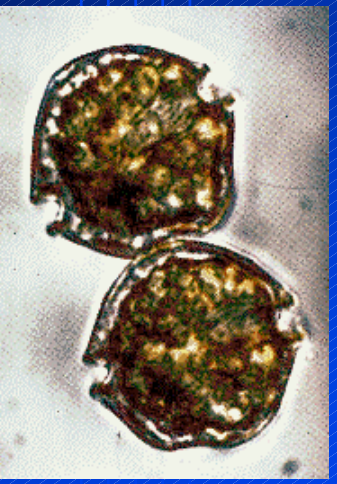
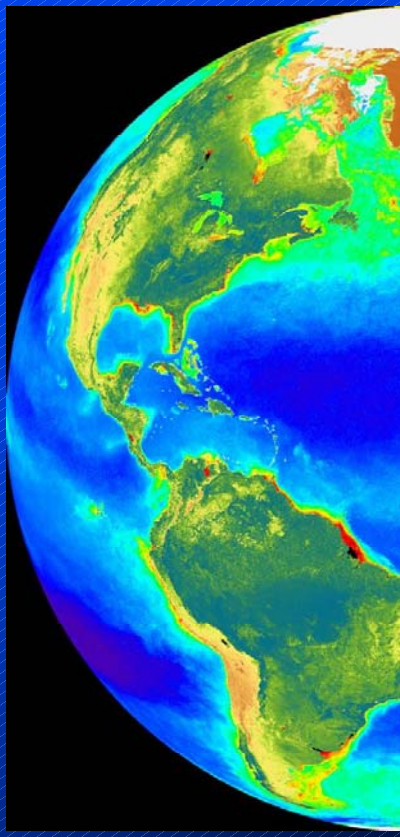
NASA's Vision for Ocean Biology & Biogeochemistry

Science Questions, Themes, Roadmaps, and Budgets





Paula Bontempi

NASA Headquarters

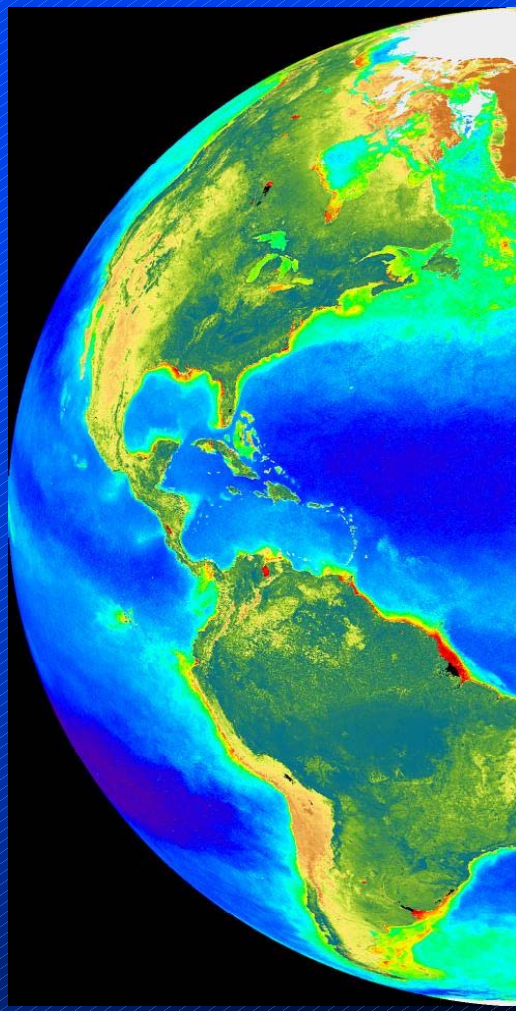
April 2004

NASA ESE Mission & Research Questions

Mission: Develop a scientific understanding of the Earth system and its response to natural and human-induced changes that enables improved prediction of climate, weather and natural hazards for present and future generations

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 Enterprise Research Strategy

