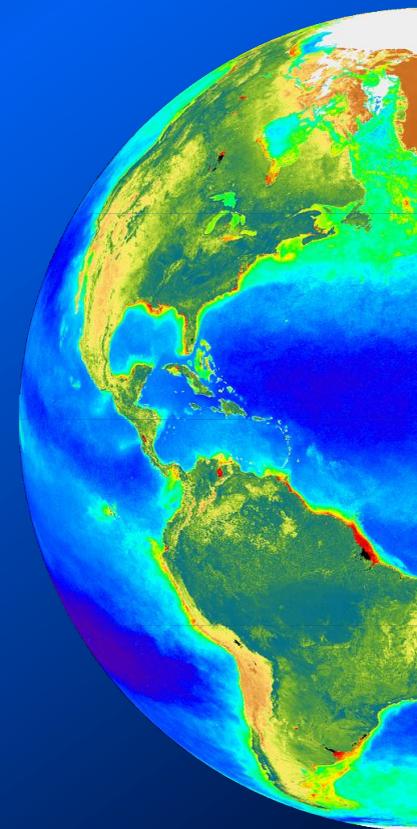
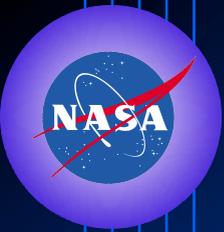


# Future Directions for NASA Ocean Biology & Biogeochemistry Research

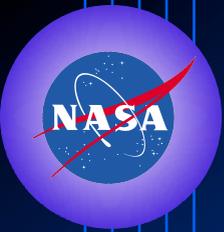


Paula Bontempi  
NASA Headquarters  
May 2006



# NASA's Guiding National Objectives

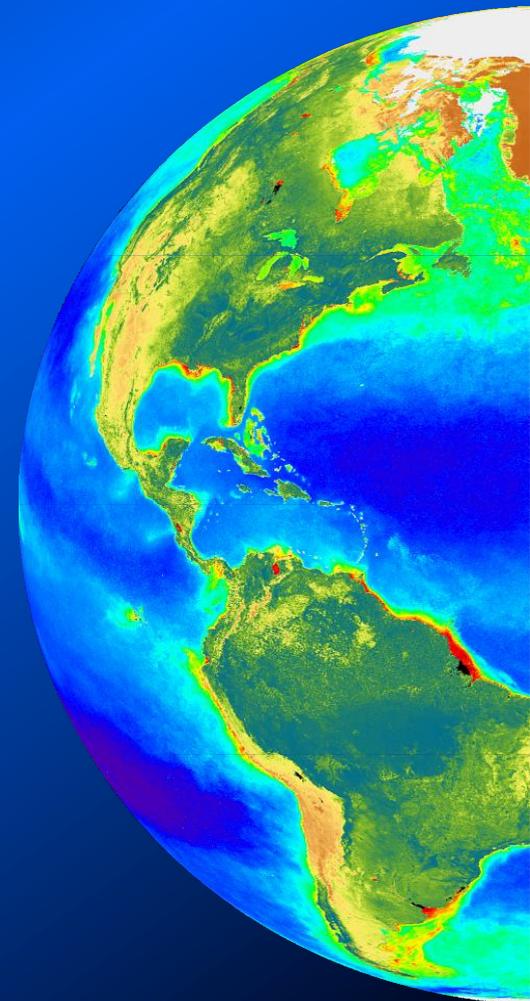
- Implement a sustained and affordable human and robotic program to explore the solar system and beyond.
- Extend human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations.
- Develop innovative technologies, knowledge, and infrastructure both to explore and support decisions about the destinations for human exploration
- Promote international and commercial participation in exploration to further U.S. scientific, security, and economic interests
- Study the Earth system from space and develop new space-based and related capabilities for this purpose.



