A.5 Carbon Cycle Science

1. Scope of Program

This announcement offers opportunities for Carbon Cycle Science investigations within the NASA Earth Science Program, the U.S. Department of Agriculture (USDA), National Institute of Food and Agriculture (NIFA), Agriculture and Food Research Initiative Competitive Grants Program (AFRI), the U.S. Department of Energy (DOE) Terrestrial Ecosystem Science Program, and the National Oceanic and Atmospheric Administration (NOAA) Ocean Acidification Program. NASA, USDA, DOE, and NOAA seek proposals to improve understanding of changes in the distribution and cycling of carbon among the active land, ocean, coastal, and atmospheric reservoirs and how that understanding can be used to establish a scientific foundation for societal responses to global environmental change.

2. Background

Priorities for new carbon cycle science research continue to derive from the research agenda of the U.S. Global Change Research Program (USGCRP) (http://www.globalchange.gov/), and, specifically, its U.S. Carbon Cycle Science Program (http://www.carboncyclescience.us/), as well as the goals and objectives of the individual agencies supporting the research.

In 2011, the U.S. carbon cycle science community completed a new plan for carbon cycle research. This reassessment of U.S. carbon cycle science priorities was conducted by the USGCRP Carbon Cycle Interagency Working Group's (CCIWG) Carbon Cycle Science Steering Group (CCSSG). The planning process culminated in the publication of *A U.S. Carbon Cycle Science Plan* (https://downloads.globalchange.gov/carbon-cycle/us-carbon-cycle-science-plan.pdf). This community plan informs U.S. research efforts on the global carbon cycle for the next decade. It is organized around three overarching questions:

- How do natural processes and human actions affect the carbon cycle on land, in the atmosphere, and in the ocean?
- How do policy and management decisions affect the levels of the primary carbon-containing gases, carbon dioxide, and methane in the atmosphere?
- How are ecosystems, species, and natural resources impacted by increasing greenhouse gas concentrations, the associated changes in climate, and by carbon management decisions?

2.1 NASA Carbon Cycle Science

The overall goals for NASA's Earth Science program are documented in NASA's Strategic Plan (http://nasascience.nasa.gov/about-us/science-strategy). Carbon Cycle Science research is supported by many different research and applied science programs at NASA, including, but not limited to, NASA's Carbon Cycle and Ecosystem focus area (http://science.nasa.gov/earth-science/focus-areas/carbon-cycle-and-ecosystems/), as well as the programs that support it (http://cce.nasa.gov/cce/index.htm). The goals of the NASA Earth Science 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 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 carbon cycle research contributes toward the goals of major USGCRP activities, including the Carbon Cycle Science Program's U.S. North American Carbon Program (NACP) and the Ocean Carbon and Climate Change Program (OCCC) (http://www.globalchange.gov/, http://www.carboncyclescience.us/, http://www.nacarbon.org/nacp/, and http://www.us-ocb.org/about/projects.html), as well as the goals and objectives of the Ocean Carbon and Biogeochemistry program supported by the National Science Foundation and NASA (http://www.us-ocb.org). NASA carbon cycle research also contributes toward the goals of the National Ocean Council's National Ocean Policy planning documents (http://www.whitehouse.gov/administration/eop/oceans/policy).

2.2 USDA Carbon Cycle Science

The USDA-NIFA mission is to advance knowledge for agriculture, the environment, human health and well-being, and communities. The purpose of the AFRI is to support research, education, and extension grants that address key problems of national, regional, and multistate importance in sustaining all components of agriculture. USDA research seeks to determine the significance of agricultural systems (including farm, crop, forest, and range lands) in the global carbon cycle, including carbon consequences of adaptation strategies within these systems, and to identify agricultural and forestry activities that can contribute toward reducing atmospheric concentrations of greenhouse gases. This carbon cycle science program falls within the USDA-NIFA'S Agriculture and Natural Resources Science for Climate Variability and Change program which seeks both fundamental and applied interdisciplinary research on impacts and feedbacks to global change and potential adaptation and mitigation strategies, as well as discovery and demonstration of decision support tools for land, ecosystem and water resource managers to mitigate carbon and greenhouse gas emissions (i.e., increase carbon uptake and sequestration and/or reduce emissions) while maintaining or enhancing productivity and associated ecosystem products, services, and structure; identify vulnerable ecosystems (including production and management systems) and their thresholds; and adapt to global change and its drivers. USDA carbon cycle research contributes toward the goals of major USGCRP activities, including the Carbon Cycle Science Program's U.S. NACP. In addition, USDA-NIFA encourages international coordination in the area of agricultural greenhouse gases via the Global Research Alliance (http://www.globalresearchalliance.org/).

The objectives of this program address the USDA Strategic Plan for 2010-2015 under Strategic Goal 2, Objective 2.2: Lead Efforts to Mitigate and Adapt to Climate Change, in particular the strategy to "Develop models, national observing and monitoring systems, decision support tools, and new technology and adaptation strategies for communities, agriculture producers, and natural resource managers;" and "Encourage the adoption of reasonable, transparent, and science-based programs to adapt to, or mitigate the effects of, climate change on agriculture and forestry." They also support the USDA Research, Education, and Economics (REE) Action Plan (http://www.ree.usda.gov/ree/news/USDA_2014_REE_Action_Plan_08-2014_Final.pdf Goal 2: Responding to Climate and Energy Needs, Subgoal 2A: Responding to Climate Variability, with direct reference to the identified REE role to "develop and deliver science-based knowledge that

empowers farmers, foresters, ranchers, land owners, resource managers, policymakers, and Federal agencies to manage the risks, challenges, and opportunities of climate variability, and position decision makers to reduce emissions of atmospheric greenhouse gases and enhance carbon sequestration."