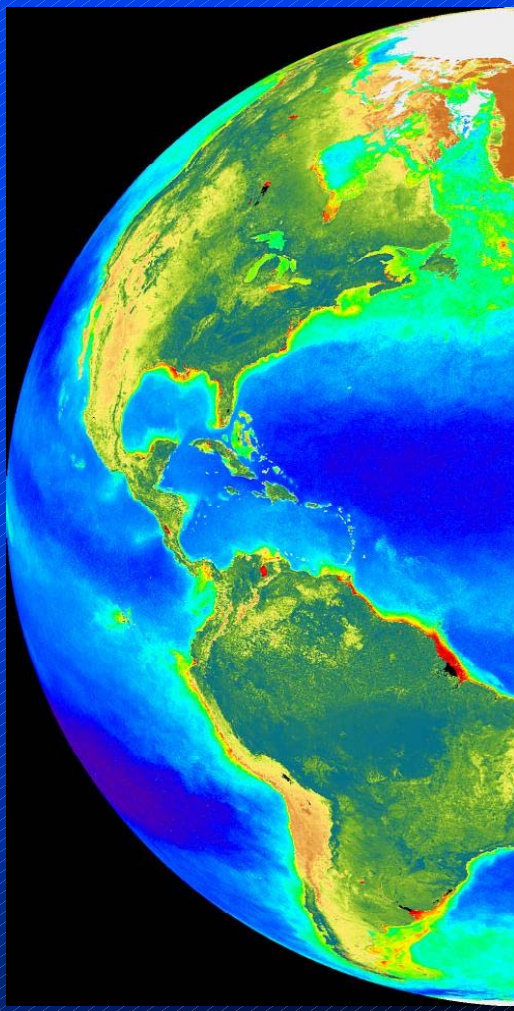
ESE Science Questions and Ocean Program Involvement

Variability	Forcing	Response	Consequence	Prediction
Precipitation, evaporation & cycling of water changing?	Atmospheric constituents & solar radiation on climate?	Clouds & surface hydrological processes on climate?	Weather variation related to climate variation?	Weather forecasting improvement?
Global ocean circulation varying?	Changes in land cover & land use?	**Ecosystems, land cover & biogeochemical cycles?**	Consequences of land cover & land use change?	Improve prediction of climate variability & change?
Global ecosystems changing?	Motions of the Earth & Earth's interior?	Changes in global ocean circulation?	**Coastal region impacts?**	Ozone, climate & air quality impacts of atmospheric composition?
Atmospheric composition changing?		Atmospheric trace constituents responses?	Regional air quality impacts?	**Carbon cycle & ecosystem change?**
Ice cover mass changing?		Sea level affected by Earth system change?		Change in water cycle dynamics?
Earth surface transformation?				Predict & mitigate natural hazards from Earth surface change?

Ocean Biology Program

Ocean Science Program Questions

- Variability
  - Global ocean circulation varying
  - Global ecosystems changing
- Response
  - Ecosystems, land cover & biogeochemical cycles (ecosystem response and effects on global C cycle)
  - Changes in global ocean circulation
  - Sea level affected by climate change
- Consequence
  - Coastal region impacts (change)
- Prediction
  - Transient climate variations
  - Carbon cycling and ecosystem change (Carbon cycling & future CO_2 & methane concentrations)

