A.45 CARBON MONITORING SYSTEM: CONTINUING PROTOTYPE PRODUCT DEVELOPMENT, RESEARCH, AND SCOPING

Notice: To achieve a balance between internal and external institutions and to facilitate transparency, each and every project selected under A.45 must have more than 50% of the funding awarded (or subawarded) to one or more external organizations. See Sections 3.2.1 and 4 for details. Proposals are due April 20, 2012

1. Scope of Program

This announcement offers opportunities for investigators to participate in continuing development towards a Carbon Monitoring System (CMS). Under its CMS initiative, as directed by Congress in 2010, NASA initiated pre-Phase A and pilot studies and a scoping effort for a carbon monitoring system (see section 2 below and http://carbon.nasa.gov/index.html). This initial phase of CMS development activities is being carried out in 2010-2012 through directed research conducted at the NASA Goddard Space Flight Center (GSFC), the Jet Propulsion Laboratory (JPL), and the NASA Ames Research Center (ARC), guided by a competed Science Definition Team (SDT). The work conducted in this prototyping effort to date leverages the much larger investment currently made by NASA in satellite observations of carbon-related properties of the Earth, as well as in carbon cycle science and carbon management research. It also takes into account the efforts of other Federal agencies, especially as coordinated through the Carbon Cycle Interagency Working Group of the U.S. Global Change Research Program.

Congress has directed that NASA increase Fiscal Year (FY) 2012 funding for its continuing development of a carbon monitoring system and expects that no less than one-half of the total funding shall be awarded externally. This solicitation requests proposals for additional CMS work to be conducted primarily by external organizations. This new work is intended to build upon the lessons learned in the pilot studies and scoping efforts and to further integrate NASA products and capabilities with those of other U.S. agencies and international entities. NASA seeks scientific and technical experts to shape and contribute to the next phase of development of a CMS – proposals offering both the development of specific next steps and the execution of the necessary tasks. Successful Principal Investigators (PI) will become members of the NASA CMS Science Team (ST).

2. Background

2.1 NASA Carbon Cycle Research

The goals of the NASA Earth Science Research Program for carbon cycle science are to improve understanding of the global carbon cycle and to quantify changes in atmospheric CO_2 and CH_4 concentrations, as well as terrestrial and aquatic carbon storage in response to fossil fuel combustion, land use and land cover change, and other human activities and natural events. NASA carbon cycle science research encompasses multiple temporal and spatial scales and addresses atmospheric, terrestrial, and aquatic carbon reservoirs, their coupling within the global carbon cycle, and interactions with climate and other aspects of the Earth system. A focus on

observations from space pervades carbon cycle research by NASA and is a basis for partnerships with other U.S. Government agencies and institutions. NASA's carbon applications research leverages NASA's investments in carbon cycle science to discover and demonstrate applications that inform resource management, policy development, and decision making.

2.2 Phase 1 of NASA Carbon Monitoring System Development

The Fiscal Year 2010 Congressional Appropriation directed NASA to initiate work towards a Carbon Monitoring System (CMS) and provided specific guidance. Funding was made available for "pre-Phase A and pilot initiatives for the development of a carbon monitoring system . . . any pilot developed shall replicate state, and national carbon and biomass inventory processes that provide statistical precision and accuracy with geospatially explicit associated attribute data for aggregation at the project, county, state and Federal level using a common dataset with complete market transparency, including extraction algorithms and correlation modeling." NASA's Phase 1 CMS activities were designed to address these objectives. To respond quickly and to leverage the significant expertise in satellite data analysis and computational infrastructure at NASA Centers, the initial pilot project work was directed to the NASA Goddard Space Flight Center (GSFC), the Jet Propulsion Laboratory (JPL), and the NASA Ames Research Center (ARC). NASA also competed a Science Definition Team (SDT) to provide expert guidance for the pilot activities and assist in pilot product evaluation (for a list of CMS SDT members, see: http://carbon.nasa.gov/cgi-bin/cms/group_members.pl?pgid=524). Further, NASA was able to select a few relevant proposals submitted under NASA's annual disciplinary ROSES solicitations for CMS-relevant research.