2.3 DOE Carbon Cycle Science

Within DOE's Office of Science, the Climate and Environmental Sciences Division (CESD) seeks to advance a robust predictive understanding of Earth's climate and environmental systems and to inform the development of sustainable solutions to the nation's energy and environmental challenges (http://science.energy.gov/~/media/ber/pdf/CESD-StratPlan-2012.pdf). Among CESD's goals, the following three pertain to the Terrestrial Ecosystems Science (TES) program and to this solicitation:

- Develop, test, and simulate process-level understanding of terrestrial ecosystems.
- Advance fundamental understanding of coupled biogeochemical processes in complex subsurface environments to enable systems-level environmental prediction and decision support.
- Synthesize new process knowledge to advance next-generation, integrated models of the human-Earth system.

TES seeks to improve the representation of terrestrial ecosystem processes that in turn can be incorporated into the land component of Earth system models, thereby improving the quality of climate model projections and providing the scientific foundation needed to inform DOE's energy decisions. TES seeks to focus its research on ecosystems that are globally important, climatically sensitive, and comparatively understudied or underrepresented in Earth system models.

TES uses a systems approach to understand ecosystems over multiple scales that can be represented in models. This emphasis on the incorporation of improved scientific understanding of ecosystems in models has two goals. First, it seeks to improve the representation of specific processes so that an analysis of scale aware interactions and interdependencies can be conducted with a systems approach. Second, it seeks to exercise models and compare projections and simulations against observations or other data sets to inform future research directions.

2.4 NOAA Carbon Cycle Science

The focus of NOAA carbon cycle science research is to better quantify the information on atmospheric composition, its influence on the energy budget, and feedbacks that contribute to changes in Earth's climate. Specifically, NOAA seeks to provide the understanding needed to link emissions of climate-relevant compounds to the radiative forcing of climate change for science-based decision support (see http://www.nrc.noaa.gov/plans.html)

NOAA is providing research 1) to understand oceanic and atmospheric processes, both natural and human-related, that affect carbon dioxide (CO_2) trends, 2) to quantify the climate roles of the radiatively important trace atmospheric species such as fine particles (aerosols), ozone, and chemically active greenhouse gases, and 3) to understand and assess stratospheric ozone

depletion.

Research activities 1) may be directly applied to climate projection and to policy decisions regarding carbon management that are related to limiting unwanted effects of future climate change and 2) provide timely and adequate information needed to broaden the suite of noncarbon options for addressing changes in climate forcing, especially in the next few decades.

NOAA's carbon cycle research supports both national and international assessments of the climate system, e.g., the synthesis and assessment products of the USGCRP, the assessment reports of the IPCC, and the reports to the U.N. Montreal Protocol on the ozone layer. Such science-based assessments and scenarios provide (1) tools for better management of carbon- and noncarbon-based climate-forcing emissions, (2) a suite of choices for both air quality and the alteration of climate forcing in the near term, and (3) longer-term assessments of strategies for managing climate-forcing emissions over the longer term.

In addition, related to carbon in the ocean, SEC. 12406. of the Federal Ocean Acidification and Monitoring Act (FOARAM, 2009) requires that NOAA oversee and coordinate a diverse research and monitoring portfolio consistent with the *Strategic Plan for Federal Research and Monitoring of Ocean Acidification* developed by the Interagency Working Group on Ocean Acidification (IWGOA). In support of these requirements, NOAA supports research and monitoring on ocean acidification that contributes towards an assessment of the impacts of ocean acidification on marine ecosystems and promotes development of adaption and mitigation strategies to better conserve ocean acidification (OA) impacted marine systems on which human communities depend. Carbon exchange between the oceanic, atmospheric, and terrestrial reservoirs is a primary factor controlling both long-term and episodic acidification events (e.g. concomitant decrease in both pH and carbonate ion concentration). The complex biogeochemistry within shallow or coastal environments can significantly challenge the predictive capacity of continued OA on marine ecosystems and dependent human societies. NOAA's ocean acidification research works to better inform fisheries, marine resource managers, and policy makers of OA implications for the nation.

3. Carbon Cycle Research Solicited

In this solicitation, NASA, USDA, DOE, and NOAA request proposals for research and/or applied science investigations aimed at addressing the three overarching U.S. carbon cycle science questions and conducting research focused on integrated scientific-societal issues. Proposals within five specific research themes are requested. Each agency participating in this solicitation will be able to support research only in a subset of these themes, and the participating agencies are noted in parentheses for each theme listed below. The five research themes solicited are:

1. Carbon research in critical regions, specifically: tropical terrestrial ecosystems, Arctic-boreal terrestrial ecosystems, North American continental margins (NASA, DOE, USDA);
2. Blue Carbon and Carbon in Associated Ecosystems (USDA, NASA) ;
3. Carbon dynamics across managed landscapes, specifically: urban-rural, forested-agricultural and terrestrial-aquatic (USDA, NASA);

4. The Impact of Rising CO_2 on Ocean Ecology (NASA, NOAA); and
5. Carbon cycle science synthesis research (NASA, USDA)

A further description of the types of research solicited under each of these themes is provided in the sections that follow.

3.1 Theme 1: Carbon Research in Critical Regions (NASA, DOE, USDA)

Many Earth system research programs have focused on temperate systems due to proximity and ease of access. However, many extra-temperate systems are increasingly recognized for their importance in critical Earth processes, particularly biogeochemical cycles associated with carbon and macronutrients. Tropical and Arctic ecosystems sequester massive quantities of carbon in soil, vegetation, and permafrost, and are directly responsible for important feedbacks to the global climate system. Recent reports have identified gaps in our knowledge of the quantity and scales of carbon cycled in and around the North American continental margins. Wetlands, peatlands, and coastal ecosystems also sequester large quantities of carbon through processes at risk of disturbance from changing climate, land use change, and rising sea levels. However, our understanding of these systems, e.g., their characteristics and dynamical behaviors, are poorly understood, thus limiting our ability to adequately predict their long-term behavior. Research is solicited for the following three critical regions.