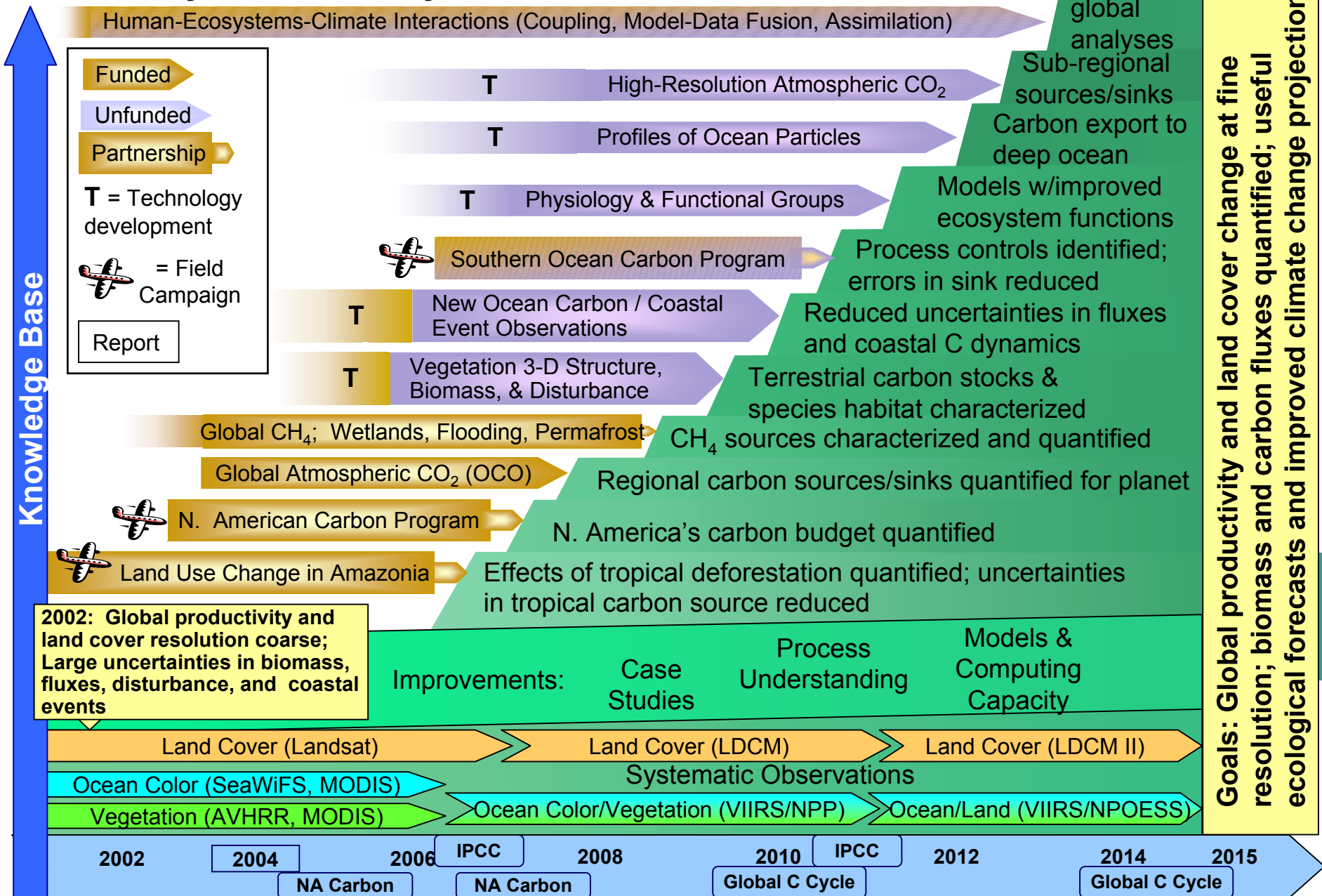


NASA ESE Focus Areas

- 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 ESE Roadmaps
  - *http://earth.nasa.gov/roadmaps/*

Carbon Cycle and Ecosystems



Carbon Cycle and Ecosystems

Knowledge Base

Human-Ecosystems-Climate Interactions (Coupling, Model-Data Fusion, Assimilation) → Integrated global analyses

Funded
Unfunded
Partnership
T = Technology development
= Field Campaign
Report

T High-Resolution Atmospheric CO_2 → Sub-regional sources/sinks

T Profiles of Ocean Particles → Carbon export to deep ocean

T Physiology & Functional Groups → Models w/improved ecosystem functions

Southern Ocean Carbon Program → Process controls identified; errors in sink reduced

T New Ocean Carbon / Coastal Event Observations → Reduced uncertainties in fluxes and coastal C dynamics

T Vegetation 3-D Structure, Biomass, & Disturbance → Terrestrial carbon stocks & species habitat characterized

Global CH_4; Wetlands, Flooding, Permafrost → CH_4 sources characterized and quantified

Global Atmospheric CO_2 (OCO) → Regional carbon sources/sinks quantified for planet

N. American Carbon Program → N. America's carbon budget quantified

Land Use Change in Amazonia → Effects of tropical deforestation quantified; uncertainties in tropical carbon source reduced

2002: Global productivity and land cover resolution coarse; Large uncertainties in biomass, fluxes, disturbance, and coastal events

Improvements: Case Studies; Process Understanding; Models & Computing Capacity

Land Cover (Landsat) → Land Cover (LDCM) → Land Cover (LDCM II)

Ocean Color (SeaWiFS, MODIS) → Ocean Color/Vegetation (VIIRS/NPP) → Ocean/Land (VIIRS/NPOESS)

Vegetation (AVHRR, MODIS)

