NASA SCIENCE MISSION DIRECTORATE

Earth-Sun System Applied Sciences Program
Carbon Management Program Element
FY2006-2010 Plan

Version 1.0

Date: 1/16/2006

Expanding and accelerating the realization of economic and societal benefits from Earth-Sun System science, information, and technology

NASA Science Mission Directorate
Earth-Sun System Division
Applied Sciences Program

Applied Sciences for the Carbon Management Program Element:

This document contains the Carbon Management Program Element Plan for FY 2006-2010.
This plan derives from direction established in the NASA Strategic Plan, Earth Science Enterprise and Space Science Enterprise Strategies, Earth Science Applications Plan, and
OMB/OSTP guidance on research and development. The plan aligns with and serves the commitments established in the NASA Integrated Budget and Performance Document.

The Program Manager and the Applied Sciences Program Leadership have reviewed the plan and agree that the plan appropriately reflects the goals, objectives, and activities for the Program Element to serve the Applied Sciences Program, Earth-Sun System Division, NASA, the Administration, and Society.

(Signature on file) _____ _____
Ed Sheffner — Date
Program Manager, Carbon Management
Applied Sciences Program
NASA Earth-Sun System Division

(Signature on file) _____ _____
Lawrence Friedl — Date
Lead, National Applications
Applied Sciences Program
NASA Earth-Sun System Division

(Signature on file) _____ _____
Ronald J. Birk — Date
Director, Applied Sciences Program
NASA Earth-Sun System Division

NASA Earth-Sun System Division: Applied Sciences Program

TABLE OF CONTENTS

I. PURPOSE AND SCOPE 1

II. GOALS AND OBJECTIVES 3

III. PROGRAM MANAGEMENT AND PARTNERS 4

IV. DECISION SUPPORT TOOLS AND COASTAL MANAGEMENT ISSUES 8

V. APPLICATION ACTIVITIES 10
ADDITIONAL ACTIVITIES & LINKAGES 21

VI. BUDGET: FY06-2010 23

VII. PROGRAM MANAGEMENT AND PERFORMANCE MEASURES 24

VIII. APPENDICES 26

A. INTEGRATED SYSTEM SOLUTIONS DIAGRAM 26
B. ROADMAP 27
C. APPLIED SCIENCES PROGRAM BUDGETS FY2006-2010 29
D. RELATED NASA AND PARTNER SOLICITATIONS AND GRANTS 30
E. ACRONYMS AND WEBSITES 31

NASA Science Mission Directorate – Applied Sciences Program

Carbon Management Program Element Plan: FY 2006 - 2010

I. Purpose and Scope

This Applied Sciences National Applications Program Element Plan is applicable for Fiscal Years 2006 through 2010. The plan documents the purpose of the program and the implementation approach to meet the program objectives using the allocated resources. The plan describes the program element approach in extending NASA Earth-Sun system science research results to meet the decision support requirements of partner agencies and organizations. The Applied Sciences Program requires this plan to function as a program management tool, describing the program structure, functional mechanisms, performance measures, and general principles that will be followed in extending NASA research results for societal benefits.

Scope within NASA and Applied Sciences Program

Each National Applications Program Element is managed in accordance with, and is guided by, the NASA Strategic Plan and Earth Science Applications Plan. The program element benefits from NASA Earth-Sun system science research results and capabilities, including the fleet of NASA research satellites, the predictive capability of models in the Earth System Modeling Framework (ESMF), Project Columbia, the Joint Center for Satellite Data Assimilation (JCSDA), and the Earth-Sun System Gateway (ESG). The Applied Sciences Program seeks to develop with its partners scientifically credible integrated system solutions in which uncertainty characterization and risk mitigation has been performed using the capability of the national Earth-Sun laboratories and others in the community of practice.

The FY06 President's Budget for the NASA Applied Sciences Program specifies between $48 million and $55 million annually for FY06 – FY10. There are two elements to the Applied Sciences Program: National Applications and Crosscutting Solutions. Each National Applications Program Element benefits from the performance results of Crosscutting Solutions (see Crosscutting Solutions Program Element Plan). Each National Applications Program Element leverages and extends research results from the over $2 billion per year supporting Earth-Sun system science and development of innovative aerospace science and technology. Additional information about the NASA Applied Sciences Program can be found at http://science.hq.nasa.gov/earth-sun/applications.

The Carbon Management Program Element is one of twelve Elements in the Applied Sciences Program of NASA'S Earth–Sun System Division. Carbon management is the re-distribution of carbon in terrestrial and aquatic environments through the implementation of policies that affect carbon emissions and sequestration. The Applied Sciences Program extends the use of NASA research results in the carbon cycle to enhance the decision support tools of NASA's operational partners with monitoring and policy mandates regarding carbon emissions and sequestration. The desired outcome is for partner organizations to use project results, such as prototypes and benchmark reports, to enhance their decision support capabilities through the use of Earth-Sun science observation, measurements and predictive models. Carbon management is a key resource management

and policy issue of the 21st century. The atmospheric concentration of CO2 increased by about twenty-five percent during the 20th century and is continuing to increase due to the burning of fossil fuels and changes in land cover and land use. Increases in the atmospheric concentration of CO2 and other greenhouse gases are producing significant changes in global climate and accompanying changes in the energy and water cycles. These changes will have profound impacts on society and the Earth's ecosystems. The US Administration launched an initiative in 2001 to address specific elements of the climate change issue. The Carbon Management Program Element responds to the Climate Change Research Initiative (CCRI) and focuses on carbon emissions and sequestration in terrestrial, oceanic and geologic systems. The Program Element responds to requirements and programs of the operational agencies responsible for implementation of the Climate Change Technology Initiative (CCTI) in regard to the use of NASA sensor systems (e.g., Terra/Aqua, Aura, SeaWiFS, Orbiting Carbon Observatory (OCO)) to measure and monitor carbon sequestration in terrestrial, lacustrine and oceanic environments and the flux of carbon among these environments and the atmosphere. Projects sponsored through this Program Element build toward an operational carbon management regime that informs resource managers and policy makers of the current state of the distribution of carbon sources and sinks and provides information on near-term and long-term impacts of mitigations. Measurements and observations from NASA's Earth orbiting systems are especially useful in integrating in situ and local measurements for regional and global scale assessments. The carbon management element, as with the other elements in Applied Sciences Program, draws upon the research and technology developed through NASA research to support integrated system solutions. Carbon management benefits from models developed by NASA centers and laboratories and international collaborations. In developing a science-based carbon management regime, knowledge of the carbon cycle is exploited to assist operational agencies (e.g., the US Department of Agriculture (USDA), Department of Energy (DOE), Environmental Protection Agency (EPA), and the US Geological Survey (USGS)) fulfill their mandates to manage carbon and to support local, regional, national, and global policy and planning for control of carbon in the environment. To be current with carbon cycle science, the Carbon Management Program Element draws upon, and contributes to, other program elements in the Applied Sciences Program and other programs in the federal government. The Carbon Management Program Element collaborates with the Carbon Cycle and Ecosystems Focus Area in the Research Program of the Earth-Sun System Division and with the Ecological Forecasting, Water Management, Air Quality, Disaster Management and Homeland Security Program Elements in the Applied Sciences Program. Activities are integrated with the Carbon Cycle Interagency Working Group (CCIWG), the Synthesis and Analysis Report (SAR) 2.2 Agency Executive Committee (the group responsible for interagency compilation of the prospectus for the SAR 2.2 report and management of the North American Carbon Program (NACP)), the CCTP carbon sequestration group, the Focus Area Working Group for carbon of the NASA/USDA Interagency Working Group for Applied Science Applications, and International Working Group on Earth Observations (IWGEO.) NASA implements the Carbon Management Program Element through partnerships with USDA, DOE and EPA and competitive solicitations. Operational agencies are key members in these partnerships: establishing requirements for decision support systems, monitoring progress, incorporating results into operational procedures, and on-going, operational use of the tools and systems based on NASA Earth observations, models and research results. An example of the strategy and implementation of the Carbon Management Program Element is the work sponsored by the Applied Sciences Program at NASA Ames Research Center. CQUEST is an on-line tool developed at Ames. The tool combines NASA Earth observations from MODIS and other sources, a NASA carbon cycle model – Carnagie Ames Stanford Approach (CASA), and NASA systems engineering in a decision support tool now under evaluation by the USDA Forest Service and Natural Resource Conservation Service for use in their mandated carbon reporting activities.

