strategic roadmapping and the NRC Decadal Survey.
- Parallel working groups, coordinated by a steering committee to combine and integrate working group products into a comprehensive focus area plan.
  - Discipline specific documents will be produced and published as needed.
- ~18 months to seek broad inputs, assess and prioritize, write and iterate, and revise for publication.
- Expect an initial call for white papers followed by workshops and major community meetings.
- Committee has had its first meetings and is iterating its first draft outline, Co-Chairs selected by Focus Area Lead (Diane Wickland) are John Foley and Michael Behrenfeld (H. Sosik, D. Barber, J. Yoder, P. DiGiacomo, C. DelCastillo)

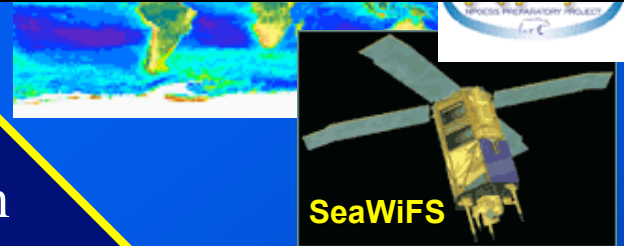
# Biological Oceanography's Three Primary Objectives: 2007



**Ocean Biology Processing/  
Cal/Val Program Plan  
(Sensors dev., RRs, SORTIE)**



**New Measurements/  
ESSP/New Initiative/  
Adv. Plan/Dec. Surv.**



**Time Series,  
Cal/Val  
(MOBY, HOTS,  
BATS)**



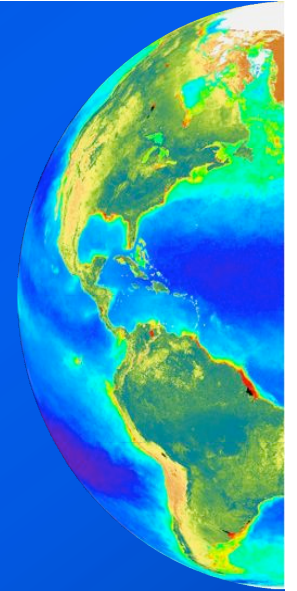
**Ocean/Coastal Processes  
from Space**



**Carbon Cycle Ecosystems  
Research**



# Ocean Biology and Biogeochemistry



*Where do we go from here?*

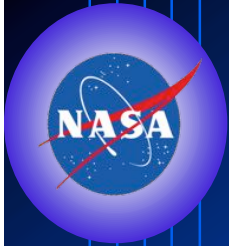
- **NASA Ocean Biology and Biogeochemistry Advance Plan (25-year community vision):**

[http://oceancolor.gsfc.nasa.gov/DOCS/ScienceTeam/OCRT\\_Apr2007/OBB\\_Report\\_03062007.doc](http://oceancolor.gsfc.nasa.gov/DOCS/ScienceTeam/OCRT_Apr2007/OBB_Report_03062007.doc)

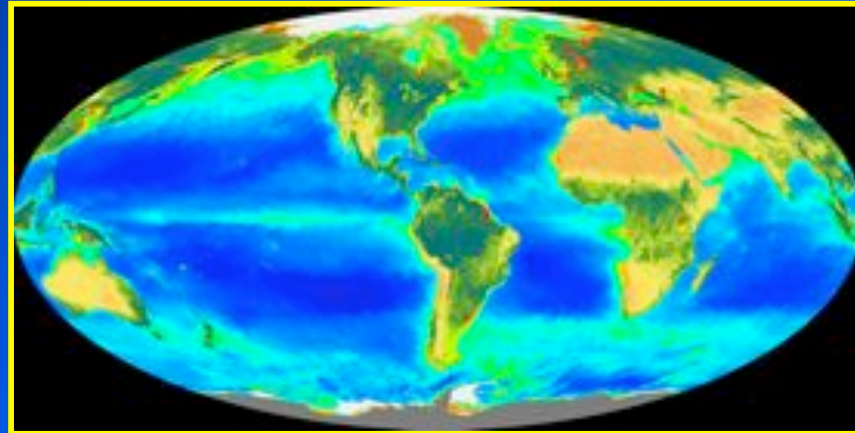
OR with a “.pdf” on the end

- **Calibration and Validation Science Plan that identifies research that needs to be undertaken to write a parallel Advance Plan**