Systematic Observations

2002 | 2004 | 2006 | IPCC | 2008 | 2010 | IPCC | 2012 | 2014 | 2015

NA Carbon | NA Carbon | Global C Cycle | Global C Cycle

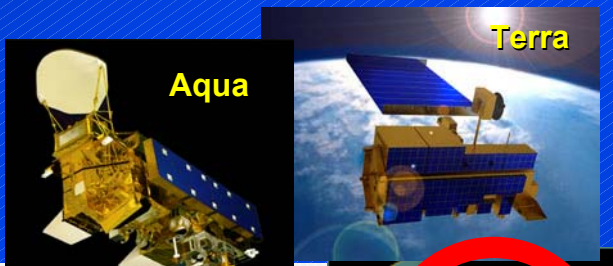
Goals: Global productivity and land cover change at fine resolution; biomass and carbon fluxes quantified; useful ecological forecasts and improved climate change projections

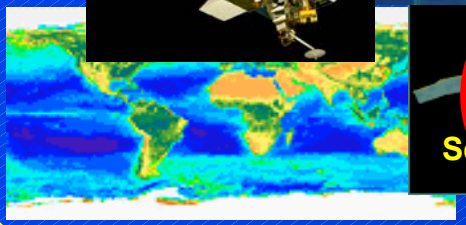
CC & E Roadmap - Oceans

- North American Carbon Program (FY04 - Partnership)
  - North America's carbon budget quantified
    - Geostationary
- New Ocean Carbon/Coastal Event Observations
  - Reduced uncertainties in fluxes and coastal carbon dynamics
- Southern Ocean Carbon Program (Partnership)
  - Process controls identified; errors in sink reduced
    - Geostationary
- Physiology and Functional Groups
  - Models with improved ecosystem function
    - LIDAR
- Profiles of Ocean Particles
  - Carbon export to deep ocean
    - LIDAR

Biological Oceanography's Three Primary Objectives: 2003

EOS Re-Compete





NASA's Program in Biological Oceanography

Time Series (MOBY, HOTS, BATS)

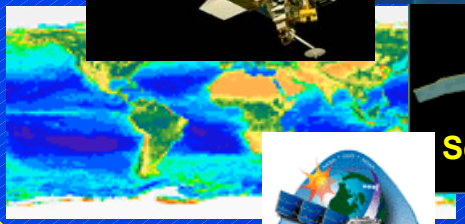
Ocean/Coastal Processes from Space

NACP

Carbon Cycle Research

Biological Oceanography's Three Primary Objectives: 2004

EOS Re-Compete/
Ocean Biology Processing



NASA's Program
in
Biological Oceanography

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

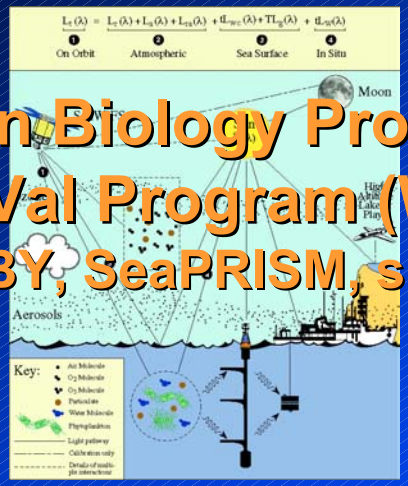
Ocean/Coastal Processes
from Space

NACP/OCCC

Carbon Cycle Research

Biological Oceanography's Three Primary Objectives: 2005

Ocean Biology Processing/ Cal/Val Program (WShop)
(MOBY, SeaPRISM, ship time)

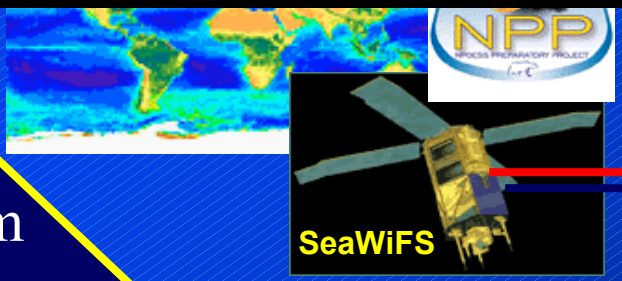


Time Series, Cal/Val

(MOBY, HOTS, BATS)