3.1.1 *Carbon Dynamics in Tropical Terrestrial Ecosystems (moist forests and, woodlands/savannas) (NASA)*

The tropics cover approximately 40% of Earth's land surface area and critically regulate many Earth system processes. Tropical terrestrial ecosystems contain great stores of biomass, and they represent a major reservoir of the planet's terrestrial carbon. These ecosystems also cycle more carbon dioxide (CO_2) and water than other biomes and play important roles in determining Earth's energy balance, which drives global systems of temperature and precipitation. Large-scale changes in tropical terrestrial ecosystems have the potential to change global patterns of temperature and precipitation. Tropical ecosystems are under significant stress from a changing climate and from anthropogenic land use changes. While generally accepted as a critical global system, tropical ecosystems are poorly understood, causing corresponding limitations to their representation in ecosystem and global-scale carbon cycle and climate system models. Social, economic, and behavioral processes can interact strongly with these processes, such that incorporation of these processes into models and projections is needed to more fully understand how many of these ecosystems have evolved and can change in the future. Important questions from microscale (microbial processes, soil and biogeochemical processes), to macroscale (plants and plant systems), to landscape and watershed scale remain unanswered regarding carbon dynamics in tropical systems.

Proposals should address improved understanding of widespread, critical tropical ecosystems. Particular emphasis is placed on research that combines measurements and/or experiments with modeling to provide improved quantitative and predictive understanding of the coupled biological, chemical, and physical processes that represent potentially strong carbon cycle feedbacks from tropical terrestrial ecosystems in a changing climate. Processes of particular

interest include those that are needed to explain the impacts on ecosystems caused by drought, temperature, and changes in hydrology, as well as improved understanding of soil biogeochemistry and methane dynamics. Preference will be given to projects that demonstrate strong potential feedbacks and wide geographic applicability.

3.1.2 *Carbon Dynamics in Arctic/Boreal Terrestrial Ecosystems (NASA, DOE)*

Arctic tundra, boreal systems, and the transitions in between represent a vast expanse of northern land mass and contain one of the largest volumes of carbon stored in the biosphere. As a consequence of a warming climate, the region may be approaching a potential tipping point with regard to the release of this stored carbon. Climate warming could trigger large-scale releases of CO_2 and CH_4 from thawing Arctic/boreal soils into the atmosphere. On the other hand, warming may induce perturbations to local hydrology of land surfaces that in turn could increase plant production and either decrease methane production or increase methane consumption, and thus potentially reduce carbon emissions to the atmosphere. These and other processes that can influence carbon dynamics and climate feedbacks are also influenced by social and economic factors and other human decisions and disturbances. Although it is widely accepted that this region is critically important to our understanding and modeling of climate change, our understanding of key processes, impacts, and feedbacks are far from robust. There are currently large uncertainties in the direction and strength of the positive and negative feedbacks and what is likely to occur in the region in response to continued climate change. These ecosystems are remote and measurements and observations that are widespread and common in temperate ecosystems are rare or absent in many of these northern ecosystems.

Therefore, this theme solicits fundamental research to advance our understanding of the function of widespread, critical northern terrestrial ecosystems, particularly in ways that influence carbon cycle feedbacks to the climate system. Particular emphasis is placed on research that combines measurements and/or experiments with modeling to provide improved quantitative and predictive understanding of the coupled biological, chemical, and physical processes that represent potentially strong carbon cycle feedbacks to climate from northern terrestrial ecosystems in a changing climate. Preference will be given to projects that focus on strong potential feedbacks and have wide geographic applicability.

3.1.3 *North American Continental Margins (NASA, USDA)*

Relative to their surface area, continental margins represent some of the largest carbon fluxes in the global ocean, but sparse sampling in space and time makes these systems difficult to characterize, quantify, and model. Recognizing the importance of continental margins to the overall North American carbon budget, specifically as acknowledged by the North American Carbon Program (http://www.nacarbon.org/nacp/index.html), terrestrial and marine carbon cycle scientists have collaborated on a series of synthesis, carbon budgeting, and modeling exercises for coastal regions of North America, which include the Gulf of Mexico, the Laurentian Great Lakes (LGL), and the coastal waters of the Atlantic, Pacific, and Arctic Oceans.

The Coastal CARbon Synthesis (CCARS) workshops and research activities have been conducted since 2007 as a partner activity between the Ocean Carbon and Biogeochemistry

(OCB) Program and the North American Carbon Program (NACP) to synthesize existing data and improve quantitative assessments of the North American carbon budget. Out of this effort has come a draft science plan for carbon cycle research in North American coastal waters that specifically identifies areas ripe for research and modeling investment, particularly focused on gaps in our knowledge of the North American continental margins' carbon cycle. One of the plan's key goals is to synthesize existing data and improve quantitative assessments of the North American carbon budget. This program element welcomes research activities to support the key findings and recommendations of the CCARS report entitled "An Interdisciplinary Science Plan for Research in North American Continental Margin Systems" that can be found on the OCB website at http://www.us-ocb.org/CCARS_Sci_Plan_DRAFT.pdf. NASA welcomes proposals to conduct research to address the goals and objectives of the CCARS Report and its implementation. This subelement solicits fundamental research to address the gaps and needs in research in the aforementioned geographical areas of focus to address the preliminary recommendations and key findings of the coastal carbon data synthesis activities articulated in the report. One example of this might be to increase the use of satellite products and development of algorithms for key carbon flux estimates. Particular emphasis is placed on research that combines measurements and/or experiments with modeling to provide improved quantitative and predictive understanding of the coupled biological, chemical, and physical processes of carbon cycling along the North American Continental Margins. The proposed work plan's relationship and direct link to the CCARS report and it's research goals and objectives must be explicitly justified within the proposal.