II. Goals and Objectives

Goals

The Carbon Management Program Element seeks to maximize the benefit of observations and measurements from NASA earth observing systems and output from NASA predictive models in decision support systems and tools used by agencies and organizations responsible for policy and resource decisions related to carbon emissions and sequestration – from local to global scales. The goal is summarized in the Carbon Management Roadmap (Appendix B), which illustrates the development of a robust carbon management regime that utilizes improvements in the understanding of carbon cycle dynamics. Prior to FY06, the carbon management program element focused on support for tools, such as CQUEST and TOPS, that provide users access to data products and model predictions. Beginning in FY06, with such tools available, the program element will focus more using available tools to enhance the decision support capabilities of partner organizations and evaluation of new data sources, such as OCO, for carbon management.

Objectives

All National Applications Program Elements are aligned to the NASA Strategic Plan and the agency's objectives as expressed in the NASA Integrated Budget and Performance Document (IBPD) and the Performance Assessment Rating Tool (PART).

FY06 objectives for carbon management by project are:

1. Virginia Tech University: Decision Support for Loblolly Pine Carbon Management: From Research to Operations
   a. Evaluation of existing DST used by land owners and industry association
   b. Integrate CERES products into CASA model for ecosystem carbon budgets
   c. Generate NPP products for annual carbon flux at 250m and 30m spatial resolution using CASA model and MODIS/Landsat data.

2. Pacific Northwest Laboratory: Projections of Land Use Change and the Carbon Cycle
   a. Enhance integrated assessment model representations of wind and solar energy using NASA data

3. Colorado State University: CO2 Fluxes between Agrciultural Land and the Atmosphere
   a. First attempt at regional simulations of carbon fluxes in mid-continent area using combined CASA-Century model approach

4. Oak Ridge National Laboratory: Spatially-Explicit Full Carbon and Greenhouse Gas Accounting at the Regional to National Scale
   a. Integrate NASA data and other data with carbon dynamics data into POLYSYS economic model
   b. Begin simulation of land use change using the ZPOLYSYS model
   c. Complete evaluation of no-till and other relevant sequestration activities

5. USDA: Decision Support Systems for Carbon Management Across the U.S. Corn Belt using NASA Remote

Sensing Data Products
a. Complete data analysis for mapping residue and tillage practice in the study region
b. Complete model validation

6. University of Maryland: North American Forest Disturbance and Regrowth
   a. Complete evaluation of FIA needs for products and predictions
   b. Begin verification and validation of data products

Other FY06 objectives:

1. Begin evaluation of OCO data in carbon management
2. Develop closer collaboration with ocean carbon community
3. Convene the first annual meeting of the carbon management program element to review and discuss the goals and objectives of the program element.

III. Program Management and Partners

A. Program Management

Program Manager
Carbon Management Element
Mr. Ed Sheffner
Applied Sciences Program
Earth-Sun System Division
NASA Headquarters

Responsibilities:

- Development of and implementation of interagency agreements and partnerships with other organizations.
- Program development including program plans and budgets.
- Development and implementation of solicitations for carbon management tasks.
- Primary responsibility for metrics, performance goals and other performance evaluation criteria.
- Point of contact for CCTP working group on sequestration, NASA/Earth-Sun System Division carbon program (for applications), and NASA/USDA focus area working group on carbon management.
- Applied Science representative on Carbon Cycle Interagency Working Group (CCIWG).
- Member of the Agency Executive Committee for the State of the Carbon Cycle Report (SOCCR) - Synthesis and Assessment Report (SAR2.2) of the Climate Change Science Program.
- Monitor projects within the program element and collaborate with the principal investigators and the carbon management community to assure that the goals and objectives of the program element are responsive to community needs and goals and objectives of the Applied Sciences Program

Deputy Program Manager
Carbon Management Element

Dr. Carlos Del Castillo
Applied Sciences Program
NASA Stennis Space Center (SSC)

Responsibilities:

- Coordinate and liaison with Program Element Management for Carbon Management tasks at NASA Centers other than Stennis.
- COTR or studies manager (as appropriate) for grants and cooperative agreements related to carbon management and funded by the Earth Science Applications Division through procurement at SSC.
- Monitor the progress of projects within the program element. First point of contact for principal investigators within the program element.

B. Carbon Management Network & Partners

NASA HQ partners:

Chair: Carbon and Ecosystems Focus Area……..... Diane Wickland
Program Manager for Ocean Processes: Earth Science Research Program
…….....Paula Bontempi
Program Manager for Ecological Forecasting: Applied Sciences Program
…….....Woody Turner
Program Manager for Water Management: Applied Sciences Program
…….....Jared Entin
Program Manager for Air Quality: Applied Sciences Program
…….....Lawrence Friedl
Program Manager for Disaster Management: Applied Sciences Program
…….....Stephen Ambrose
IPA: Terrestrial Processes …….....William Emanuel

NASA Centers:

ARC:
Dr. Chris Potter and Dr. Ramakrishna Nemani, Modeling of carbon sequestration; enhancement of decision support tools for carbon emissions and sequestration

GSFC:
Dr. Jeff Masek, Calibration of MODIS and Landsat datasets to exploit extended record of Landsat for land cover change and its impact on carbon cycling and carbon management

Johnson Space Center (JSC):
Dr. Kamlesh Lulla, Coral reef studies – link to oceanic sources and sinks

Partner agency contacts:

USDA:
Bill Hohenstein, Global Change Program Office
USDA/Forest Service: Richard Birdsey, US Forest Service, chair, carbon management focus area working; Sequestration Working Group for CCTI; Chip Scott, Forest Inventory and Analysis (FIA) program
USDA/ARS: Paul Doriaswamy, Agricultural practices and soil carbon
USDA/NRCS: Jeff Goebel and John Brenner, carbon flues in agrciultrual land

EPA:
Ken Andrasko, Sequestration Team, Office of Atmospheric Programs
Tim Worth, carbon fluxes in agriculture

DOE:
Jeff Amthor, Climate Change Research Division, Germantown, MD
Dr. Roger Dahlman, Lead in CCTI; Measurement, Monitoring and Verification Working Group for CCTI; lead agency for implementation of 1605(b) guidelines

DOE/CSITE:
Craig Brandt, carbon accounting

DOE/ORNL:
Dr. Tris West, Carbon accounting
Dr. Tom Wilbanks, carbon management
Dr. Robert Cook, carbon data distribution

USGS:
Dr. Tom Loveland, Land cover and land cover change information for carbon sequestration

EPA:
Dr. Jane Leggett

Universities contacts:

Colorado State University (CSU):
Dr. Ingrid Burke, Impact of wild fires on carbon cycling and carbon sequestration
Dr. Keith Paustian, carbon fluxes in agrciulture
Dr. Richard Conant, carbon fluxes in agrciulture

MSU:
Dr. Roger King, Forest structure visualization; monitoring carbon accumulation in forest biomass and soils
University of Georgia (UG):
Dr. Ed Kanemasu, Agricultural decision support and carbon sequestration in developing countries

University of Maryland (UM):
Dr. David Roy, Impact of fires on carbon sequestration
Dr. Joseph JaJa, Distribution of data products
Paul Davis, Distribution of carbon products

Virginia Polytechnic University:
Dr. Randy Wynne: Decision support for carbon management

California State University Monterey Bay:
Venessa Genovese, Steven Klooster, Carbon modeling and predictive tools

Pennsylvania State University:
Dr. Klaus Keller, Carbon management and land use change

University of Illinois:
Dr. Atul Jain, carbon management and land use change

University of Tennessee:
Tools for full carbon accounting

Other Organizations:

Conservation International:
Dr. Marc Steininger, Fires in tropical forests

UNEP:
Dr. Ashbindu Singh

DAACS and Earth Science Modeling Center Partners:

Land Processes DAAC
Oak Ridge national Laboratory DAAC
Socioeconomic Data and Applications Center (SEDAC)

IV. Decision Support Tools and Management Issues

Priority Decision Support Tools

CQUEST

CQUEST and TOPS are two decision support tools that will be benchmarked in coming years in projects funded in FY04 through the Carbon Cycle and Ecosystems solicitation. Projects cofunded by USDA Forest Service, the USDA Agricultural Research Service and the Natural Resources Conservation Service will evaluate the tools against their requirements.

TOPS

CQUEST and TOPS are two decision support tools that will be benchmarked in coming years in projects funded in FY04 through the Carbon Cycle and Ecosystems solicitation. Projects cofunded by USDA Forest Service, the USDA Agricultural Research Service and the Natural Resources Conservation Service will evaluate the tools against their requirements.

LobDST

The Loblolly Pine Decision Support Tool (LobDST) includes growth and yield prediction equations and rerlated management activities for the geographic range of loblolly pine. Predictions have been validated at the stand level.

LobDST

The Loblolly Pine Decision Support Tool (LobDST) combines growth and yield prediction equations and management activities to assist land mangers make decisions on planting and harvesting loblolly pine plantings. The tool is used commonly by industrial landowners, government agencies and others for forest plantation management.

COLE

The Carbon On Line Estimator (COLE) is used by the USDA Forest Service and the National Council for Air and Stream Improvements (NCASI). The DST combines FIA and ecological data to develop carbon accounting estimates for reporting under section 1605(b) of the Energy Policy Act of 1992 and other purposes.

Potential Carbon Management Management Issues: FY06-FY10

Program management activities and participation in CCSP/CCTP:

1. Headquarters:
   - Participation in carbon cycle working group of the CCSP.
   - Participation in the sequestration working group of the CCTP.
   - Identification of collaborative projects with USDA working through the NASA/USDA Interagency Working Group and the USDA Remote Sensing Coordinating Committee.
   - Member - Carbon Cycle Interagency Working Group
   - Contribute to planning, implementation and management of the North American Carbon Program.

2. Ames
   - Participate in interagency (USDA, DOE, EPA) Greenhouse Gas Accounting Rules and Guidelines Working Group
   - NACP Tier three Site Measurement Guidelines working group.

3. Fellowships:
   - NASA Fellowships for the period FY2002 through 2006 with potential impact on the carbon management program:

Cross-Application Activities

The program consists of functional elements that contribute to all of the National Applications activities. The intention is to have the performance of these functions leverage accomplishments, and therefore the apparent resource investment, to the greatest extent possible into the National Applications partnerships. These functions are: Geoscience Standards and Interoperability, Human Capital Development, Integrated Benchmark Systems, and Solutions Networks. Examples of leveraged activities are:

- The Earth-Sun System Gateway is a "portal of portals" providing an access point through an Internet interface to all web-enabled NASA research results.
- A Solutions Networks capability to discover candidate configurations of NASA research results with the potential to improve partner's decision support systems.
- A Rapid Prototyping Capability to support NASA and partners in reducing uncertainty and testing the validity of NASA research results in decision support tools.
- Systems integration capability, knowledge tools and skilled human capital to help conduct studies on the systematic transitioning of the results of research to operational uses and the capability of operational systems to support scientific research.
- A student-based, human capital development program for building capability in entry level participants in the community of practice while developing solutions for state and local applications.

V. Application Activities

A. Projects

All National Applications Program Elements authorize peer-reviewed projects to support each element's goal and objectives. To secure funding and authorization to undertake activities supporting NASA and the Applied Sciences Program, project teams are responsible for developing project plans and managing the activities. The project plans specify the Earth-Sun observations, models, and other research results to extend to decision support tools as well as the activities to produce appropriate deliverables. The plans integrate contributions from appropriate the partners, NASA Centers and other contributors from the community of practice. Projects are expected to extend the benefits of NASA research results to the maximum extent possible, including the use observations from sensors on: Aura, Terra, Aqua, TRMM, NPP, NPOESS, Hydros, Topex, Jason, OCO and Aquarius.

B. Solicitations

The Applied Sciences Program utilizes full and open competitions to fund proposals from the community to contribute the Agency's objectives. This implementation strategy will continue to be critical part of extending the benefits of NASA Earth-Sun system research results and contributing to the improvement of future operational systems. The Program has participated in providing opportunities to the community in recent solicitations, including REASoN, Decisions 2004, and Decisions under ROSES. The proposals related to this National Applications Program Element that have been funded under these solicitations are described in Section V.D. Program Element Projects.

C. Congressionally Directed Activities

As of the publication of this document, an assignment of FY06 congressionally mandated activities was not completed by the Agency.