NASA's initial Carbon Monitoring System activities involve studies to develop two pilot products and conduct scoping efforts:

- A Biomass and Carbon Storage Pilot Product (hereafter referred to as the Biomass Product)
- An Integrated Emission/Uptake ("Flux") Pilot Product (hereafter referred to as the Flux Product)
- A Scoping Study and research to scope potential new carbon monitoring products

Brief summaries of the CMS Phase 1 activities and progress to date are provided below. More complete information, progress reports, and links to available data and data products are provided at http://carbon.nasa.gov.

2.2.1 *Biomass Pilot Study Activities and Progress*

The NASA CMS Biomass project is designed to address the urgent need for geospatially explicit, consistent carbon and biomass inventory information to inform policy making. Phase 1 activities bring together two complementary approaches. The first is a continental-scale approach using satellite remote sensing data products to produce U.S. biomass maps at moderate resolutions (100 m, 250 m). The second is a local-scale approach that utilizes fine-scale airborne data to map biomass to hectare or stand-scale resolution based on plot-scale (~30 m) mapping. The local-scale work will develop protocols for fusing remotely sensed observations with field data, provide accurate validation test areas for the continental-scale biomass product, and demonstrate efficacy for prognostic ecosystem modeling. This research is being conducted in

close collaboration with the USDA Forest Service, including researchers affiliated with its Forest Inventory and Analysis (FIA) Program.

2.2.1.1 *National Biomass Product*

The national biomass project includes work to:

- Provide a benchmark analysis of continental U.S. aboveground biomass/carbon stocks at spatially-refined and temporally-constrained resolutions using state-of-the-art remote sensing observations, including data from the Moderate Resolution Imaging Spectrometer (MODIS), Landsat, the Ice, Cloud and land Elevation Satellite's (ICESat) Geoscience Laser Altimeter System (GLAS), the Advanced Land Observing Satellite's (ALOS) Phased Array type L-band Synthetic Aperture Radar (PALSAR), and the Shuttle Radar Topography Mission (SRTM).
- Assess the accuracy and the utility of the U.S. product using the FIA program's forest inventory plots and address uncertainty in magnitude and spatial scales.
- Evaluate the national biomass/carbon mapping with the local-scale mapping.

Processing of the following data sets has been completed:

- MODIS seasonal vegetation index, leaf area index (LAI), and bands at 250 m resolution over the U.S. for the period of 2004-2006.
- LAI estimates at 30 m spatial resolution from Landsat for the growing season period of the mid decade 2004-2006.
- ALOS PALSAR data, including orthorectification, radiometric calibration, and terrain-correction, for the continental U.S.
- GLAS lidar data over forests processed into the Lorey's height metric and filtered for slope effects and adequate signal-to-noise.

Biomass estimation was performed at two different spatial resolutions (100 m, and 250 m) as recommended by the CMS SDT. The following tasks have been completed:

- Assessment of the methodology to estimate aboveground biomass.
- Development of a 100 m resolution biomass map for California and quantification of the errors and uncertainties at the pixel and county scales.
- Development of a national biomass map at 250 m resolution and the assessment of pixel-level uncertainty.
- Several sensitivity analyses.

Tasks to be completed in 2012 include a comprehensive uncertainty analysis of the methodology and products and sensitivity and pixel-scale uncertainty analyses to propagate errors through the estimation process.

Initial scoping of a potential biomass change product also will be conducted in 2012.

2.2.1.2 *Local-Scale Biomass Product*

Two counties in Maryland were selected to initiate the local-scale biomass product development. Field data include both existing measurements that were part of the FIA, as well as 300 new plots. The following remote sensing data sets have been assembled:

- Small footprint airborne lidar. These data were obtained in 2005, wall-to-wall at a point density of about 1 point per square meter.
- Landsat time-since-disturbance. A 30-year time series of Landsat data was used.
- Radar data. ALOS PALSAR data were processed for 5 dates in 2010. These data were geocoded, calibrated and mosaicked at 30 m resolution.

Data were analyzed using several differing approaches. Two statistical methods, ordinary least squares regression (OLS), and Bayesian model averaging (BMA) were tested. Random forest (RF) and quantile random forest machine learning algorithms (QRF) were also used. The Ecosystem Demography (ED) model was evaluated.

Results of initial analyses are considered to be encouraging, and lead to the following conclusions: it appears that existing, county-level lidar data sets can be useful for local-scale biomass mapping in the U.S., even if they are several years old and of low point density; all of the statistical methods evaluated performed reasonably well, suggesting the choice of statistical estimation method may not be critical; and high-resolution mapping is required to accurately estimate nonforest biomass.