Also within this subelement, USDA has particular interest in projects that would include assessments of projected changes in and vulnerability of coastal ecosystems such as coastal wetland forests and marshes, including both below- and above-ground processes, due to both climate change and sea level rise, and associated changes in hydrology, water tables, salinity, and frequency and intensity of disturbance. Integration of social, behavioral, and/or economic sciences is strongly encouraged.

3.2 Theme 2: Blue Carbon and Carbon in Associated Ecosystems (NASA, USDA)

"Blue carbon" refers to carbon in coastal and marine ecosystems. This theme specifically focuses on wetlands, peatlands, mangroves, seagrasses, tidal marshes, coastal forests, and estuary systems across the globe. These areas are subject to environmental and climate variability and change, typically removing some fraction of carbon from the atmosphere and ocean and storing it in plants and the sediment. Once these regions are impacted by environmental or climate change, restoration and adaptation become a challenge. Additionally, research has pointed to a release of carbon dioxide from the blue carbon ecosystems as a result of environmental and climate change impacts. The destruction of these areas can also have large effects on local economics. For example, in addition to providing protection to coastal communities and nurseries for many fish species, the aforementioned coastal ecosystems are highly productive, storing large quantities of carbon.

NASA and USDA are interested in the research and modeling studies that underpin the approaches to the aforementioned "blue carbon" regions' conservation and management, bringing in how processes and human actions in these areas and beyond are affecting these

ecosystems. Climate change is affecting these ecosystems that are important for the global carbon balance via numerous direct and indirect mechanisms and their interactions with human decisions, policies (such as national accounting), resource management and socioeconomics and behavior.

This theme calls for research in the following topical areas:

a) using historical or existing remotely sensed and *in situ* data and/or proposing new remotely sensed and *in situ* observations to map the aforementioned blue carbon geographical areas (e.g., seagrasses); this effort must be linked to research that attempts to quantify the carbon stored in these systems,

b) understanding historical and future carbon fluxes in to and out of the aforementioned blue carbon areas due to projected changes in climate, environmental change or disturbance, and/or human actions, including but not limited to: management/decision making, urbanization, before and after land use change, sea level rise, etc., and

c) understanding the potential feedback(s) of naturally or anthropogenically-driven change in an aforementioned blue carbon system (e.g., mangroves) to the climate system and the impact of this change on key carbon cycle processes (in both natural and managed systems).

Projects should integrate process research with modeling and should span different temporal or spatial scales (e.g., proposals may include the role of the microbial community in the blue carbon area under study). Geographic study regions may span regional or watershed to continental, but the compelling reason that geographic area is worthy of scientific study must be justified and should be placed in a global context. Proposers to USDA can include below-ground/sediment level processes. Projects that integrate human dimensions into the research, models, and analyses are strongly encouraged.

For proposals requesting NASA support: Unless otherwise specified above, proposed investigations must utilize remotely sensed (e.g., MODIS) observations as a primary research tool, but may also seek to improve existing satellite observations or explore the development of new algorithms for new carbon cycle properties from space-based assets (beyond traditional observations) in support of the project objectives. Coordinated or individual efforts may be linked with other projects or proposals and these linkages must clearly and explicitly be called out by all involved proposals and investigators. Project planning to propose any new data collection are strongly encouraged to speak with the cognizant program manager prior to submitting the proposal to ensure the scope of the planned proposed effort are appropriate to the solicitation.

Investigators should make clear any special requirements or platform needs, i.e., ship modifications, additional boats, specific sampling requirements in a separate section. Information about high-end computing requirements will be collected using a question on the NSPIRES cover pages and a required appendix to the proposal document (see Section I(d) of the *ROSES Summary of Solicitation* for details of this requirement and information about the template to be used for the appendix). For example, 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 includes 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. Proposers should include any required supporting paperwork that provides insight in to costs or requests in support of the use of the vessel. Proposers must take responsibility for making all arrangements to secure the availability of the needed sensors and vessel and explain these plans in the proposal.

All data collected will be subject to the standard NASA Earth Science data policy (http://nasascience.nasa.gov/earth-science/earth-science-data/data-information-policy/). Proposals seeking NASA funding and planning to collect field data should contain a table that, to the extent possible, details what data will be collected, on what cruise or field visit, and when, and provide a detailed plan for submission to a NASA data center, such as the SeaWiFS Bio-optical Archive and Storage System (SeaBASS - http://seabass.gsfc.nasa.gov), within one year of collection. All proposals submitted in response to this solicitation must include a section in the statement of work describing how errors and uncertainties will be addressed. The research supported will be expected to characterize uncertainties and quantify errors associated with data, analytical approaches, model results, and scientific interpretations. This work must be described in the proposal. 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, when relevant to the type of study being proposed, the types of data and data products 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. The data management plan must be included within the 15-page limit for the Scientific/Technical/Management section of the proposal. A valid data management plan may include only the statement that no detailed plan is needed, as long as a clear justification is provided.

For proposals requesting USDA support:
It is expected that many proposals in response to this theme may be appropriate for both NASA and USDA funding. Thus, just as for proposals requesting NASA support, all proposals must include a data management plan that assures preservation of and ready access to information and data outputs from the project. Data management plans developed according to NASA requirements are acceptable to USDA; otherwise USDA suggests that the data management plans include or address following:

- Describe types of data, metadata, and other generated materials, formats, and standards used, and whether it will change or be updated. Indicate if data is sensitive or proprietary;
- Detail planned policies for access and sharing data, including provisions for appropriate protections of security, confidentiality and intellectual property, and mechanisms for obtaining access;
- Address provisions for reuse, redistribution and production of derivatives, and plans for archiving data and other products for preservation of access.
- Submission to an appropriate data center or archive is required, but it need not be a NASA data center.