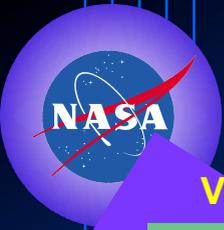
# NASA Earth Science Research Questions

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

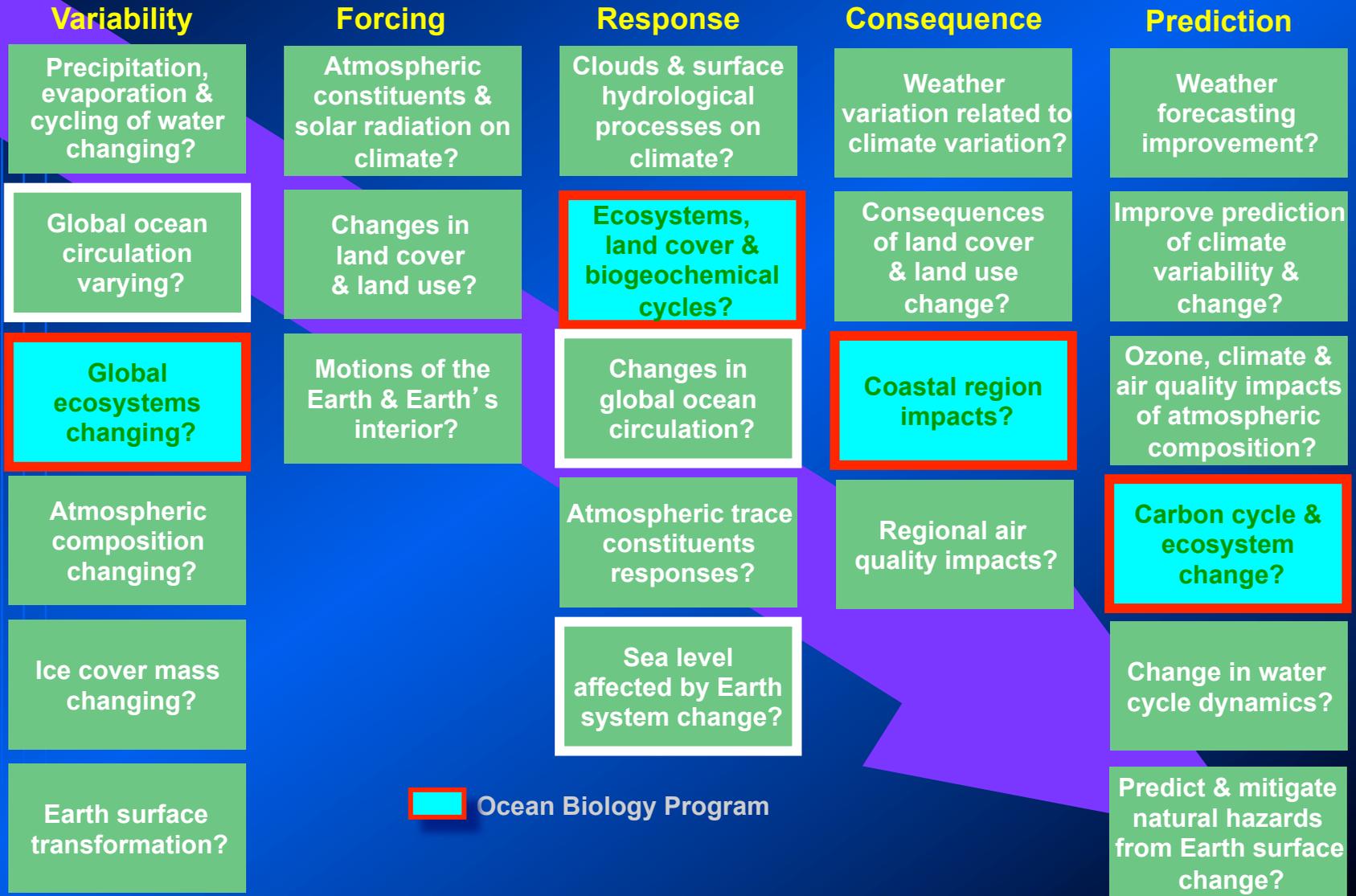
- How is the global Earth system *changing*?
- What are the primary *forcings* of the Earth system?
- How does the Earth system *respond* to natural and human-induced changes?
- What are the *consequences* of changes in the Earth system for human civilization?
- How well can we *predict* future changes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