[http://oceancolor.gsfc.nasa.gov/DOCS/ScienceTeam/OCRT\\_Apr2007/CalValPlanV5.pdf](http://oceancolor.gsfc.nasa.gov/DOCS/ScienceTeam/OCRT_Apr2007/CalValPlanV5.pdf)



# Earth's Living Ocean: The Unseen World



## **NASA Ocean Biology and Biogeochemistry Program**

NASA Ocean Biology & Biogeochemistry Program

Team from April 2005: Michael Behrenfeld, Heidi Dierssen, Paul DiGiacomo, Steve Lohrenz, Chuck McClain, Frank Muller-Karger, Dave Siegel, (Paula Coble)

May 2006-October 2006: Posted for Public Comment

Reviewers: Tony Freeman, Norm Nelson, Jim Yoder

March 2007: Briefed to NRC

<b>Timeline</b>							
<b>Mission Themes</b>	<b>Immediate (1 – 5 Years)</b>	<b>Near-Term (5 - 10 Years)</b>	<b>Long-Term (10 - 25 Years)</b>				
<b>Global Separation of In-water Constituents &amp; Advanced Atmospheric correction</b>	<b>Advanced radiometer &amp; scattering lidar</b> <ul style="list-style-type: none"> <li>• 5nm resolution from UV through visible</li> <li>• Ozone &amp; extended NIR atmosphere bands</li> <li>• Atmosphere &amp; subsurface particle scattering profiles</li> </ul>	<b>Ocean radiance and atmosphere aerosols</b> <ul style="list-style-type: none"> <li>• Advanced radiometer</li> <li>• Scattering lidar for aerosol speciation</li> <li>• Polarimeter for global aerosol coverage</li> <li>• 500 m passive resolution</li> </ul>	<b>Radiometry, aerosols, and physiology lidar</b> <ul style="list-style-type: none"> <li>• Global radiometry system</li> <li>• Aerosol height &amp; species</li> <li>• Midnight/noon obs of variable stimulated fluorescence</li> </ul>				
<b>High Spatial &amp; Temporal Resolution Coastal</b>	<b>Coastal carbon – GEO</b> <b>Support analysis of current satellite data</b> <b>Landsat DCM partnership</b> <b>Development of suborbital sensor systems</b>	<b>High-res coastal imager</b> <ul style="list-style-type: none"> <li>• 20 bands from UV - NIR</li> <li>• 10 m res – 100 km swath</li> </ul> <b>GEO carbon mission</b> <b>Deployment of suborbital systems</b>	<b>Constellation of imaging spectrometers</b> <ul style="list-style-type: none"> <li>• High temporal res</li> <li>• LEO, MEO or GEO</li> <li>• Include SAR</li> </ul> <b>Continued deployment of suborbital systems</b>				
<b>Plant Physiology &amp; Functional Composition</b>	<b>Support analysis of global passive data</b> <ul style="list-style-type: none"> <li>• Assess functional groups using hyperspectral data</li> <li>• Estimate algal carbon &amp; chlorophyll to characterize physiology</li> </ul>	<b>Support analysis of global &amp; GEO data</b>	<b>Variable fluorescence lidar constellation</b> <ul style="list-style-type: none"> <li>• Map physiological provinces at different times of day</li> <li>• Dawn/dusk variable fluorescence lidar</li> <li>• Noon/midnight lidar</li> </ul>				
<b>Mixed Layer Depth</b>	<b>Synthesis/analysis of observational forecast fields &amp; on orbit remote sensing</b> <b>Mixed layer model development</b>	<b>Prototype mixed layer sensor development</b> <ul style="list-style-type: none"> <li>• field testing of novel approaches for remote detection of mixed layer depth &amp; light availability</li> </ul>	<b>Mixed layer depth mission</b> <ul style="list-style-type: none"> <li>• Space-borne proof-of-concept mission for global mixed layer depth mapping</li> </ul>				