Additional local-scale validation sites will be acquired and analyzed in 2012.

2.2.2 *Flux Pilot Study Activities and Progress*

The NASA CMS Flux project is incorporating a large suite of NASA observational, modeling, and assimilation capabilities to generate global maps of land-atmosphere and ocean-atmosphere carbon exchange and to attribute atmospheric CO_2 concentrations to spatially resolved sources and sinks. The inclusion of atmospheric CO_2 data from the Greenhouse gases Observing Satellite (GOSAT) is intended to provide a methodology that will transfer, with minimal change, to the inclusion of NASA Orbiting Carbon Observatory-2 (OCO-2) data.

Computations have been performed for the period July 2009 through June 2010, which align with the first full year of GOSAT observations. Terrestrial carbon fluxes were computed using two versions of the Carnegie-Ames-Stanford-Approach (CASA) data-constrained model, NASA-CASA and CASA-GFED. Similarly, two data-constrained estimates of ocean-atmosphere carbon fluxes were computed using the NASA Ocean Biogeochemical Model (NOBM) model and the “Estimating the Circulation and Climate of the Ocean, Phase II (ECCO-2)” configuration of the Massachusetts Institute of Technology General Circulation Model (MITgcm)/Darwin model.

The computed surface flux estimates were compared with estimates from observations (e.g., flux towers) and with other estimates, in order to evaluate their realism. Along with inventories of other carbon emissions (e.g., fossil fuels), the bottom-up flux estimates were run in the Goddard

Earth Observing System version 5 (GEOS-5) Atmospheric General Circulation Model (AGCM) to simulate three-dimensional distributions of atmospheric CO_2. Comparison with observations (ground-based and space-based) allowed evaluation of different combinations of the surface flux computations. Attribution of GOSAT CO_2 concentration measurements to sources and sinks was performed using the GEOS-Chem four-dimensional variational assimilation system.

The major initial objectives of the project have been achieved. Computation of bottom-up surface flux estimates, running these through an atmospheric transport model, and using an adjoint-based inverse model to infer carbon fluxes was completed for July 2009 - June 2010. This work identified important challenges associated with using the NASA data and models that will need to be resolved. The discovery of intriguing differences between models and data or patterns of geographic variability produced by the models have prompted further analyses, and ongoing work in 2012 is focused on resolving these differences and better understanding the strengths and limitations of computing CO_2 flux distributions using spaceborne measurements.

Additional uncertainty analyses will be conducted in 2012, and the product time period will be extended to 2005-2011 for the bottom-up estimates, using EOS and other observations, and June 2009 - March 2011 for the atmospheric inversions using GOSAT observations.

2.2.3 *Scoping Efforts and Progress*

2.2.3.1 *Scoping Study*

The goal of the Scoping Study is to identify research, products, and analysis system evolutions required to support carbon policy and management as global observing capability increases. The process involves significant community interaction. It began with a planning session in San Diego, CA, in March 2010. A workshop was held in Boulder, CO on July 13-14, 2010, with participants from a broad range of Government agencies (NASA, NOAA, USDA, USGS, EPA, DOE), industry, and academia (the workshop report is available at: http://carbon.nasa.gov/pdfs/2010 CMS_Scoping Study Workshop Report.pdf). A Community Forum was held on October 5, 2011, in Alexandria, VA.

NASA systems engineering expertise is being applied to considerations of system design that extend beyond the two existing pilot projects. The objectives of the design study are to engage users to define well-posed questions; extract product performance goals; conduct preliminary error analysis to predict future performance; conduct preliminary assessment of key performance sensitivities and gaps; produce a notional 10-year roadmap for future CMS product deployment; and identify potential future needs for observations, data systems, models, and analysis; risks; opportunities; and architectural options for sustained CMS product delivery. User engagement is being coordinated with CMS SDT members working on carbon applications.

A generalized analysis framework is also being developed, in consultation with the Biomass pilot team, to evaluate uncertainties and sensitivities of biomass. Additionally, a framework for representing key sources of uncertainty in carbon flux estimates is being developed and, in consultation with the Flux pilot team, various analyses and Observing System Simulation Experiments (OSSEs) are being executed to help construct a flux error budget and explore sensitivities. The sensitivity of flux estimates to transport model errors will be assessed.