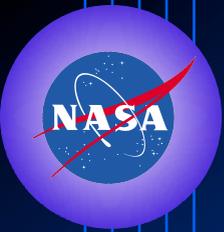
# Ocean Science Program Derives from Earth Science Research Strategy



ES Science Questions and Ocean Program Involvement



Ocean Biology Program



# NASA Earth Science Focus Areas

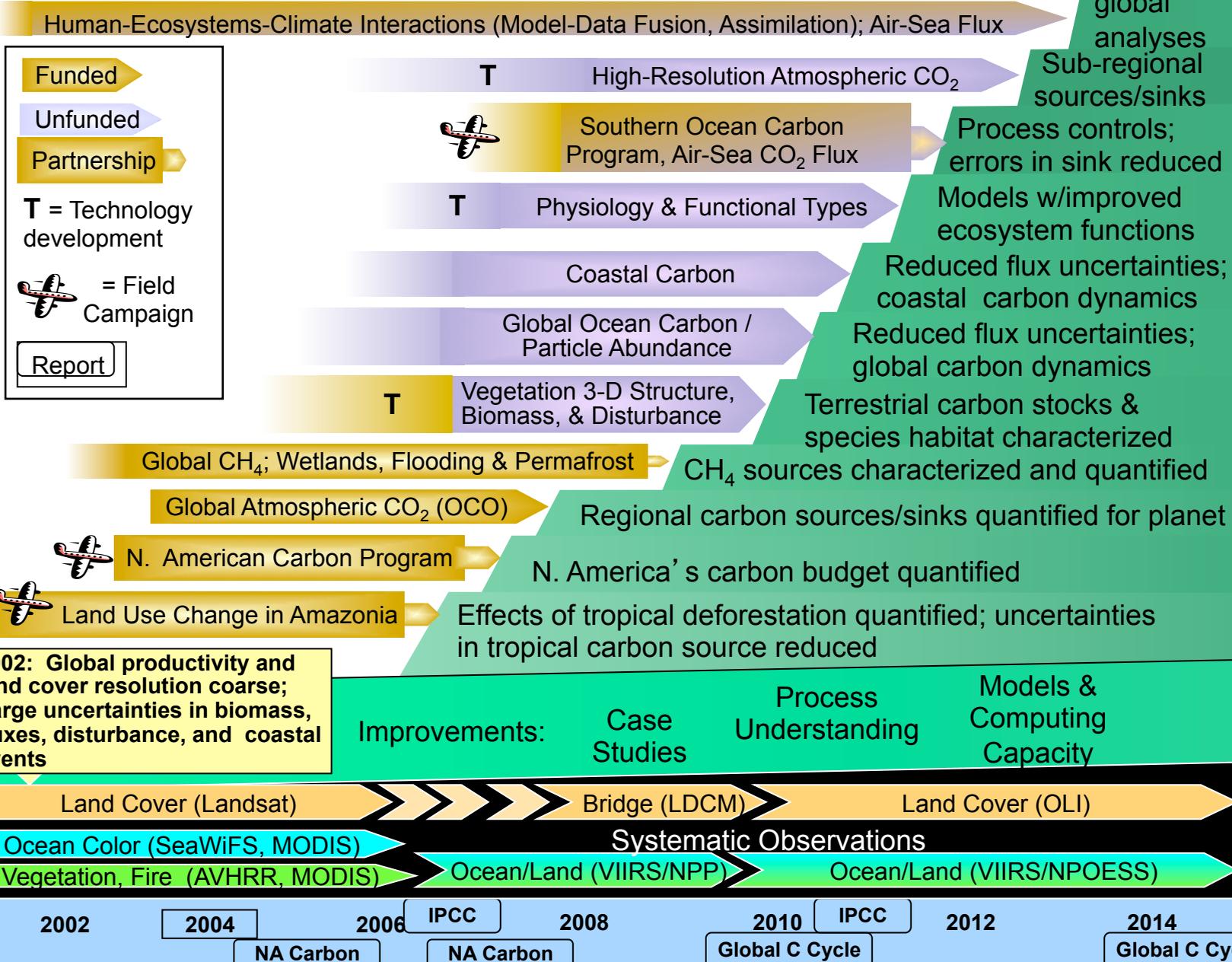
- Atmospheric Composition
- Carbon Cycle and Ecosystems
- Climate Variability and Change
- Earth Surface and Interior
- Water and Energy Cycle
- Weather
- Approaches and milestones are outlined in the former Earth Science Roadmaps