NASA's Program in Biological Oceanography

New Measurements/ ESSP



Ocean/Coastal Processes from Space

NACP/OCCC

Carbon Cycle Research

Obstacles to Address

- Loss of SIMBIOS, SeaWiFS projects and associated funds
- Design and funding of robust cal/val program
  - MOBY – SeaPRISM
  - Ship time
- Coastal focus – cal/val activities will require new instrumentation and technology development, instrument protocols, need augmentation
- MODIS repro – the DAAC/MODAPS issues in connectivity, computation, and integration
  - Discipline-based processing – clear funding?
- Climate Data Records – Data Product Selection
- Aqua and Terra MODIS – on to VIIRS
- CCSPO NACP involvement without program augmentation
- Balance among process studies, modeling proposals, new measurements

Ocean Biology Processing Group

- Move from missions to measurements
- Integration of SeaWiFS, MODIS, VIIRS processing
  - Common data format
  - Web-based data access
- SeaDAS platform enhancement
- Presence of Cal/Val group
- Interface with:
  - Calibration/Validation
  - Atmospheric Correction
  - Measurement Working
  - Science data analysis community
  - Other end users
  - GSFC DAAC

OceanColor WEB

MODIS | SeaWiFS | IOCCG | Products | News | People | Documents | Validation | Questions

Data Access

Level 1 and 2 Browser

Visually search the ocean color data archive and directly download and/or order data from single files to the entire mission. Extensive online HELP and tutorials available.

Level 3 Browser

Browse the entire Level 3 global ocean color data set for many parameters and time periods and download either JPEG images or digital data in HDF format.

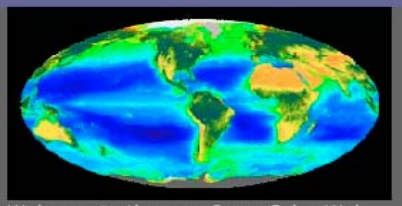
Oceans FTP Site

The Oceans FTP site contains the most recent 10 days worth of all MODIS/Aqua data and products, as well as the complete Level 3 mapped data archive.

GES DAAC

The GES DAAC hosts the recently reprocessed MODIS/Terra ocean color data, the SeaWiFS, OCTS, and CZCS data sets and Terra and Aqua SST data (in conventional MODIS format).

Latest News



Welcome to the new OceanColor Web. This site is intended to serve as the entry point into all of NASA's ocean color-related activities as part of the evolution of the individual ocean mission-based activities into an integrated ocean measurement-based program.

We have just begun the process of integrating the various mission-specific services, information, and documentation that have been developed over a number of years, so we expect that this website will be evolving quite rapidly. We encourage everyone to use the online forum, which is linked through the *Questions* button above, to provide feedback, ask questions and offer suggestions.

Subscribe: Ocean Mailing List

Support Services

SeaDAS

SeaDAS is a comprehensive image analysis package for the processing, display, analysis, and quality control of ocean color data

SeaBASS

SeaBASS is an archive of in situ oceanographic and atmospheric data used for algorithm development and satellite validation.

Cruise Support Services

Overflight predictions; Near real-time imagery and data for cruise support.

MQABI

MODIS (Ocean) Quality Assurance Browse Imagery Tool that allows access to MODIS Sea Surface Temperature products and statistics

Curator: OceanColor Webmaster
Authorized by: gene carl feldman
Updated: 05 February 2004

Security, Privacy, and Accessibility Policy

NASA

http://oceancolor.gsfc.nasa.gov

Data Product/Measurement Selection

- Model for measurement/data product/algorithm selection
  - SeaWiFS-type model for community round robins
  - Measurement-based working groups
- 41 Standard Data Products (Level 3) from MODIS
  - Reduce data volume in Goddard DAAC
  - Process to select data products and algorithms
  - Data kept on-line at NASA-GSFC processing center
  - Provide capability to PIs to implement own algorithms and process data
  - “Permanent” NASA archive/large orders filled by GSFC DAAC
- Climate Data Records
  - Which measurements or parameters?
  - Accuracy?
  - Data merging and assimilation (multi-mission)

Mission Updates

- SeaWiFS
  - 6-year time series
  - September 1997- Present (December 2004)
- Terra MODIS
  - Temporary hold on data processing except SST
  - July 2000-December 2002 in GSFC DAAC
- Aqua MODIS
  - Concentrate efforts on product reduction and refinement
  - June 2002-Present
- NPP (NPOESS Preparatory Project) VIIRS (Visible Infrared Imager Radiometer Suite) – October 2006
  - Science Team formation: algorithm review- ocean color, sea ice, SST, atmospheric correction + detailed operations and accuracy of sensors (VIIRS)
  - To evaluate planned Environmental Data Record (EDR) product algorithms for use as Climate Data Records (CDRs) + assist in defining required data system
  - Operational focus, science research discussion
- NPOESS (National Polar-Orbiting Environmental Satellite System)VIIRS – 2013
  - Operational focus - CDRs