**Bold Green Text Represents Satellite Missions**

**Bold Blue Text Represents Development Activities leading to Missions**

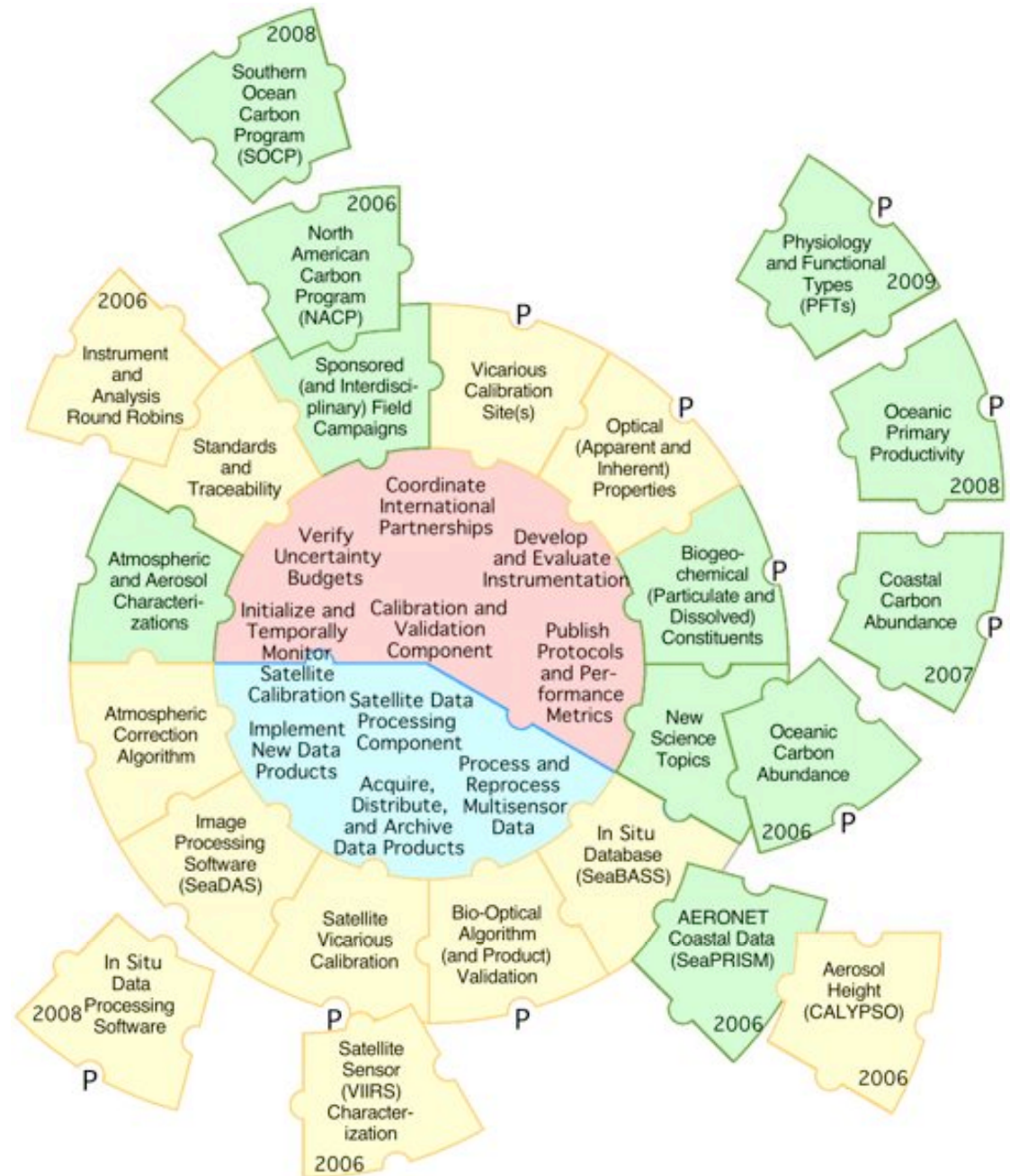
**■ Cross-hatch indicates secondary contribution to Mission Theme**