*<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

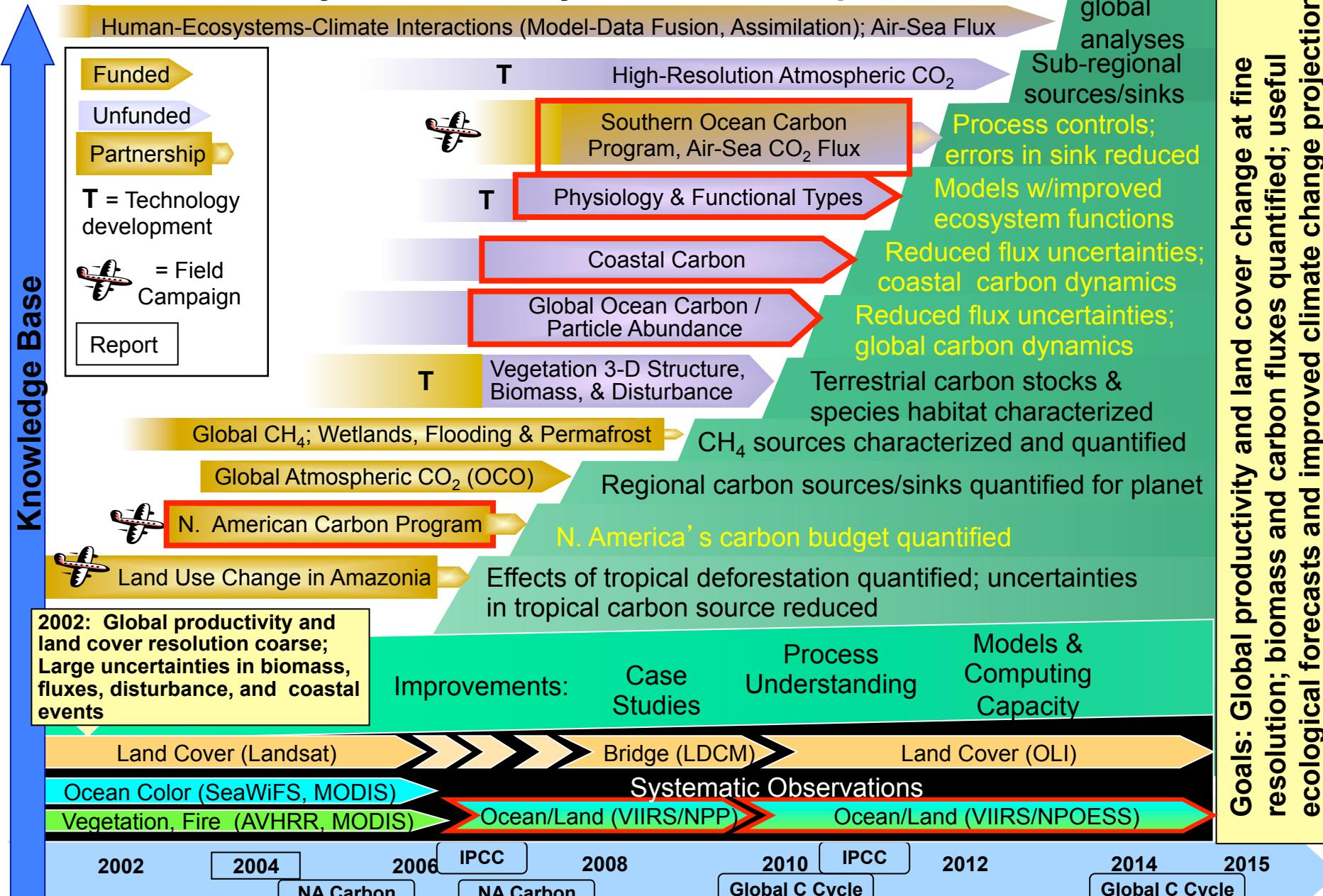
# Carbon Cycle and Ecosystems Roadmap

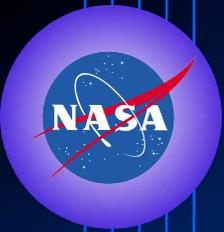
Knowledge Base



**Goals: Global productivity and land cover change at fine resolution; biomass and carbon fluxes quantified; useful ecological forecasts and improved climate change projections**

# Carbon Cycle and Ecosystems Roadmap

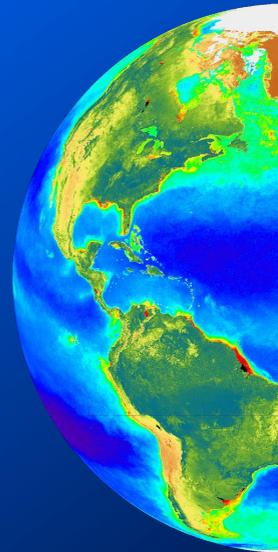




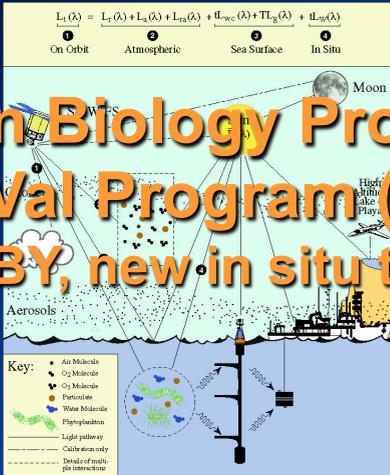
# Ocean Biology and Biogeochemistry

*Where do we go from here?*

- Agency – advance planning, reorg
- SMD reorg + Earth science advance planning
- Focus Area advance planning
- Programmatic advance planning – the next 20-30 years of ocean biology and biogeochemistry research



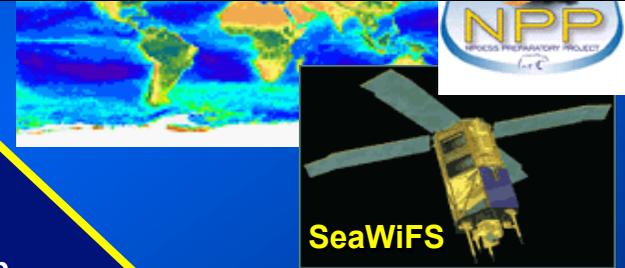
# Biological Oceanography's Three Primary Objectives: 2006