The procurement rules and management practices of the Agency require that congressionally mandated activities follow the same principles of planning and accountability as all other funded projects. Only activities that are aligned with NASA's mission, are technically credible, and are appropriately budgeted will be approved to receive funding from the Program. The project teams of congressionally mandated activities are responsible for developing project plans and managing the activities.

D. Program Element Projects

Included below are the brief descriptions of the funded projects managed under this National Applications Program Element. Complete and detailed descriptions are documented in the Project Plans for each activity.

Project: LEDAPS-Forest Disturbance — Directed Project

The goals of this project are to (i) adapt the MODIS MODAPS processing system for use with Landsat imagery; (ii) generate decadal surface reflectance products for Landsat MSS, TM, and ETM+; (iii) map disturbance rate and type (e.g. fire, logging, other) from the Landsat surface reflectance data, and (iv) work with Applied Science Partners to integrate the LEDAPS products and processing system into decision support systems for carbon management and forest inventories. The project will rely primarily on the NASA/EarthSat SDP GeoCover product, which affords cloud-free, orthorectified coverage for North America for decadal epochs centered on 1975, 1990, and 2000. The project will be completed within 4 years. The disturbance maps will be used within carbon accounting and biogeochemical models, while the surface reflectance data will be used within the US Forest Service Forest Inventory Analysis (FIA) program.

Budget ($K)

Procurement

FY06	280
FY07	240
FY08	
FY09	0
FY10	0

Project Manager	*Centers*	*Timeframe*	*Partners*
Ed Sheffner	GSFC	FY04 - FY07	USDA-FS

Earth Science Products: AVHRR, MODIS, Landsat, TOPS

Other Apps.

Deliverables

Description	*End Date*	*IBPD Metric #*
V&V Report	3/30/2006	
Benchmark report	6/30/2006	

Notes: Project is co-funded with the terrestrial biology element of the research program.

Project: Linking Landscape Scale Carbon Monitoring and Forest Management — Solicitation

Project will enhance the information available on carbon stocks and sequestration potential in forests of varying age and composition. This will be accomplished by 1) development of a consistent set of landscape level estimates of carbon stocks and associated uncertainties; 2) evaluation of two process models that simulate effects of natural disturbance and forest management activity on forests; and 3) benchmarking decision support tools for forest carbon management.

Budget ($K)

Procurement

FY06	370
FY07	379
FY08	
FY09	
FY10	

Project Manager	*Centers*	*Timeframe*	*Partners*
Matt Fladeland	ARC	FY05 - FY07	USDS/FS, CSUMB, CSU, NASA/ARC

Earth Science Products: MODIS, CASA, CQUEST

Other Apps.: Agrciultrual efficiency

Deliverables

Description	*End Date*	*IBPD Metric #*
Harmonize classifications and	2/1/2006	
Complete initial estimates of	12/1/2006	
Link models to multiscale data sets	12/1/2006	
Evaluation of existing Forest	9/1/2006	
V and V for products	2007	
Benchmark enhancements	2007-8	

Notes: Project funded by carbon cycle solicitation of 2004 (NRA-04-OES-01.)

Project: Decision Support for Loblolly Pine Carbon Management: From Research to Operations				Solicitation	
This project will apply products from NASA observations and models to enhance three decision support tool (LobDST, CQUEST and COLE) used by private land holders and the forest industry to reduce uncertainties regarding predicting carbon sequestration in forest land and monitoring such sequestration.				*Budget ($K)* *Procurement*	
				FY06	652
Project Manager	*Centers*	*Timeframe*	*Partners*	FY07	551
Matt Fladeland	Edwin Sheffner	FY06 - FY08	Vir. Tech U., NCASI, CSUMB, NASA/ARC	FY08	
				FY09	
				FY10	
Earth Science Products	ASTER, MODIS, AVHRR, SRTM, CQUEST, CASA			*Other Apps.*	
Deliverables	*Description*	*End Date*	*IBPD Metric #*	Agricultural efficiency	
	Evaluation of existing decision	9/1/2006			
	V and V for output from DSTs	9/1/2007			
	Benchmark DST	2008			
Notes: Project begins in FY06 with FY05 funding					

Project: Projections of Land Use Change and the Carbon Cycle — Solicitation

This project will use NASA data and model outputs to improve long term projections of emissions of CO2, CO and CH4 due to differences in land use. Collaboration with EPA will be focus of carbon management

Budget ($K)

Procurement

FY06	136
FY07	142
FY08	81
FY09	89
FY10	

Project Manager	*Centers*	*Timeframe*	*Partners*
Matt Fladeland	ARC, SSC, GSFC	FY05 - FY09	PNNL, EPA, Penn State U., U. of Illinois

Earth Science Products: MODIS, TOPS

Other Apps.: Air quality

Deliverables

Description	*End Date*	*IBPD Metric #*
Terrestrial carbon cycle model	2/1/2006	
Implementation of terrestrial	6/1/2006	
Improved wind and solar energy	10/1/2006	

Notes: Project is co-funded with research. Carbon management element will be more apparent in final three years. Funded under the carbon cycle solicitation of 2004 (NRA-04-OES-01.)

Project: Decision Support for Carbon management Across the US Corn Belt				Solicitation	
Enhance tools to assess the economic and environmental impacts of management decisions on crop yield and carbon sequestration by using NASA observations, etc., to 1) establish a baseline for soil carbon across a section of the US Corn Belt; 2) verify and validate NASA Earth observation products that can distinguish soil tillage intensity based on amount of crop residue cover; 3) apply the EPIC-Century model to assess soil carbon sequestration and crop yield for various agricultural practices; and 4) enhance a DSS for carbon management.				*Budget ($K)* *Procurement*	
				FY06	328
Project Manager	*Centers*	*Timeframe*	*Partners*	FY07	224
Matt Fladeland	ARC, SSC, GSFC	FY05 - FY07	USDA-ARS, NASS, NRCS; SSAI	FY08	
				FY09	
				FY10	
Earth Science Products	MODIS, ASTER, Hyperion			*Other Apps.*	
Deliverables	*Description*	*End Date*	*IBPD Metric #*	Agricultural efficiency	
	Expand data base for Illinois and	9/30/2006			
	Begin evaluation of ASTER and	6/30/2006			
	V and V for data products	9/30/2006			
	Begin integration of data products	9/30/2006			
Notes: Project funded under carbon cycle solicitation of 2004 (NRA-04-OES-01.)					

Project: Accounting for CO2 Fluxes in Agricultural Lands				Solicitation	
Project will enhance the quantification of CO2 fluxes freom agricultrual lands by using remote sensing products. Agricultural lands are major sources and sinks of carbon. The priject will first reduce the error term regarding the function of ag lands in a region as a source or sink, and , second, provide vital information for predicitng the portneial of, and monitoring carbon sequestration in agricultural land.				*Budget ($K)* *Procurement*	
				FY06	70
Project Manager	*Centers*	*Timeframe*	*Partners*	FY07	80
Matt Fladeland	ARC, SSC	FY05 - FY09	USDA/CSREES, NRCS	FY08	275
				FY09	250
				FY10	
Earth Science Products	MODIS, CASA, CQUEST			*Other Apps.*	
Deliverables	*Description*	*End Date*	*IBPD Metric #*	Agricultural efficiency	
	Begin testing regional simulations	6/30/2006			
	Verification and validation of	8/1/2006			
	Evaluation of USDA-NRCS	10/1/2006			
Notes: Project funded under the carbon cycle solicitation of 2004 (NRA-04-OES-01) and co-funded by USDA/CSREES. Project focuses on carbon management in final three years.					