<b>Top Priority Science Question</b>	<b>Color Code</b>	<b>Example of Benefits to Society</b>
How are ocean ecosystems and the biodiversity they support influenced by climate or environmental variability and change, and how will these changes occur over time?		Improved management of ecosystem goods and services
How do carbon and other elements transition between ocean pools and pass through the Earth System, and how do biogeochemical fluxes impact the ocean and Earth's climate over time?		Information based policy on greenhouse gas emissions and nutrient loading
How (and why) is the diversity and geographical distribution of coastal marine habitats changing, and what are the implications for the well-being of human society?		Mapping and assessment of coastal habitats for future development plans and tourism
How do hazards and pollutants impact the hydrography and biology of the coastal zone? How do they affect us, and can we mitigate their effects?		National security and improved forecasting of natural and human-induced hazards



# Competed and Core Responsibilities

The competed (green) and shared (yellow) connecting-core elements. The latter includes competed, contracted, and internal (red and blue) core contributions, the mixture of which is determined largely by the topic type. For example, the calibration and validation component is expected to be involved in managing the vicarious calibration site(s), which means it will also be involved in the optical properties element (at least the AOP portion) as well as the standards and traceability element, so all these elements are colored yellow.





- **Ocean Optics Protocols**
  - **Uncertainties with methods**
- **IOP Instrument Uncertainties**
  - **how PIs measure instrument performance and uncertainties**
  - **data processing**
  - **review existing protocols**
- **HPLC Quantitation in Coastal Waters**
  - **Go beyond existing dynamic range of SH experiments (0.2-26.2 mg m<sup>-3</sup>)**
- **Common AOP Data Processing Interface**
  - **Automatic interface for submitting data in common format**
- **Vicarious Calibration Site Selection + alternatives**
  - **Revisit site selection since 1980's, BOUSSOLE, BATS, HOT**
  - **Other approaches?**

***\*\* PIs funded via ROSES required to participate in workshops and meetings\*\****

- **Workshops proposed by community members:**
  - **P. Coble on CDOM**
  - **Y. Gao on atmospheric deposition of iron to ocean**



## SeaBASS + Data Policy



- **Recently notified that the Ocean Biology and Biogeochemistry Research Program is not in compliance with the EOS data policy and Guidebook for Proposers**

- **NASA Guidebook for Proposers:**

<http://www.hq.nasa.gov/office/procurement/nraguidebook/>

- **NASA Earth Science Data and Information Policy**

**This policy covers science data obtained from satellites, suborbital platforms, and field campaigns (cal/val and other) and their resultant standard products. These data are collected by NASA at significant public investment for research.**

**At the advent of the EOS Program, NASA adopted this policy of "no period of exclusive use"**

**by science team members or principal investigators, and is far-reaching for what is made public (metadata, documentation, algorithm scientific source code). This policy also applies to all data in Cooperative Agreements from the data programs, REASoN, ACCESS, and upcoming MEaSURES.**

**NASA makes these data available under OMB Circular A-130, "not more than the marginal cost of distribution" at data centers. In all possible cases (exceptions are result of international data sources), we distribute the data at no distribution charge.**



## SeaBASS + Data Policy



- **The Guidebook (F.13) does state that new data obtained is non-proprietary and is in the public domain. It notes that if placing data in the public domain is a burden than NASA may fund it.**
- **As a Federal Agency, NASA requires prompt public disclosure of the results of its sponsored research and, therefore, expects significant findings from supported research to be promptly submitted for peer reviewed publication with authorship(s) that accurately reflects the contributions of those involved. Likewise, as a general policy and unless otherwise specified, NASA no longer recognizes a “proprietary” period for exclusive use of any new scientific data that may be acquired through the execution of the award; instead, all data collected through any of its funded programs are to be placed in the public domain at the earliest possible time following their validation and calibration. Small amounts of data (for example, as might be taken during the course of a suborbital (rocket or balloon), Space Shuttle, or Space Station investigation) are usually left in the care of the Principal Investigator. In any case, NASA may require that any data obtained through an award be deposited in an appropriate public data archive as soon as possible after calibration and reduction. If so, NASA will negotiate with the organization for appropriate transfer of the data and, as necessary, may provide funds to convert the data into an easily used format using standard units.**
- **Effective immediately:** we urge you to submit all data from grants to SeaBASS. All data in SeaBASS are available with contact information for PI attached.