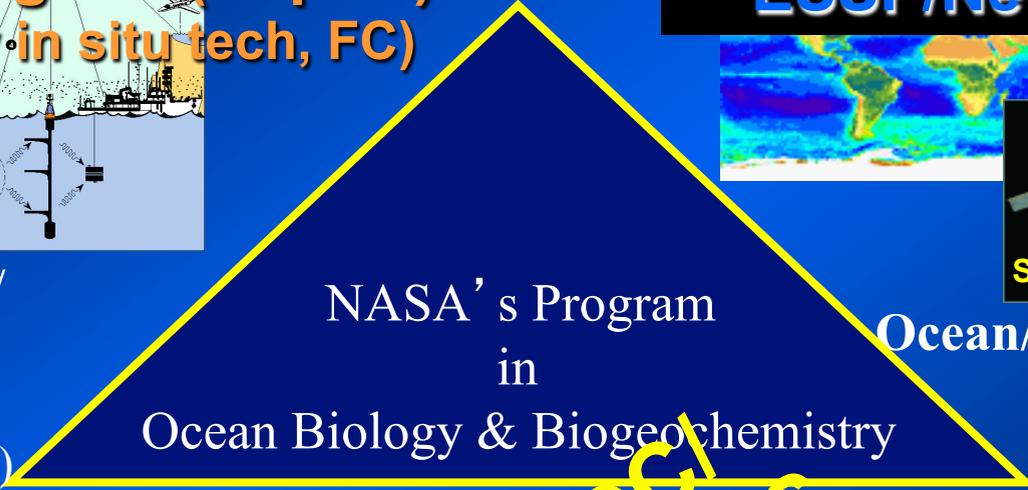
Ocean Biology Processing/  
Cal/Val Program (Report)  
(MOBY, new in situ tech, FC)