Project: Spatially Explicit Full Carbon and Greenhouse Gas Accounting at the Regional to National Scale				Solicitation	
Enhance capabilities to estimate and monitor changes in carbon stocks and greenhouse gas emissions caused by changes in land use and land management.				*Budget ($K)* *Procurement*	
				FY06	198
Project Manager	*Centers*	*Timeframe*	*Partners*	FY07	199
Matt Fladeland	ARC, SSC	FY05 - FY07	DOE/ORNL, U. of Tennessee	FY08	
				FY09	
				FY10	
Earth Science Products	MODIS			*Other Apps.*	

	Description	*End Date*	*IBPD Metric #*
Deliverables	Automate methods for annual V and V of product - net carbon	3/1/2006	
	Integrate remote sensing products	5/1/2006	
	Begin simulations of land use	5/1/2006	
	POLYSYS model input	10/1/2006	
		10/1/2006	

Notes: Project is funded through the carbon cycle solicitation of 2004 (NRA-04-OES-01.)

Project: North American Forest Distrubance and Regrowth				Solicitation	
Analysis of foresrt disturbance using the combination of Landsat 30m data and USDA/FS FIA plot information. This analysis will explot the 30+ archive of Landsat data as made avilable through the LEDAPS project.				*Budget ($K)* *Procurement*	
				FY06	90
Project Manager	*Centers*	*Timeframe*	*Partners*	FY07	246
Matt Fladeland	ARC, GSFC, SSC	FY05 - FY09	Univ. of Maryland, GSFC, USDA/FS Oregon State U.	FY08	375
				FY09	375
				FY10	
Earth Science Products	Landsat archive, AVHRR, MODIS, LEDAPS			*Other Apps.*	
Deliverables	*Description*	*End Date*	*IBPD Metric #*	Invasive species	
	Evaluation of exisitng USDA/FS	9/1/2006			
	Coordination with data products	10/1/2006			
Notes: Project is funded under th carbon cycle solicitation of 2004 (NRA-04-OES-01.) First three years of the project are funded mostly by the research program. Full applications funding pending review of progress after thrid year.					

<table>
<tr><td colspan="4">Project: Global Land Cover</td><td colspan="2">Solicitation</td></tr>
<tr><td colspan="4" rowspan="2">Data and data products from MODIS, SRTM and other sources for use in carbon management and other projects</td><td colspan="2">Budget ($K)

Procurement</td></tr>
<tr><td>FY06</td><td>350</td></tr>
<tr><td>Project Manager</td><td>Centers</td><td>Timeframe</td><td>Partners</td><td>FY07</td><td></td></tr>
<tr><td rowspan="3">Ed Sheffner</td><td rowspan="3"></td><td rowspan="3">FY03 - FY0</td><td rowspan="3">University of Maryland</td><td>FY08</td><td></td></tr>
<tr><td>FY09</td><td></td></tr>
<tr><td>FY10</td><td></td></tr>
<tr><td>Earth Science Products</td><td colspan="3">MODIS, SRTM, Landsat GeoCver</td><td colspan="2">Other Apps.</td></tr>
<tr><td>Deliverables</td><td colspan="3"><u>Description</u> <u>End Date</u> <u>IBPD Metric #</u></td><td colspan="2">Agricultural efficiency, invasive species, ecological forecasting, coastal management, etc.</td></tr>
<tr><td colspan="6">Notes: REASon CAN</td></tr>
</table>

<table>
<tr><td colspan="4">Project: Program Element Team Meeting</td><td colspan="2">Project Management</td></tr>
<tr><td colspan="4" rowspan="2">Annual meeting to review and discuss program elements goals and objectives.
Participants will include all funded PIs in the the propgram element and others.</td><td colspan="2">Budget ($K)

Procurement</td></tr>
<tr><td>FY06</td><td>15</td></tr>
<tr><td>Project Manager</td><td>Centers</td><td>Timeframe</td><td>Partners</td><td>FY07</td><td>15</td></tr>
<tr><td rowspan="3">Ed
Sheffner</td><td rowspan="3">ARC, GSFC, SSC, GISS, JSC, JPL</td><td rowspan="3">FY06 - FY10</td><td rowspan="3">University of Arizona</td><td>FY08</td><td>15</td></tr>
<tr><td>FY09</td><td>15</td></tr>
<tr><td>FY10</td><td>15</td></tr>
<tr><td>Earth Science Products</td><td colspan="3"></td><td colspan="2">Other Apps.</td></tr>
<tr><td>Deliverables</td><td colspan="3"><u>Description</u> <u>End Date</u> <u>IBPD Metric #</u></td><td colspan="2">Agricultural efficiency, invasive species, ecological forecasting</td></tr>
<tr><td colspan="6">Notes: Joint meeting with agricultural efficiency, invasive species and, possibly, ecological forecasting. Meeting may be held in conjunction with another national meeting such as AGU, ASPRS, ESA, etc.</td></tr>
</table>

E. Additional Activities & Linkages

NASA and Science Mission Directorate Priorities

- Federal Enterprise Architecture (FEA) is a business and performance-based framework to support cross-agency collaboration, transformation, and government-wide improvement.
- The Global Information Grid (GIG) is the first stage of a U.S. military global, highbandwidth, Internet protocol-based communications network (a.k.a., ëthe Internet in space').
- The Joint Center for Satellite Data Assimilation (JCSDA) is a multi-agency collaboration to accelerate and improve the quantitative use of research and operational observational spacecraft observations in weather and climate prediction models. NOAA (NESDIS, NWS, OAR), NASA, Navy, Air Force, and NSF (through UCAR) collaborate in JCSDA.
- Metis is a visual modeling software tool for planning, developing, and analyzing agencies' enterprise architectures. The Applied Sciences Program is using Metis to identify possible linkages between observations, models, and decision support tools to support the IWGEO and NASA/NOAA R2O activities.
- Observing System Simulation Experiments (OSSEs) use simulated observations to assess the impacts of future observational spacecraft instruments on weather and climate prediction and provide opportunities to test new designs and methodologies for data gathering and assimilation.
- Project Columbia is a NASA-wide project to develop a new, fast supercomputer (using an integrated cluster of interconnected processor systems) to support the Agency's mission and science goals, including enhanced predictions of weather, climate, and natural hazards.