NASA ESE and Other Research Solicitations

- Previous Solicitations – 2003-2004
  - REASoN CAN
  - Interdisciplinary Science – 59/348 = 17 %
  - NPP – 24/68 = 35%
  - EOS Recompetition – 192/566 = 34%
  - New Investigator Program

- Solicitations Closed, Under Review [due date]
  - Carbon Cycles (North American Carbon Program) – interagency with DOE [7 April 2004] - ~ $12M/yr
    - 298 proposals received / 40 aquatic

- Open Solicitations [due date]
  - Oceans and Ice [4 May 2004] – approx. $5-6M/yr
    - 315 NOIs received
  - Earth System Science Fellowships [1 June 2004]

- Get announcements at http://research.hq.nasa.gov/code_y

- Other solicitations
  - ECOHAB – Closed 28 January 2004

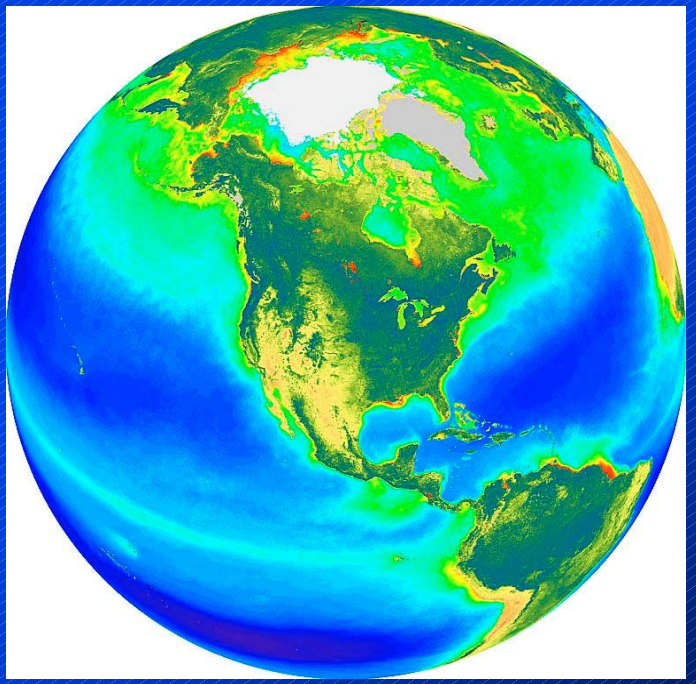
Future Directions – Program Structure

- Move from missions to measurements- ocean biology and biogeochemistry discipline processing
  - Pilot of SeaWiFS, MODIS ocean data
    - Incorporation of CZCS, OCTS (ReaSoN CAN)
  - Data distribution via SeaWiFS-type interface (enhanced SeaDAS)
  - Data product review – 41 MODIS ocean data products
    - Community discussed and selected (Climate Data Records DS II)
  - CDRs
    - Parameters, accuracies
    - Inter-sensor product comparability
    - International component via IOCCG

- Robust (permanent but fluid) Calibration and Validation data program (e.g., SIMBIOS)
    - MOBY, SeaPRISM

Future Directions- Program Science

- Hyperspectral geostationary
  - GOES - R
- Space-based LIDAR
- New measurements



- Technology development
  - Physiology and funct. groups
  - New ocean carbon/coastal event observations
  - Profiles of ocean particles
  - ESSP (AO in 2004) and IIP
  - High risk/high yield

- Need for robust modeling capabilities, data assimilation, computational capacity

- In situ tech./field components – cal/val + new measurements

Discussion Sessions – Working Group Formation

- Calibration/Validation Working Group
  - Vicarious, on-board, robust
  - Workshop in 2004
- Future Measurements/Future Technologies/Sensors
  - Timeline, what next, ESSPs
- Current Measurements/Data products/Algorithm Selection
  - Data Product Reduction - MODIS
  - Community round robins
- Climate Data Records
  - For ocean color remote sensing