3.3 Theme 3: Carbon Dynamics Across Managed Landscapes (USDA, NASA)

Land use and resource management decisions generate complex patterns of native vegetation, managed forests, agricultural systems, and urban and suburban landscapes. This mosaic of land use and land cover (LULC) has significant spatial and temporal variation in terrestrial carbon stocks, rates of carbon exchange, and potentials for carbon sequestration. Urban, suburban, and adjacent/supporting agricultural and forest regions are becoming increasingly important in the global carbon cycle. For example, as of the 2010 Census, more than 80% of the population of the U.S. now lives in cities and their suburbs, while more than 50% of the land area is under agricultural management. More than 90% of global anthropogenic greenhouse gas emissions are attributable (directly or indirectly) to cities, and urban populations drive to a large extent many of the activities of the rural and forested areas due to their demand for food and fiber, resources, and recreational areas. In recognition of their contributions to global greenhouse gas emissions, a number of cities, regions, and nations have issued bold goals for greenhouse gas emission reductions. Effective actions to quantify the effects of such actions will depend, however, on understanding the processes controlling the uptake, storage, and release of greenhouse gases along urban to rural gradients and the social, behavioral, and economic drivers and influences on these processes. In many tropical areas for example, forest and peat land clearing through fires for industrial oil palm plantations results in significant carbon loss hence increased greenhouse gas emissions, and this decision is driven by many factors, including demands for these resources/products through a global economy.

Development choices pay a central role in determining local, regional, and global carbon emissions through such factors as energy consumption, transportation, and construction, as well as management for terrestrial carbon sinks via vegetation carbon uptake and storage. However, there are very few data available to systematically evaluate how alternative patterns of urban and regional development and LULC change interact with ecosystem processes and atmospheric carbon dynamics. Studies of the processes and mechanisms controlling carbon cycling in urban and surrounding regions can provide a useful test-bed for developing carbon cycle information that can provide a sound basis for carbon management at local and regional scales.

Land-use changes of interest across the range of urban-suburban-forested-agricultural systems include, for example, deforestation, reforestation and afforestation, urban encroachment, land conversions to and from agricultural and forestry uses, changes related to renewable energy production, changes in crop, range, pasture, or forest management systems, and fragmentation of land-cover types. Also of importance are the interactions at the intersections of different land

uses/land cover - how does one land use affect the adjacent land use or land cover and what is the resulting net impact on carbon fluxes and stores. This could also include consideration of the tradeoffs between carbon sequestration or greenhouse gas reductions and other goods and services needed by society and of the natural and socioeconomic drivers of these land changes and decisions. Changes and disturbances of interest include, for example, changing precipitation patterns, altered fire regimes, increasing temperatures and/or concentrations of CO_2, CH_4, and other greenhouse gases, extreme events, nitrogen deposition, agricultural management decisions, and biotic or socioeconomic disruptions.

To better guide and strengthen the development of models of the processes dominating terrestrial (both above- and below-ground) and atmospheric carbon dynamics, effective use of advanced measurement and observational capabilities is needed. Integration of a broader range of data and information will also, in time, lead to improved predictive model capabilities. For example, structural information retrieved from radar data can provide additional information on the above-ground biomass useful for carbon assessments. Carbon cycle research under this theme is, therefore, expected to help quantify the carbon signatures (spatial and temporal changes in fluxes) of ecosystems across a range of human influence and control, requiring measurements, modeling and analysis. Projects that can capitalize on ongoing activities, and/or projects that investigate systems of high potential carbon flux (both emissions and sequestration) or climate feedback are encouraged.

3.4 Theme 4: The Impact of Rising CO_2 on Ocean Ecology (NASA, NOAA)

Recent planning documents for carbon cycle science, including the 2011 *A U.S. Carbon Cycle Science Plan* (https://downloads.globalchange.gov/carbon-cycle/us-carbon-cycle-science-plan.pdf), point to large unknowns in global carbon dynamics, including a need to determine the synergistic effects of rising CO_2 on ecosystems in the presence of altered patterns of climate and associated changes in weather, hydrology, sea level, and ocean circulation. Concurrently, the United States Ocean Carbon and Biogeochemistry program (www.us-ocb.org) points to two overarching research priorities: oceanic uptake and release of atmospheric CO_2 and other greenhouse gases and environmental sensitivities of biogeochemical cycles, marine ecosystems, and interactions between the two. With these overarching goals in mind, this program element solicits proposals that seek to address one aspect of these scientific issues: to delineate, understand, and quantify the impact of rising atmospheric CO_2 on aquatic ecology.

This subelement solicits fundamental research to advance our understanding of the impacts of rising atmospheric CO_2 on aquatic ecosystems, including, but by no means limited to, ocean acidification and the resulting impacts of aquatic uptake or release of carbon dioxide on aquatic organisms and ecosystems. Higher atmospheric CO_2 levels are likely to change the competitive balance among ecosystem dynamics, functional groups, and biodiversity (e.g., dramatic shifts in species). Efforts will be needed to determine the combined effects of rising CO_2 and altered patterns of climate on ecosystem structure and function in aquatic habitats. Additionally, linkages between land and ocean ecosystems represent an area that is sensitive to changes in carbon cycling, particularly the rise in CO_2 concentrations resulting from environmental change, and that has important significance for functional groups, ecosystems, and for society. These land-ocean linkages are only beginning to be examined in the context of carbon export to the

coastal oceans and the impact of this export on diverse end points such as coastal ocean acidification and fisheries. Therein, particular emphasis is placed on research that combines measurements and/or experiments with modeling to provide improved quantitative and predictive understanding of the coupled biological, chemical, and physical processes that represent potentially strong carbon cycle and ecosystem feedbacks under changing environmental and climatic conditions. Preference will be given to projects that focus on strong potential feedbacks and have wide geographic applicability, as well as emphasis on human influences in the proposed research. Proposals must include substantive use of NASA satellite data for consideration by NASA. No such requirement is necessary for consideration by NOAA's Ocean Acidification Program.