E. IBS Request

Evaluation reports should be prepared in FY06 for the following projects:

1) Decision Support for Lobloll Pine Carbon Management (Wynne/Potter)
2) Carbon Management in the US Corn Belt (Doraiswamy)
3) Carbon Fluxes in Agrciultural Lands (Ogle)
4) Spatially Explicit Framework for Carbon Accounting
5) Forest Distrubance and Regrowth (combined Masek, Birdsey, Goward)

V&V reports should be started for the following projects:

1) LEDAPS Forest Distrubance (Masek)
2) Carbon Management in the US Corn Belt (Doraiswamy)
3) Carbon Fluxes in Agrciultural Lands (Ogle)
4) Spatially Explicit Framework for Carbon Accounting

Benchmark reports: None expected by end of FY06

- A Rapid Prototyping Center to support NASA and partners in testing and verification of Earth science results in decision support tools
- Transition from Research to Operations Network (R2O) is a network that focuses on systematically transitioning the results of research to operational uses.

Program Response to IBS Request

To be supplied by program management.

E. Crosscutting Request

DEVELOP is a student-based program for rapidly prototyping solutions for state and local applications and helping students develop capabilities related to applied Earth-Sun science.

The Earth-Sun System Gateway is a "portal of portals" providing an access point through an Internet interface to all web-enabled NASA research results.

Program Response to Crosscutting Request

To be supplied by program management.

VI. Budget: FY06-010

The following table lists the Carbon Management Program budget (procurement) for FY2006:

Project	FY06 Procurement Allocation ($K)
LEDAPS-Forest Disturbance	$ 280
Linking Landscape Scale Carbon Monitoring and Forest Management	$ 370
Decision Support for Loblolly Pine Carbon Management: From Research to Operations	$ 652
Projections of Land Use Change and the Carbon Cycle	$ 136
Decision Support for Carbon management Across the US Corn Belt	$ 328
Accounting for CO2 Fluxes in Agricultural Lands	$ 70
Spatially Explicit Full Carbon and Greenhouse Gas Accounting at the Regional to National Scale	$ 198
North American Forest Distrubance and Regrowth	$ 90
Global Land Cover	$ 350
Program Element Team Meeting	$ 15
Total =	$ **2489**

Appendix C lists program-wide budget allocations for FY2006-10.

VIII. Program Management and Performance Measures

The Carbon Management Program Element team uses performance measures to track progress, identify issues, evaluate projects, make adjustments, and establish results of the Program Element. The program's Goals and Objectives (Section II) state planned achievements. These measures help monitor progress within and across specific activities to ensure the program meets its goals and objectives. The management team analyzes these measures retrospectively in order to made adjustments proscriptively to the program approach and objectives.

The measures are in two categories. Program management measures are internally focused to assess the activities within the program. Performance measures are externally focused to assess if the program activities are serving their intended purpose. In general, the Program Manager uses these measures to evaluate the performance of activities conducted and sponsored by the Program, especially the projects. In addition, the Science Mission Directorate uses this information in preparing IBPD directions and PART responses.

Program Management Measures (Internal):

Inputs:
1) Potential issues and DSTs identified for carbon management - number, type, range
2) Eligible partners to collaborate with - number, type, range
3) Potential results/products identified to serve carbon management - number, type, range

Outputs:
1) Assessments or evaluations of DSTs - number, range
2) Assessments of Earth-Sun science results/products to serve DSTs - number, range
3) Agreements with partners - presence
4) Reports (evaluation, validation, benchmark) - number, type

Quality and Efficiency:
1) Earth-Sun science results/products - number used per DST, ratio of utilized to potential
2) Agreements - ratio of agreements to committed partners
3) Reports - partner satisfaction, timeliness, time to develop
4) Reports - ratio of validations to potential products, ratio of benchmarks to validations

Performance and Results Measures (External):

Outcomes:
1) Earth-Sun science products adopted in DSTs - number, type, range; use in DST over time
2) Earth-Sun science products in use - ratio of products used by partners to reports produced
3) Partner and DST performance - change in partner DST performance, number and type of public recognition
of use and value of Applied Science observatioins in DST

Impacts:

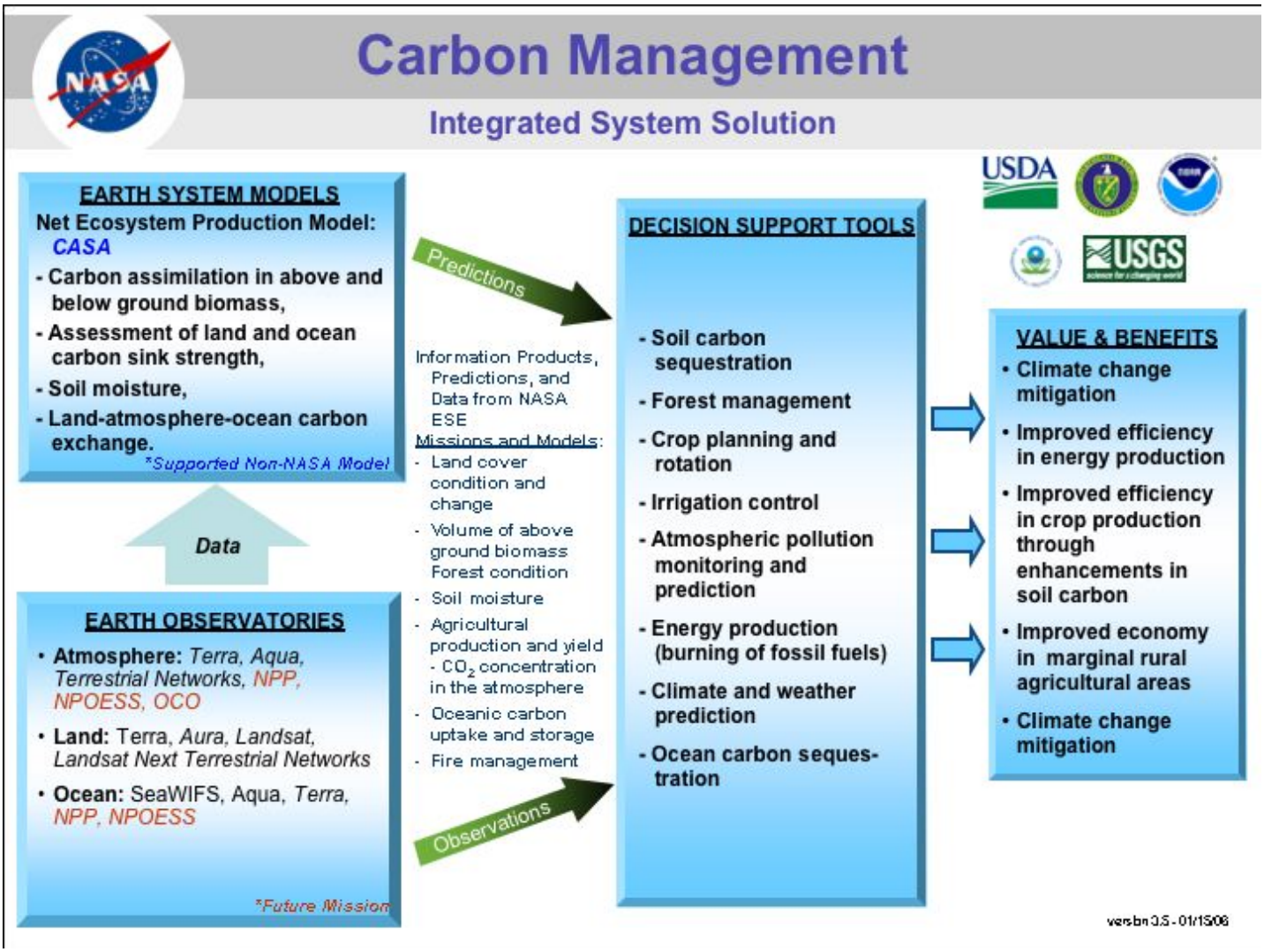
1) Partner value - change in partner metrics (improvements in value of partner decisions)