New Measurements/  
ESSP/New Initiative



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

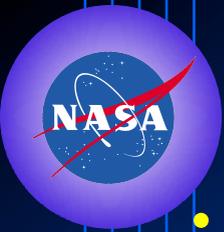


NASA's Program  
in  
Ocean Biology & Biogeochemistry

Ocean/Coastal Processes  
from Space

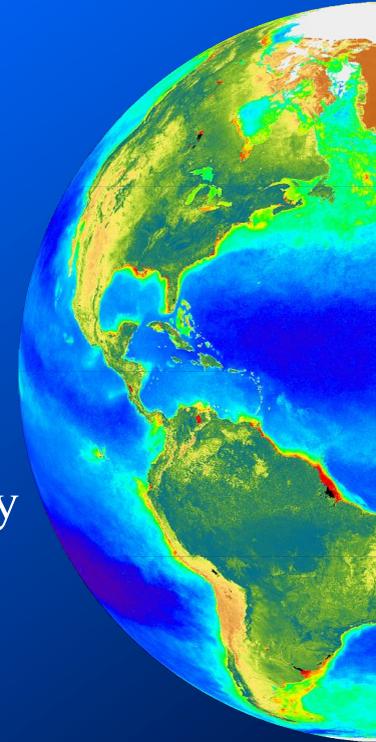


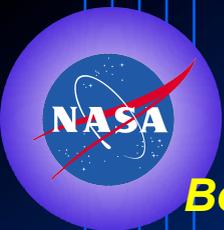
Carbon Cycle, Ecosystems  
Research



# The Next Steps

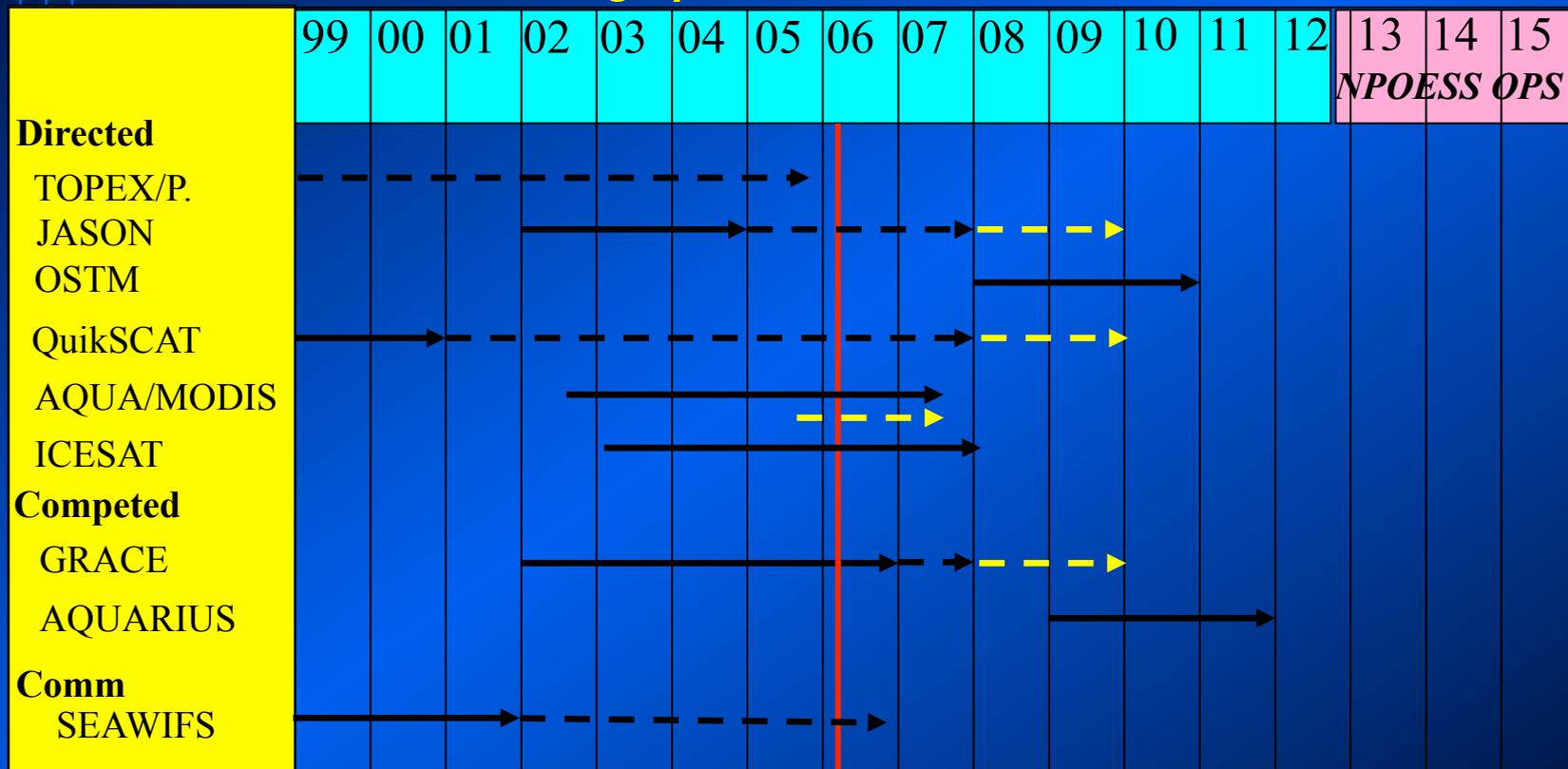
- **Near term (1-2 years)**
  - Data Product algorithm selection (ESDRs)
  - Data Policy - link to MAP efforts
  - International efforts in IMBER, SOLAS
  - Interagency Opportunities – ORION, NACP, OCCC
  - Calibration & Validation Program Plan
  - Research Program plan, FA science and tech. inputs
    - Feed in to Focus Area, Earth Science, ESTO, Agency
- **Moderate term (<10 years)**
  - New Measurements/missions
  - Dedicated sensors/missions for ocean research
- **Long term (30 years)**