Work in 2012 will be focused on completing these tasks and addressing architectural considerations for sustained CMS data product delivery.

2.2.3.2 *Scoping Research for Potential New Carbon Products*

NASA funded several research studies to perform initial scoping for potential future ocean carbon monitoring products.

Three CMS studies explore the feasibility of two new pilot products. The first involves development and production of global maps of monthly global air-sea CO_2 fluxes. This work combines NASA satellite remote sensing observations, *in situ* ocean CO_2 measurements, and complementary data collection efforts of related properties, including oxygen (O_2), dissolved inorganic carbon (DIC), and biological properties with global ocean biogeochemistry models and data assimilation. Remote sensing data products used include ocean color and sea surface temperature (for data assimilation), wind products, and ocean salinity measurements from Aquarius (for model forcing and carbon data assimilation). A common ocean biogeochemistry model is currently running for 20 years forced by reanalysis data. The usefulness of assimilating ocean color chlorophyll data was evaluated using MODIS-Aqua data. Preliminary results are mixed: basin-scale distributions of air-sea fluxes and pCO_2 were improved with chlorophyll assimilation, as measured by correlation with *in situ* data, but a few model runs actually produced degraded results. Prognostic alkalinity and particulate inorganic carbon (PIC) have been identified as important missing components in some models, and efforts are currently being pursued to introduce them into the models.

Two other studies in representative coastal regions examine land-ocean exchanges and fluxes and consequences for coastal carbon budgets. Two separately-funded NASA Interdisciplinary Science (IDS) projects are conducting complementary research on the linkages between the Mississippi River watershed and the northern Gulf of Mexico and between the watersheds along the U.S. East coast and the adjacent continental margin, including the Chesapeake Bay. All four of these studies will provide a foundation for developing a more comprehensive modeling effort to assess the contribution of coastal ecosystems to regional carbon budgets and specifically examine critical areas of need for carbon monitoring. Moreover, these projects provide an analysis of carbon dynamics integrated across terrestrial and ocean margins, a system of high uncertainty in current global carbon budgets.

Two additional scoping projects are establishing a foundation for entirely new types of ocean carbon products. The first project seeks to develop a technique for routinely assessing phytoplankton carbon biomass (C_{phyto}) in the field. If successful, it will create a foundation for (1) evaluating and evolving satellite C_{phyto} products, (2) characterizing light- and nutrient-stress effects in the field independently of radiotracer measurements, and (3) distinguishing physiological and biomass responses to climate forcings in satellite time-series of ocean color.

In the second study, a series of biological and biooptical observations made in the field during the NASA-sponsored Impacts of Climate change on the Eco-Systems and Chemistry of the Arctic Pacific Environment (ICESCAPE) field campaign are being used to address the role of

calcifying phytoplankton in the carbon dynamics of the Arctic Ocean. Among the measurements made, apparent optical properties will provide critical matchups for satellite measurements, as well as radiometry, for use in real-time estimates of chlorophyll and PIC. These data products will be useful for identifying long-term changes in coccolithophore abundance and carbon dynamics in the Arctic Ocean from satellite ocean color data.

3. Phase 2 of NASA Carbon Monitoring System Development

The approach NASA has adopted in prototyping, researching, and scoping a carbon monitoring system emphasizes exploitation of the satellite remote sensing resources, computational capabilities, scientific knowledge, airborne science capabilities, and end-to-end system expertise that are major strengths of the NASA Earth Science program. Significant effort is being devoted to rigorous evaluation of the carbon monitoring products being produced, as well as to the characterization and quantification of errors and uncertainties in those products. The emphasis has been on regional, national, and global satellite-based carbon monitoring products relevant to national needs for completely transparent carbon and biomass inventory processes that provide statistical precision and accuracy with geospatially explicit associated attribute data. NASA's approach takes into account data and expertise that are the domain of other U.S. Government agencies and anticipates continuing close communications and/or partnerships with those agencies and their scientific and technical experts as U.S. national efforts toward integrated carbon monitoring mature. It also recognizes a need for complementary local-scale (airborne and *in situ*) information to demonstrate quantitative remote sensing methods; to aid in scaling up from project, county, and/or state levels; and for essential evaluation of regional-, national-, and global-scale products. Additionally, the current approach lays the groundwork for CMS-related applications of future NASA satellite sensors now in development (i.e., Orbiting Carbon Observatory-2 (OCO-2) and Ice, Cloud, and Land Elevation Satellite-2 (ICESat-2)) or in preformulation (i.e., Deformation, Ecosystem Structure, and Dynamics of Ice - Radar (DESDynI-Radar); Active Sensing of CO_2 Emissions Over Nights, Days, and Seasons (ASCENDS), Pre-Aerosol; Clouds; and ocean Ecosystem (PACE), and Hyperspectral Infrared Imager (HyspIRI)).