In addition to the stated measures, the Carbon Management Program Element Manager periodically requests an assessment of its plans, goals, priorities, and activities through external review. The Carbon

VIII. Appendicies

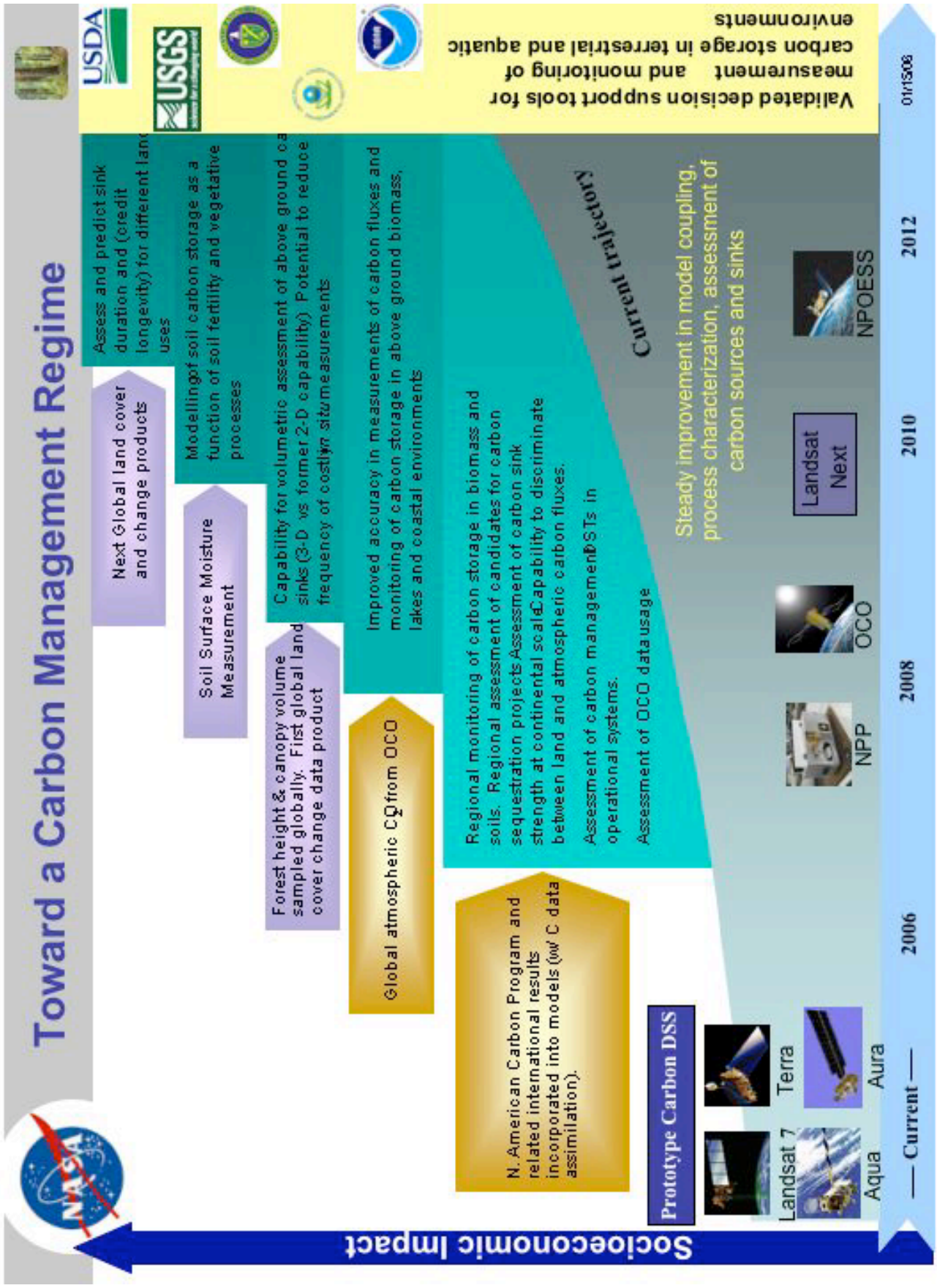
A. Integrated System Solutions Diagram

The figure below illustrates how Science measurements, model products, and data fusion techniques support the Carbon Management Program's partners and their decision support tools and shows the value and benefits of Science to society.



B. Roadmap

The Carbon Management Program draws upon, and contributes to, the Carbon Science Program of the Earth-Sun System Division. NASA/Earth-Sun System Division-sponsored science supporting climate, weather and natural hazards objectives will generate observations, models and technology that are the primary contributions of the Carbon Management Program to Carbon Management decision support tools and systems. The roadmaps for Carbon Science and Carbon Management are similar - as illustrated below. The major milestones of the science program, such as the introduction of OCO observations and the impact that will have on understanding the flux of carbon among land, ocean and atmosphere, are also milestones for the Carbon Management Program. These roadmaps illustrate the anticipated major objectives and timing for the program in the next ten to fifteen years. The roadmaps were updated in September 2004. Figure 4. Carbon Science Roadmap


Toward a Carbon Management Regime
Socioeconomic Impact
Validated decision support tools for measurement and monitoring of carbon storage in terrestrial and aquatic environments
USDA
USGS
Next Global land cover and change products
Soil Surface Moisture Measurement
Forest height & canopy volume sampled globally. First global land cover change data product
Global atmospheric CO2 from OCO
N. American Carbon Program and related international results incorporated into models (w/ C data assimilation).
Prototype Carbon DSS
Assess and predict sink duration and (credit longevity) for different land uses
Modelling of soil carbon storage as a function of soil fertility and vegetative processes
Capability for volumetric assessment of above ground carbon sinks (3-D vs former 2-D capability). Potential to reduce frequency of costly in situ measurements
Improved accuracy in measurements of carbon fluxes and monitoring of carbon storage in above ground biomass, lakes and coastal environments
Regional monitoring of carbon storage in biomass and soils. Regional assessment of candidates for carbon sequestration projects Assessment of carbon sink strength at continental scale Capability to discriminate between land and atmospheric carbon fluxes.
Assessment of carbon management DSTs in operational systems.
Assessment of OCO data usage
Current trajectory
Steady improvement in model coupling, process characterization, assessment of carbon sources and sinks
Landsat 7
Terra
Aqua
Aura
NPP
OCO
Landsat Next
NPOESS
— Current —
2006
2008
2010
2012
01/15/06

The overall program budget allocations are given below to provide the context in which this National Application is conducted. The allocations are based on Agency and program priorities and are subject to change according to the availability of funds and programmatic strategies. All values are in $ thousands.