3.5 Theme 5: Carbon Cycle Science Synthesis Research (NASA, USDA)

Recent research investments in synthesis research under the North American Carbon Program (NACP) have been highly productive, producing, in addition to their scientific findings, new and valuable information regarding how carbon measurements can be used, the capabilities of carbon cycle models, and uncertainties and errors in these measurements and models. However, it seems clear that there is still more that could be learned in the coastal carbon synthesis effort, and, at least in the case of the NACP midcontinent study, more data to be analyzed. Therefore, focused, follow-on research that extends and/or completes NACP synthesis research is solicited.

Also, the agencies believe that additional relevant carbon cycle science programs, projects, and topic areas would benefit from new synthesis studies addressing the important science questions of this solicitation. Candidate programs, projects, and topics include, but are not limited to Free Air Carbon Dioxide Enrichment (FACE), Greenhouse Gas Reduction through Agricultural Carbon Enhancement Network (GRACENet), AmeriFlux, Consortium for Agricultural Soils Mitigation of Greenhouse Gases (CASMGS), Rapid Soil Carbon Assessment, International Soil Carbon Network, ocean acidification trends and impacts by region, ocean biogeochemistry, disturbance, mortality, and ecosystem fluxes. New synthesis studies must be directed toward addressing the scientific topics outlined in Themes 1-4 in Sections 3.1-3.4 above.

Model-measurement intercomparisons and model-model intercomparisons that include measurements or observations represent approaches with focused scientific objectives that are of interest for synthesis research. Activities and infrastructure essential to the support of synthesis research, including data preparation, management, and distribution may be proposed as part of a scientific synthesis study. Proposers are encouraged to make use of existing infrastructure and/or partner with established data centers whenever possible. Proposals offering support infrastructure only, with no scientific synthesis research, will be considered nonresponsive to this program element.

3.6 Cross-cutting research Topics

3.6.1 *Human Activities*

It is recognized that human activities are the major cause of increasing atmospheric greenhouse gases. In addition, as indicated in all three questions guiding the 2011 publication *A U.S. Carbon*

Cycle Science Plan, human activities and decisions, as well as societal and economic forces, strongly affect the Earth's carbon cycle dynamics, both directly and indirectly. Thus, the agencies participating in this solicitation strongly encourage proposers to consider offering research investigations that address human activities, including impacts on coupled human-biogeophysical systems and societal responses involving adaptation, mitigation, and/or integrated, adaptive management of carbon in the environment.

3.6.2 *Space-based Atmospheric Carbon Observations*

Past solicitations for interagency carbon cycle science research encouraged studies using space-based atmospheric carbon observations to be better prepared for upcoming observations from the Orbiting Carbon Observatory-2 (OCO-2) and Greenhouse Gases Observing Satellite (GOSAT) missions. Because other solicitations from NASA have called for similar studies, and because the GOSAT data are now becoming mature and used, this solicitation is not calling explicitly for such studies. Instead, studies are encouraged that use and/or combine existing space-based CO_2 and/or CH_4 observations (with or without other types of observations) to concentrate on the topics covered within Sections 3.1 through 3.5 of this solicitation. In particular, Sections 3.1, 3.2, and 3.4 are all quite relevant for the use of these atmospheric carbon observations. Also, validation of satellite atmospheric carbon data products remains a strong interest in support of the use of these observations and research to support surface remote sensing observations and infrastructure to evaluate current CO_2 and CH_4 data products would be welcome.

3.6.3 *Research Approaches and Analysis Tools*

The agencies value certain research approaches and analysis tools and believe they have much to offer in advancing current understanding of the global carbon cycle. Proposers are strongly encouraged to consider including one or more of the approaches described below in this section in their research plans.

3.6.3.1 *Improved Observations*

Scientific understanding of the carbon cycle can be limited by the amount and quality of relevant observations and studies that offer improvements in observations are of interest when they focus on improving the observations necessary to achieve a particular carbon cycle science goal during the course of the study. However, proposers should note that this solicitation is not an appropriate vehicle for proposing technology development or instrument development work; any such proposals will be considered nonresponsive. However, studies which involve improved measurement of the carbonic acid system within poikilohaline environments may be considered, if proposed as a means to improving quantification of coastal carbon fluxes and achieving better constraint of coastal acidification processes.

3.6.3.2 *Modeling*

Modeling approaches are of great interest and essential for developing predictive capacity for carbon cycling. The agencies are interested in all types of models that address carbon cycle dynamics (budgets and/or fluxes), including: data assimilation modeling, atmospheric transport

and inversion modeling, ecosystem component modeling, socioeconomic modeling, model improvement through incorporation of new/better data and process information, analysis of model outputs, modeling at global and regional scales, models at the scale of key processes, and model intercomparison studies (including the data preparation and management activities necessary to support them). Utilization of, or explicit links to, widely used, open source models is encouraged, where appropriate.

3.6.3.3 *Coordination with other Federal Research Projects*

The U.S. Carbon Cycle Science Program coordinates the carbon cycle research of ten Federal agencies. Some of these agencies direct or compete their carbon cycle research in ways not compatible with an interagency solicitation of this nature at this time. Thus, it is imperative that efforts be made to coordinate and encourage synergies across all contributions to the U.S. Carbon Cycle Science Program. Proposers to this solicitation are, therefore, strongly encouraged to offer studies that collaborate with, leverage, complement, or build upon existing carbon cycle science or related projects of other U.S. agencies (e.g., NSF, USGS, other elements of USDA or NOAA). Explicit evidence of these interagency collaborations, if the proposed study is dependent on them, must be provided in the proposal.

3.7 Additional Requirements for All Proposals

Proposers are advised to take great care to match their proposed activities to the research themes solicited (see Section 3) and the scientific goals (see Section 2) and programmatic considerations (see Sections 3.6.5 and 4.3-4.6) of each agency. Proposers are encouraged to contact the relevant agency point of contact listed in Section 5 if they have any questions regarding the appropriateness of or requirements for a particular type of study.