CMS activities proposed for the next phase of development should be consistent with this overall approach. NASA will consider 1) approaches that derive from or evolve the current pilot products and scoping efforts, 2) alternative approaches to the development of current carbon monitoring products, and 3) new carbon monitoring products, including those in need of further scoping research. In order for NASA CMS results to have value for decision making, rigorous product evaluation and characterization and quantification of errors and uncertainties must be an integral part of the program and, likely, an element of most studies. NASA's objective is not necessarily to support a balanced program, including all of these types of activities, but rather to provide an opportunity for differing approaches, products, and/or priority objectives to be proposed. NASA intends to select only the very best, most promising, and highest priority activities for investments in carbon monitoring. NASA expects to select only proposals that offer to meet national needs and are consistent with NASA's assigned responsibilities.

A NASA Carbon Monitoring System Science Team (CMS ST) will be established to include the Principal Investigators selected under this solicitation, members of the CMS SDT through the

duration of their current CMS SDT awards, and representatives of the initial NASA Center-led pilot product production teams through the duration of their current awards. The CMS ST will be responsible for providing broad research community involvement in the development and evaluation of NASA CMS products; coordinating their NASA-funded CMS activities to ensure maximum returns for science, management, and policy; and providing scientific, technical, and policy-relevant inputs to help set priorities and directions for future NASA CMS activities. In addition to conducting their own CMS work, ST members will provide insights as to how to choose among multiple approaches and/or alternative products. ST members will provide important perspectives on product development and implementation and how to quantitatively evaluate products. The ST will assist in making connections to ongoing and newly developing activities with similar and/or complementary objectives being undertaken by other entities, especially other U.S. Federal agencies. The ST will expand on current CMS connections to the policy and applications communities and will help foster dialogue that will communicate current and future CMS products and inform the development of any new pilot products. The ST will be led by a carbon science, management, and/or policy expert who will serve as the CMS ST Leader.

3.1 Investigations Solicited

NASA requests proposals for investigations to advance the development of a carbon monitoring system, for NASA CMS ST membership, and for a NASA CMS ST Leader.

3.1.1 *Carbon Monitoring Research Activities*

NASA is interested in receiving proposals for the following types of prototyping, research, and scoping activities for carbon monitoring:

- Extend, enhance, or evolve the current pilot products (i.e., biomass and flux products) using either the current methodological approach(es) or an alternative approach(es) to producing the product(s);
- Develop new regional and global carbon monitoring products utilizing satellite remote sensing data and/or other types of NASA products (e.g., model products, airborne remote sensing data);
- Scope new carbon monitoring products that utilize remote sensing data (e.g., existing airborne or satellite data, airborne or satellite data to be acquired though the proposed investigation, or data anticipated from NASA satellites now in development or preformulation), and provide an initial demonstration of feasibility and/or utility for decision making with respect to carbon management or policy;
- Characterize and quantify errors and uncertainties in existing and proposed carbon monitoring products, including errors and uncertainties in the algorithms, models, and associated methodologies utilized in creating them;
- Conduct rigorous evaluation of the utility of existing and proposed carbon monitoring products for carbon science, management, and policy;
- Evaluate current and planned NASA CMS products with regard to their baseline cost, quality, complexity, and contribution to decision making in comparison with other existing and planned carbon monitoring products; and/or

- Develop or adapt NASA CMS products and methods to support sustainable assessment analyses for future assessments, including National Climate Assessments (NCA) beyond 2013 (for more information about the NCA, see http://www.globalchange.gov/images/NCA/fact-sheets/nca-fact-sheet--11-8-2011.pdf).