## NASA Research Opportunities



- **ROSES – Research Opportunities in Space and Earth Science**
  - Omnibus solicitation with former Space Science
  - Released in February each calendar year w/rolling deadlines for NOIs, Proposal Due Dates
  - Updates to different sections in Table of Contents via Amendments by E-mail
- **Solicitations Closed, Under Review**
  - International Polar Year - \$6M/yr [May 2007]
  - Earth System Science Research using Data and Products from the Terra, Aqua, and ACRIMSAT Satellites- \$25M/yr [May 2007]
  - Ocean Biology and Biogeochemistry (Southern Ocean Carbon Program (GasEx)) – [June 2007]
- **ROSES 2007 - <http://nspires.nasaprs.com/> - “Solicitations” – boiler plate**
  - **Carbon Cycle Science** (~\$7-9M/yr – 6.6.2007) w/USDA
    - Global carbon cycle modeling and analysis;
    - Regional studies that provide critical understanding of and offer to reduce major uncertainties about the global carbon cycle;
    - Studies of the carbon cycle implications of ocean acidification; and
    - Decision-support systems for carbon management
  - **High-end Computing** – (up to \$2M/yr – 9.18.2007) - Ecological forecasting (fisheries)
  - **Ocean Biology & Biogeochemistry w/Suborbital Science** (up to \$2M/yr – TBD)
  - **Ecology and Oceanography of Harmful Algal Blooms** (partner agency)



## NASA Research Opportunities



- **New Investigator Program in Earth Science – (1/8 or 1/10) [31 August 2007] – [mwei@nasa.gov](mailto:mwei@nasa.gov)**
  - Designed for scientists and engineers with Ph.D. degrees within the last 5 years
  - Must be US citizen or legal permanent resident (with Green card) at the time of award (immediately after selection)
  - Both Research and Education plans are required, with Research carrying approx. double the weight of Education, motivating scientists/engineers to recognize that our job does not end with publishing papers.
  - 3-year awards at \$80-120K/year
  - A source of PECASE nominations, but not the only source
- **Earth System Science Fellowship Program – Graduate Students - Annual (1/4-1/7)**
  - Support to graduate students pursuing master's and/or Ph.D. degrees in disciplines addressing Earth system science and remote sensing
  - Up to 3 years of support at \$24K/year (Increase to \$30K/year anticipated in FY2008)
  - Applications due February 1 every year; announcement of selections late May; award start-date September 1
  - Foreign students, if enrolled full-time at a US institution, may apply



## Ocean Research Priorities Plan



- **Ocean Research Priorities Plan** - <http://ocean.ceq.gov/>
  - Four near-term research priorities identified
    - Sensors for Marine Ecosystems

NOPP BAA (NASA, NOAA, NSF, ONR) in development for  
Summer 2007 (\$7-9M/yr) – FY08



## Role of the Community



- Design and feedback of a robust Calibration/Validation Program & Ocean Biology and Biogeochemistry Research Advance Plan– Workshops/reports/research
  - Collaboration among PIs – integration of efforts with selected proposals
  - Engage ORION and IOOS
  - SOLAS, IMBER, CLIVAR, NACP, OCCC (ship time, etc.)
  - MERIS Data; ESA’s ENVISAT Science team, Venice Tower
- Enhancement of ocean biology processing group
  - Data product/algorithm selection and round robins; Data reprocessing, merging, assimilation, modeling – Earth System Data Records
- National and International Workshops – SOLAS, IMBER, OOI, NACP, OCCC
- Annual Ocean Color Research Team Meetings – modeling, innovative technologies, future measurements and initiatives