NASA HQs Ocean Biology Program Manager is official lead

Community Involvement

- Design of a robust Calibration/Validation Program – workshop in 2004

- Enhancement of ocean biology processing group
  - Data product/algorithm selection and round robins
  - Data reprocessing, merging, assimilation - CDRs
  - Data access

- Workshops – JGOFS, OOI, IOOS

- CCSPO - NACP oceans implementation plan
- CCSP – OCCC plan

- Annual Ocean Color Research Team Meetings – modeling, innovative technologies, future measurements and initiatives

- U.S. Commission on Ocean Policy report

Ocean Commission Report

- Mandated by Oceans Act of 2000 (Public Law 106-256), authorized by Congress, appointed by the President, establish findings and make recommendations to the President and Congress for a coordinated and comprehensive national ocean policy
- The process of change needs everyone to participate in a national change in attitudes and paradigms
- Preliminary report released April 20; available via (http://oceancommission.gov)
- 30-d period to get comments back; governors of all states review document
- Report will outline a governance framework that includes:
  - a National Ocean Council to help coordinate federal agencies,
  - considerations on changes in structure of the federal government,
  - strengthening regional partnerships
- Recommends US look at things holistically, using ecosystem-management principles, upholding public trust
- Education needs to be a major emphasis if we want change over the long term
- Strengthening science, technology, engineering for earth observation (supporting IOOS) and interfacing management and science
- US needs to work hard, help other nations, provide leadership at international level
- Many detailed recommendations and suggestions on how to pay for them

Shaping the Future – Other Agencies

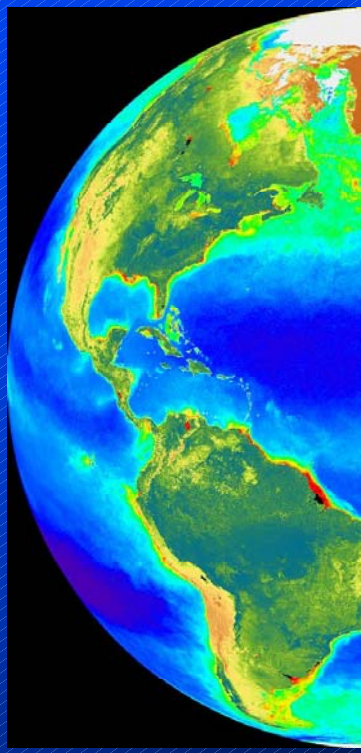
- Climate Change Science Program Office - CCSPO
  - Ecosystems IWG and Carbon Cycle IWG (North American Carbon Program (NACP))
- Carbon Cycle Science Program Office- OCCC (Ocean Carbon and Climate Change)
- Climate Change Technology Program Office - CCTPO
  - Basic Energy Working Group, Basic Research Working Group
- Integrated Global Observing Strategy – IGOS - Coastal Theme
- Synergy with NSF's OOI (ORION); NOAA's IOOS
- Ecology and Oceanography of Harmful Algal Blooms - ECOHAB (NSF, NOAA, EPA, ONR, NASA)
- Coordination with IPO for future missions
- Sponsorship of the Ocean Optics Meetings with ONR
- Working on U.S. Commission on Ocean Policy recommendations

New Measurements/Missions/Opportunities

- Synergy with IOOS, OOI, CCSP
- ESSP – Earth System Science Pathfinder
  - unique, specific, highly-focused mission requirements in Earth science research; addressing Global Change Research to accommodate new scientific priorities and infuse new scientific participation into the ESE
  - http://essp.gsfc.nasa.gov/
  - Announcement of Opportunity – late 2004
- IIP – Instrument Incubator Program (ESTO)
  - innovative remote-sensing concepts and the assessment of these concepts in ground, aircraft, or engineering model demonstrations
  - http://esto.gsfc.nasa.gov/obs_technologies_iip1.html
- SBIR – Small Business Innovation Research
  - increase private sector commercialization of innovations and support and encourage minority and disadvantaged businesses
  - http://sbir.gsfc.nasa.gov/

The Next Steps

- Near term (1-2 years)
  - Cal/Val Program
  - MODIS Data Product reduction and future algorithm selection (CDRs)



- Long-term (<10 years)
  - New Measurements/missions
  - Dedicated sensors/missions for ocean research

- Ocean Color Research Team Meeting in April 2005
  - 2 days of science, ½ day of administration and infrastructure discussion