Proposals must offer investigations focused on developing, producing, or advancing a carbon monitoring product or suite of products; providing rigorous evaluation of a NASA carbon monitoring product or products; or conducting research that significantly advances NASA's readiness to produce a new carbon monitoring product (*e.g.*, biomass in near-surface ocean waters).

Remote sensing data must be an essential element in all proposed carbon monitoring investigations. It is expected that all investigations will either involve or have a direct relationship to NASA satellite data or NASA data products. Multiplatform, multisensor investigations are encouraged, including those employing both satellite and airborne observations. All sources of remotely sensed data to be used must be well justified in terms of their importance and appropriateness for the work to be conducted, as well as their overall utility and priority within NASA's overall approach to monitoring carbon for science, management, and a policy.

Proposals must explain the societal relevance of the carbon monitoring activities proposed and provide justification regarding the importance of this work to U.S. national interests in current or potential carbon monitoring for science, management, and policy.

NASA reserves the right to not select any proposals under any one of the types of activities detailed above.

3.1.2 *Carbon Monitoring System Science Team Membership*

All proposals must request CMS ST membership for one or more key investigators and include one to two paragraphs describing the contributions they anticipate making to the activities of the CMS ST. This section should address one or more of the following:

- Representing concerns of the broad carbon monitoring community with respect to the nature, quality, and utility of NASA CMS products;
- Coordinating their CMS activities to ensure maximum returns and enhance or create complementarity, integration, and synergy;
- Providing important perspectives on product development, implementation, and evaluation;
- Providing insights as to how to choose among alternative approaches and products;
- Making connections to ongoing and newly developing activities with similar and/or complementary objectives being undertaken by other entities, especially other U.S. agencies; and/or
- Providing scientific, technical, and policy-relevant inputs to help set priorities and directions for future NASA CMS activities.

The CMS ST will conduct its business through periodic meetings with more frequent interactions through teleconference calls and email.

3.1.3 *Carbon Monitoring System Science Team Leader*

Proposals are requested for a CMS ST Leader. The CMS ST Leader will be responsible for providing scientific leadership and direction to the CMS ST and scientific inputs regarding CMS activities to NASA management. He/she will be responsible for calling and organizing ST meetings and related activities in coordination with NASA CMS managers and Carbon Cycle and Ecosystems Office staff. He/she will be responsible for organizing and delivering to NASA a final report summarizing the findings of the CMS ST regarding CMS Phase 2 activities and recommended next steps.

Team Leader proposals should include a separate section of up to three additional pages in the *Scientific/Technical/Management* section that describes only the activities to be undertaken as CMS ST Leader and addresses the following aspects of team leadership:

- The carbon science, carbon management, and/or carbon policy qualifications and leadership skills of the proposing Team Leader;
- A clear articulation of the proposed Team Leader's vision for the NASA CMS and its contribution to science and society;
- The ability of the proposing Team Leader to represent CMS's overall goals and objectives to the broader community and to decision makers in need of carbon monitoring information; and
- A management plan that describes the approach to science team leadership, how interactions with the ST and NASA management will be conducted, and how science team business and meetings will be organized and conducted.

In addition, the *Budget Justification: Narrative and Details* section of the proposal must include a detailed budget for only the Team Leader activities and a narrative and justification for the Team Leader work that are separate from those for their CMS ST member activities.

Proposers who wish to be considered for CMS ST Leader also should indicate their candidacy by answering the relevant cover sheet question.

NASA reserves the option to select a Team Leader from among the ST members should proposals of adequate merit and suitability not be received for the Team Leader role.

3.2 Additional Proposal Requirements

3.2.1 *Requirements for the Cost Plan*

Each proposal submitted must have more than 50% of the requested funding awarded or subawarded to one or more external organizations (see section 4.2 below for details on what organizations will be considered "internal" and "external").

All proposals must include in their cost plans resources for activities to be undertaken as a CMS ST member, including funds for travel to ST meetings. The proposed budget should include funds to participate in two ST meetings lasting three days each. For planning purposes, proposers should budget for one meeting in the western U.S. and one meeting in the Washington, DC, area.

3.2.2 *Requirements Regarding the Duration of Award*

The scientific tasks of the ST members will be of no more than 18 months duration and proposers may not propose for a longer period of performance.