  - New initiative - where Ocean biology/biogeochemistry research needs to go





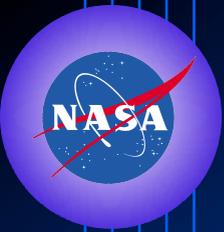
# NASA Current and Approved Oceans and Ice Missions

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



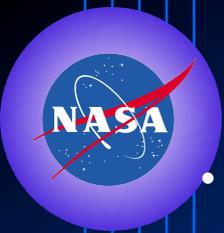
Today

- Primary Mission
- Approved Extended Mission
- Conditionally Approved Extended Mission



# Mission Updates

- **SeaWiFS**
  - 8 1/2-year time series
  - September 1997- present
- **Terra MODIS**
  - Spinning up revisit
  - SST available
- **Aqua MODIS**
  - Concentrate efforts on product selection and refinement
  - June 2002-Present
- **NPP (NPOESS Preparatory Project) VIIRS (Visible Infrared Imager Radiometer Suite)**
  - September 2009 launch?
  - Useful ocean data from VIIRS ?
- **NPOESS (National Polar-Orbiting Environmental Satellite System)VIIRS**
  - Operational focus – systematic observations – triggered Nunn-McCurdy in late 2005, proposed options for fix 1<sup>st</sup> week of June