Table 1: Applied Sciences Procurement Allocation – FY06

C. Applied Sciences Program Budgets FY2005-09

Program Element	FY06 Procurement Allocation*
National Applications	
Agricultural Efficiency	$ TBS
Air Quality Management	$ TBS
Aviation	$ TBS
Carbon Management	$ TBS
Coastal Management	$ TBS
Disaster Management	$ TBS
SENH	$ TBS
Ecological Forecasting	$ TBS
Energy Management	$ TBS
Homeland Security	$ TBS
Invasive Species	$ TBS
Public Health	$ TBS
Water Management	$ TBS
Program Director Discretionary Fund	$ TBS
Center Director Discretionary Fund Tax	$ TBS
National Applications Total	$ 0
Crosscutting Solutions	
Integrated Benchmarked Systems	$ TBS
Solutions Networks	$ TBS
Competitive Solicitations	$ TBS
Human Capital Development	$ TBS
Geoscience Standards & Interoperability	$ TBS
Crosscutting Solutions Total	$ 0
Applied Sciences Program Procurement Total	$ 0

Table 2: Applied Sciences Program NASA Institutional Allocations – FY06

FY06 Institution Cost	NASA Total	HQ	ARC	GSFC	JPL	LaRC	MSFC	SSC
National Applications	$ 0	$ TBS	$ TBS	$ TBS	$ TBS	$ TBS	$ TBS	$ TBS
Crosscutting Solutions	$ 0	$ TBS	$ TBS	$ TBS	$ TBS	$ TBS	$ TBS	$ TBS
Total	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0

D. Related NASA and Partner Solicitations and Grants

Appendix D lists NASA Earth-Sun system science research projects, Earth science fellowships, GLOBE activities, and Earth science New Investigators related to Carbon Management activities.

Institution	*PI*	*Title/Subject*	*Timeframe*
None		None Listed	

E. Acronyms and Websites

ACRONYMS:

AIRS	Airborne Infrared Sounder
AIWG	Applications Implementation Working Group
ALI	Advanced Land Imager
AMSR-E	Advanced Microwave Scanning Radiometer-EOS (Japanese)
ARC	Ames Research Center
ARS	Agricultural Research Service
ATBD	Algorithm Technical Basis Documents
AVHRR	Advanced Very High Resolution Radiometer
CANMET	Canadian Meteorological Service
CASA	Carnegie-Ames-Stanford Approach
CCIWG	Carbon Cycle Interagency Working Group
CCRI	Climate Change Research Initiative
CCSP	Climate Change Science Program
CCTI	Climate Change Technology Initiative
CCTP	Climate Change Technology Program
CERES	Clouds and the Earth's Radiant Energy System
CO	Carbon Monoxide
CO2	Carbon Dioxide
COLE	Carbon On-Line Estimator
COTR	Contracting Officer's Technical Representative
CQUEST	Carbon Query and Evaluation Support Tools
CSREES	Cooperative State Research, Education and Extension Service
CSU	Colorado State University
DAAC	Distributed Active Archive Center (Data Active Archive Center)
DOA	US Department of Agriculture
DOC	US Department of Commerce
DOE	US Department of Energy
ENSO	El Niño - Southern Oscillation
EOS	Earth Observing Systems
EPA	US Environmental Protection Agency
EPACT	Energy Policy Act of 1992
EROS	Earth Resources Observation System
ETM+	Enhanced Thematic Mapper Plus
EVI	Enhanced Vegetation Index
FEA	Federal Enterprise Architecture
FIA	Forest Inventory and Analysis
FPAR	Fraction of Absorbed Photosynthetically Active Radiation
FS	Forest Service
FTE	Full Time Equivalent
FV	Forest Visualization System
FWRC/GRI	Forest and Wildlife Research Center

GCM	Global Climate Model
GIG	Global Information Grid
GRI	Global Reporting Initiative/Geospatial Research Institute
GSFC	Goddard Space Flight Center
IBPD	Integrated Budget and Performance Document
IPA	Independent Pixel Approximation
IPCC	International Panel on Climate Change
ISCCP	International Satellite Cloud Climatology Project
IWGEO	Interagency Working Group on Earth Observations
JCSDA	Joint Center for Satellite Data Assimilation
JSC	Johnson Space Center
LaRC	Langley Research Center
LDAS	Land Data Assimilation System
LEDAPS	Landsat Ecosystem Disturbance Adaptive Processing System
LIDAR	Light Detecting and Ranging
MISR	Multi-angle Imaging Spectro-Radiometer
MODAPS	MODIS Data Processing System
MODIS	Moderate Resolution Imaging Spectroradiometer
MOPITT	Measurements Of Pollution In The Troposphere
MSFC	Marshall Space Flight Center
MSS	Multi-Spectral Scanner (Landsat 1)
MSU	Mississippi State University
NACP	North American Carbon Program
NASA HQ	NASA Headquarters
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NDVI	Normalized Difference Vegetation Index
NESDIS	National Environmental Satellite Data Information Service
NGO	Non Governmental Organization
NPP	NPOESS Preparatory Project/Net Primary Productivity
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
NWS	National Weather Service
OAR	Office of Oceanic and Atmospheric Research
OCO	Orbiting Carbon Observatory
OMB	Office of Management and Budget
OSSE	Observing System Simulation Experiment
OSTP	Office of Science and Technology Policy
PART	Program Assessment Rating Tool
R2O	Research to Operations Network
RAQMS	Regional Air Quality Modeling system
RSTC	Remote Sensing Applicability with Transportation
SAR	Synthesis and Analysis Report
SDP	Scientific Data Purchase
SEA	State Enterprise Architecture

SSC	Stennis Space Center
TM	Thematic Mapper
TOPS	Terrestrial Observation and Prediction System
UCAR	University Corporation for Atmospheric Research
UGA	University of Georgia
UM	University of Maryland
USDA	US Department of Agriculture
USFS	US Forest Service
USGCRP	US Global Change Research Program
USGS	United States Geological Survey
WUR	Wood Utilization Research

WEBSITES:

AIWG: http://aiwg.gsfc.nasa.gov
Applied Sciences Program: http://science.hq.nasa.gov/earth-sun/applications
DEVELOP: http://develop.larc.nasa.gov
Earth-Sun System Gateway (ESG): http://esg.gsfc.nasa.gov/
Earth-Sun Science System Components: http://www.asd.ssc.nasa.gov/m2m
NASA FY2005 Budget: http://www.ifmp.nasa.gov/codeb/budget2005
Research and Analysis Program: http://science.hq.nasa.gov/earth-sun/science/
Science Mission Directorate: http://science.hq.nasa.gov
Science Strategies: http://science.hq/nasa.gov/strategy/