3.2.3 *Requirements for a Data Management Plan*

Proposals must include a data management plan of no more than two pages that addresses the dissemination and sharing of research results and compliance with NASA Earth Science data policy (http://science.nasa.gov/earth-science/earth-science-data/data-information-policy/). The data management plan should include the types of data and data products, algorithms, models and model outputs, or other materials to be produced in the course of the project; the standards to be used for data and metadata formats; and plans for providing access to and/or archiving the data and other research products. The data sharing plan called for in section 2.3.5 of the *Guidebook for Proposers* may be included in the data management plan. For new data products proposed, the data management plan must include provisions for quality assessment, timely public release consistent with NASA policies, and long-term archive of the data product(s).

The data management plan must be included within the 15-page limit (or 18-page limit for ST Leader proposals) for the *Scientific/Technical/Management* section of the proposal.

3.2.4 *Requirements for Proposals Requesting Acquisition of New Airborne Data*

New proposals requiring data from airborne sensors must detail in their cost plan all costs for acquiring the new data sets, including costs for aircraft hours, deployment costs, mission peculiar costs, data processing costs, and other costs associated with deploying the sensors and aircraft (this provision applies to all sensors and platforms, including NASA sensors and platforms, as well as non-NASA sensors and platforms). In addition, for any proposed activities requiring NASA aircraft or NASA facility sensors, proposers should submit a Flight Request to the Airborne Science Flight Request system at http://airbornescience.nasa.gov (and then click on "FLIGHT REQUEST"). Questions regarding the flight request system or process should be addressed to Marilyn Vasques, Flight Request Manager (Marilyn.Vasques@nasa.gov or 650-604-6120). If the instrument or aircraft platform are not NASA facilities, proposers must take responsibility for making all arrangements to secure the availability of the needed sensors and aircraft and explain these plans in the proposal.

4. Programmatic Information

4.1 Constraints on the Allocation of Available Funding

NASA received the following direction from Congress regarding its Fiscal Year 2012 (FY 2012) funding for CMS activities: "Carbon Monitoring - The Committee recommends $10,000,000 from within available funds to continue the development of a carbon monitoring system initially funded in Fiscal Year 2010. The Committee expects no less than one-half of this amount shall be awarded externally." Thus, at least $5,000,000 of the funds competed under this solicitation will be awarded to external organizations. Also, the total FY 2012 funding that will be made available under this solicitation for awards to internal organizations is not likely to exceed $3,000,000 because NASA has existing commitments for continuing CMS activities in FY 2012 that will require up to ~$2,000,000.

The way that this Congressional recommendation will be implemented is that each proposal must have more than 50% of the funding awarded or subawarded to one or more external organizations. NASA Civil Servants are prohibited from including their salary costs in the documents that are peer reviewed (See http://tinyurl.com/29ax6n7). However, NASA Civil Servant Co-Investigators on proposals submitted by external organizations must share their total costs with the submitting external organizations so that they can achieve the required balance between internal and external costs.

NASA reserves the option of funding co-investigator institutions either as subawards of the Principal Investigator institution's award or as separate awards directly to the co-investigator institutions. In some instances, use of separate awards will enable greater transparency in NASA's accounting and reporting of internal and external funding.

4.2 Definitions of "Internal" and "External"

Solely for the purposes of this solicitation and in order to ensure that NASA is fully responsive to the guidance from Congress, the following definitions of "internal" will be applied to proposing organizations:

- Any work to be performed by U.S. Government organizations (including NASA Centers and laboratories of other Federal agencies) and Federally Funded Research and Development Centers (FFRDCs) will be considered internal.
- Any work to be performed by an organization on-site at a U.S. Government organization facility or FFRDC will be considered internal.
- Any work to be performed by an organization under an existing agreement (*i.e.*, grant, cooperative agreement, contract, interagency agreement) with a U.S. Government organization or FFRDC will be considered internal.

For the purposes of this solicitation and in order to ensure that NASA is fully responsive to the guidance from Congress, the following definitions of "external" will be applied to proposing organizations for work not to be conducted on-site at a U.S. Government organization facility or FFRDC:

- Any work to be performed by an education, private sector, or nonprofit organization and to be funded through one or more new awards (i.e., grant, cooperative agreement, contract) will be considered external.
- Any work to be performed by a local, state, regional, or Federally-recognized tribal government organization will be considered external.