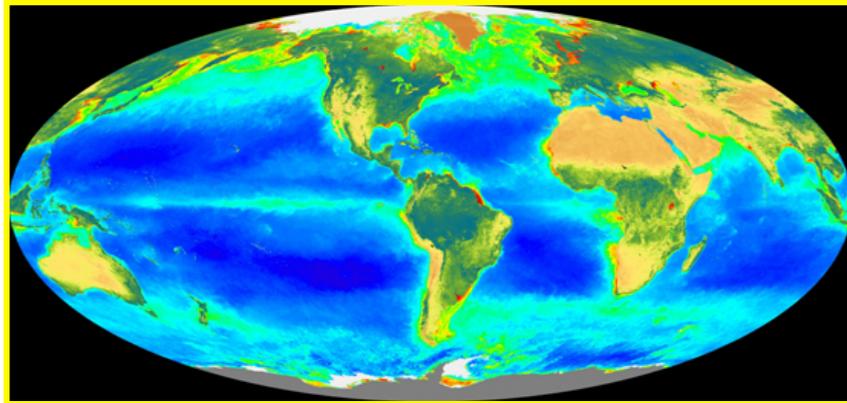


# NASA Research Opportunities

- **ROSES – Research Opportunities in Space and Earth Science**
  - Omnibus solicitation with former Space Science
  - Released in January each calendar year
  - Rolling deadlines for NOIs and Proposal Due Dates
  - Updates to different sections in Table of Contents via Amendments by E-mail
- **Solicitations Closed, Under Review**
  - Ocean Biology and Biogeochemistry – Calibration [7 April 2006]
  - North American Carbon Program (OCCC) - [April/May 2006 panel]
- **ROSES 2006 - <http://nspires.nasaprs.com/>**
  - **Interdisciplinary Research in Earth Science (~\$11M – 4.17.2006)**
    - Landscapes to Coasts
    - Coupled Carbon and Climate Modeling
  - **International Polar Year – (\$6M – 5.1.2006)**
    - Integrated analysis/modeling efforts; field campaigns, tech development for UAV instruments
  - **EOS Science Research (~\$25M – 7.18.2006)**
    - Algorithms, Science Data Analysis (new products, integrated research, intra and inter-sensor data fusion) – CCSP, OAP, GEOSS



# Earth's Living Ocean: The Undiscovered World (The Unseen World)



NASA Ocean Biology & Biogeochemistry Program



- 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?
- How do **carbon and other elements** transition between ocean pools and pass through the Earth System, and how do these biogeochemical fluxes impact the ocean and Earth's climate over time?
- 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?
- How do **hazards** impact the hydrography and biology of the coastal zone? How do they affect us, and can we mitigate their effects?



Timeline  Mission Themes	Immediate (1 – 5 Years)	Near-Term (5 - 10 Years)	Long-Term (10 - 25 Years)	Ecosystems	Biogeochemistry	Habitats	Hazards
	<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>5m 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 sensor - GEO (mission of opportunity)</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 mission SAR ATL/SCAT</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**

Top Priority Science Question	Color Code	Example of Benefits to Society
How do ocean ecosystems function and how do their biological communities change over time?		Improved management of ecosystem goods and services
How do carbon and other elements transition between the ocean and other global reservoirs, how do they change, and how do they impact the Earth system over time?		Information based policy on greenhouse gas emissions and nutrient loading
What are the variety and geographical distribution of coastal marine habitats? How do these change and what are the implications for human health?		Mapping and assessment of coastal habitats for future development plans and tourism
How do natural hazards and pollutants impact the hydrography and biology of the coastal zone?		National security and improved forecasting of natural and human-induced hazards