In addition to the requirements specified under each research theme in Sections 3.1-3.5 and the cross-cutting activities in Section 3.6 above, all proposals must adhere to the requirements detailed below.

3.7.1 *Error and Uncertainty*

All proposals must address how error and uncertainty will be dealt with in the study and describe how an understanding of the errors associated with measurement, quantification, and/or interpretation will be conveyed along with the research results.

3.7.2 *Project Management Plan*

Proposals must include a project management plan that presents a management structure describing roles and responsibilities for all Co-Investigators and Collaborators and how the research activities will be coordinated and integrated. The proposal budget section and proposal cover page must include budgetary information for all funded Co-Investigators. Involvement of students and postdoctoral scientists, where possible, is encouraged. The project management plan section should be inserted after the science and technical section of the proposal and does not have a page limit.

3.7.3 *Data Management Plan*

Research data obtained through public funding are a public trust. These data must be publicly accessible to be in compliance with the data policy of the U.S. Global Change Research Program of full and open access to global change research data (see http://www.usglobec.org/reports/datapol/datapol.usgcrp.html). Proposals submitted in response to this solicitation must include a data management plan describing the researcher's data sharing plan, if the proposed research involves the acquisition of data. This includes data from measurements, observations, and experiments and from model simulations that would be costly to duplicate. The description must include plans for sharing and disseminating the data that are to be acquired in the course of the proposed research, particularly how the acquired data will be preserved, documented, quality assured, and archived for access by others. It is not necessary to identify the archive in the proposal, but a process for determining the archive should be described. The data management plan must include, when relevant to the type of study being proposed, the types of data and data products or other materials to be produced in the course of the project and the standards to be used for data and metadata formats. The data sharing plan called for in section 2.3.5 of the NASA *Guidebook for Proposers* should be included in the data management plan. The data management plan section should be inserted after the Project Management Plan section of the proposal and does not have a page limit, unless otherwise specified within the program subelement.

Selected investigations also will be expected to comply with the data policy of the agency funding their study. The relevant agency data policies and archive descriptions that are now available online can be found at the following Web links:

NASA: http://science.nasa.gov/earth-science/earth-science-data/data-information-policy/ and http://earthdata.nasa.gov/data/data-centers
USDA: http://nifa.usda.gov/resource/data-management-plan-nifa-funded-research-projects
DOE: http://science.energy.gov/ber/funding-opportunities/digital-data-management/, http://cdiac.ornl.gov/, http://www-pcmdi.llnl.gov/ipcc/about_ipcc.php and http://ameriflux.lbl.gov/data/data-policy/

3.7.4 *Principal Investigator Meeting Attendance Required*

All Principal Investigators (PI) of proposals funded under this solicitation will be required to attend the PI meetings of the agency funding their project or another PI meeting designated by that agency. Travel funds should be budgeted to allow at least the lead PI to attend one PI meeting during each year of the project.

3.7.5 *Agency-Specific Requirements and Opportunities*

3.7.5.1 *NASA Requirements and Opportunities*

To be eligible for NASA funding, the proposed research must make substantial use of remotely sensed data from satellites or airborne platforms.

3.7.5.2 *USDA Requirements and Opportunities*

3.7.5.2.1 USDA International Partnerships

To be eligible for USDA-NIFA funding, projects must show relevance to U.S. agriculture and forestry. However, joint multilateral approaches can maximize the effectiveness of national efforts, develop the much needed expertise on mitigation for agricultural systems, and spread the knowledge gained and improved technologies resulting from international research cooperation and investment in mitigation practices and technologies. Thus, to attain USDA's goals for agriculture and forestry, applicants may include international partnerships and activities, as long as they clearly describe how the international activities proposed contribute to and support advances in the viability and sustainability of U.S. agriculture and forestry.

3.7.5.2.2 USDA Restrictions on Indirect Costs

In addition, budgets for all USDA-NIFA funded projects must comply with USDA-NIFA restrictions on indirect costs and allowable expenses (see Section 4.3.3) or be willing to adjust budgets to comply with these restrictions upon being recommended for an award. Additional information can be found at http://nifa.usda.gov/indirect-costs. Proposals funded by USDA-NIFA must show relevance to U.S. agriculture, including rangelands, forestry, food systems, or rural communities. Subcontracts to foreign institutions are allowed by USDA-NIFA, but cannot include salaries for regular employees of non-U.S. institutions.

3.7.5.2.3 USDA Requirements for Responsible and Ethical Conduct of Research

In accordance with sections 2, 3, and 8 of 2 CFR Part 422, institutions that conduct USDA-funded extramural research must foster an atmosphere conducive to research integrity, bear primary responsibility for prevention and detection of research misconduct, and maintain and effectively communicate and train their staff regarding policies and procedures. In the event an application to NIFA results in an award, the Authorized Representative (AR) assures, through acceptance of the award that the institution will comply with the above requirements. Award recipients shall, upon request, make available to NIFA the policies, procedures, and documentation to support the conduct of the training. See http://nifa.usda.gov/responsible-and-ethical-conduct-research for more information.

3.7.5.2.4 USDA Reporting Requirements

Grantees are to submit initial project information and annual summary reports to NIFA's electronic, web-based inventory system (see http://nifa.usda.gov/tool/reeport) that facilitates both

grantee submissions of project outcomes and public access to information on Federally funded projects. The details of these reporting requirements are included in the award terms and conditions.