Please note that it is possible for work performed by certain organizations to be considered "internal" under some circumstances (*e.g.*, work conducted under an existing support contract with a U.S. Government laboratory) and "external" under other circumstances (*e.g.*, work the organization will lead under a new funding award).

In the spirit of full transparency, NASA will post and maintain up-to-date information regarding the totals for FY 2012 CMS funding awarded internally and externally. This information will be made available on the NSPIRES Web site (http://nspires.nasaprs.com/external/) with the CMS selection announcement and on the NASA CMS Web site (http://carbon.nasa.gov/index.html).

4.3 Eligibility

This solicitation is open to all types of institutions and organizational sectors. While the emphasis is on involving external organizations and researchers in evolving NASA's investments in carbon monitoring, NASA encourages partnerships of among all types of organizations.

NASA Centers, other U.S. Government agencies, and FFRDCs are encouraged to submit proposals consistent with the funding constraints detailed in sections 3.2.1 and 4.1. Researchers currently funded under Phase 1 of CMS may propose under this solicitation, but should take care to tailor their activities and budget requests to take into account their commitments to Phase 1 CMS activities in FY 2012.

No-cost or low cost proposals from other U.S. Government agencies and FFRDCs will be especially welcome. NASA is very interested in proposals that provide liaison with related Federal programs and/or offer to begin the process of integrating the carbon monitoring programs and mandated activities of the other agencies with NASA's CMS activities.

4.4 Evaluation Criteria

Proposals will be evaluated according to the criteria specified in section C.2 of the *NASA Guidebook for Proposers*, with additional factors noted in this section.

In addition to the factors given in the *Guidebook for Proposers*, the determination of a proposal's intrinsic merit shall take into account the following additional considerations:

- The experience of the investigators and their institutions in engaging in data sharing and providing timely access to data and research products on related and relevant projects,
- The quality and completeness of the data management plan, and

- The quality and appropriateness of the proposed approach to product evaluation and/or characterizing uncertainties and quantifying errors.

In addition to the factors given in the *Guidebook for Proposers*, the determination of a proposal's relevance shall take into account the following additional considerations:

- The relative priority of the activities proposed for carbon monitoring-related decision making, and
- The degree to which the proposed activities match established roles and responsibilities for NASA.

In addition to the factors given in the *Guidebook for Proposers*, the determination of a proposal's cost shall take into account the following additional considerations:

- Strict compliance with the requirement to have more than 50% of the requested funding awarded or subawarded to one or more external organizations (as explained in section 3.2.1. and consistent with the definitions of "internal" and "external" provided in section 4.2).

For Team Leader Proposals, in addition to the factors given in the *Guidebook for Proposers*, the determination of a proposal's intrinsic merit shall take into account the following additional considerations:

- The carbon science, management, and/or policy qualifications of the proposed CMS ST Leader,
- The leadership abilities of the proposed CMS ST Leader, to include his/her ability to fairly represent the broader community, communicate with carbon monitoring stakeholders and decision makers, and effectively engage a large and diverse group of researchers, and
- The quality and appropriateness of the proposing Team Leader's approach to science team leadership and his/her plan for interacting with NASA management.

5. Summary of Key Information

Expected program budget for awards	~ $8M
Number of new awards pending adequate proposals of merit	~15-40
Maximum duration of awards	18 months
Due date for Notice of Intent	Not requested
Due date for Proposals	**April 20, 2012**
Planning date for start of investigation	July 1, 2012
Page limit for the central Science-Technical-Management section of proposal	15 pp for CMS ST Member proposals (18 pp for CMS ST Leader proposals); see also Chapter 2 of the *NASA Guidebook for Proposers*

Relevance to NASA	This program is relevant to the Earth science strategic goals and subgoals in NASA's *Strategic Plan*; see Table 1 and the references therein. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers* at http://www.hq.nasa.gov/office/procurement/nraguidebook/.
Submission medium	Electronic proposal submission is required; no hard copy is required or permitted. See Section IV of the *ROSES Summary of Solicitation* and Chapter 3 of the *NASA Guidebook for Proposers*.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov/ (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH11ZDA001N-CMS
NASA points of contact concerning this program	Diane E. Wickland Earth Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Tel: 202-358-0245 Email: Diane.E.Wickland@nasa.gov Kenneth W. Jucks Earth Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Tel: 202-358-0476 Email: Kenneth.W.Jucks@nasa.gov