3.7.5.3 *DOE Requirements and Opportunities*

Proposers should be aware that DOE is looking for proposals that pose their research goals, objectives, and approach in the context of representing terrestrial ecosystem processes in Earth system models. The emphasis on applicability to models can be accomplished through process research that specifies mechanisms for the incorporation of results into state-of-the-art process, ecosystem or Earth system models, by proposing direct improvements to such models or through synthesis activities that draw on existing data sets. This is not necessarily guidance to include modeling in every application, but rather to pose the questions in the context of identified (or previously unrecognized) needs for Earth system models as well as to propose a clear mechanism whereby the results of the proposed research would be made available to the modeling community.

3.7.5.4 *NOAA Requirements and Opportunities*

Projects in collaboration with NOAA scientists are highly encouraged.

NOAA seeks to fund studies only focused on U.S. landscapes and seascapes, with priority regions within the U.S. Exclusive Economic Zone (EEZ) up to and including polyhaline coastal environments.

4. Programmatic Information

All proposals will be submitted to a NASA-led peer review process in accordance with the guidelines provided in this solicitation and the *NASA Guidebook for Proposers*. NASA, USDA, DOE, and NOAA will collaborate in the planning and conduct of the peer review. This peer review will be followed by a programmatic review in which NASA, USDA, DOE, and NOAA program officers will assess program balance across the highly rated proposals and evaluate any logistical, implementation, cost, or management concerns. The NASA, USDA, DOE, and NOAA program officers will recommend for selection the proposals that best address the objectives of this solicitation within resource constraints. The program officers will also recommend the division of funding responsibilities between the agencies consistent with each agency's mission (see Section 2 and the evaluation criteria in Section 4.2.2 below). Co-funding is possible, and NASA, USDA, and DOE reserve 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. The funding recommendations will be forwarded to each participating agency's Selection Official for confirmation. The Selection Official for NASA will be the Associate Director for Research, Earth Science Division. The Selection Official for USDA will be the Assistant Director, Institute of Bioenergy Climate and Environment at the National Institute of Food and Agriculture. The Selection Official for DOE will be the Director, Climate and Environmental Sciences Division. The Selection Official for NOAA will be the Chief,

Research Programs Division. NASA will announce the official selection of proposals for award, recognizing the agency or agencies that have agreed to be responsible for funding.

Proposals that USDA, DOE, or NOAA have agreed to be responsible for will be forwarded to the appropriate agency for final negotiations and implementation of awards. Respondents selected for funding by USDA, DOE, or NOAA will be required to submit additional documentation. Further information will be provided to applicants selected for funding by those agencies.

4.1 Evaluation Criteria

Proposals will be evaluated according to the criteria specified in Section C.2 of the NASA Guidebook for Proposers. In addition to the factors given there, the evaluation of intrinsic merit for a proposal shall consider the experience of the offeror (investigators and their institutions) in engaging in data sharing and providing timely access to data and research products on related and relevant projects.

The evaluation criteria (of approximately equal weight) that will be considered in evaluating a proposal are its relevance to NASA's, USDA's, DOE's or NOAA's objectives; intrinsic merit; and cost reasonableness with respect to both time allocated for personnel as well as overall financial request. *The failure of a proposal to be rated highly in any one of these elements is sufficient cause for the proposal to not be selected*.

Also, the following factors will be applied:

4.1.1 *Relevance*

Evaluation of a proposal's relevance includes the consideration of all of the following factors:

(i) The potential contribution of the effort to NASA's, USDA's, DOE's or NOAA's mission as expressed in their most recent strategy documents and Section 2 of this solicitation.
(ii) The specific objectives and goals given in Section 3 of this solicitation.
(iii) The quality and completeness of the project management plan.
(iv) The quality and completeness of the data management plan.

4.1.2 *Merit*

Evaluation of intrinsic merit includes consideration of all of the following factors:

(i) Overall scientific or technical merit of the proposal. This includes the unique and innovative methods, approaches, or concepts, demonstrated by the proposal; the appropriateness and feasibility of the proposed methods or approaches; the clarity and delineation of objectives; the probability of success and risk-reward balance for the project; and the quality and appropriateness of the approach to characterizing uncertainties and quantifying errors.
(ii) Offeror's (i.e., proposing institution's) capabilities, related experience, facilities, techniques, or unique combination of these which are integral factors for achieving the proposal's objectives.
(iii) The qualifications, capabilities, and experience of the proposed Principal Investigator, team leader, or key personnel critical in achieving the proposal objectives.

(iv) Evaluation against the state-of-the-art. (Review panels are instructed not to compare proposals to each other; all comparative evaluations are conducted by agency program personnel.)

4.1.3 *Cost*

Evaluation of the cost of a proposed effort shall include the realism and reasonableness of the proposed cost, and the comparison of that proposed cost to available funds. Low cost, while desirable, does not offset the importance of realism and reasonableness of the proposed budget. Review panels evaluate cost realism and reasonableness; however, comparison of the proposed cost to available funds is performed by agency program personnel.

4.2 Programmatic Information Specific to NASA

Those investigators whose research requires high-performance computing should refer to the *ROSES Summary of Solicitation*, Section I(d), "NASA-provided High-End Computing Resources." This section describes the opportunity for successful proposers to apply for computing time on either of two NASA computing facilities at Goddard Space Flight Center's Computational and Information Sciences and Technology Office or at Ames Research Center's Advanced Supercomputing Division.

NASA encourages use of the new NASA Earth Exchange (NEX) collaboration facility for large-scale global high resolution carbon cycle data analysis and modeling projects. Proposers should refer to Appendix A.1, Section 4.4, for additional information about NEX and the resources it offers. Proposals should include a section that justifies the need for using NEX, specifies the data storage and processing needs, and includes NEX in its data management plan. NEX resource availability will be considered during the proposal review and selection process. Additional constraints and requirements for proposals to use NEX are available at https://c3.nasa.gov/nex/resource_updates.

4.3 Programmatic Information Specific to USDA

4.3.1 *Legislative Authority and Background*

Section 7406 of the Food, Conservation, and Energy Act of 2008 (FCEA) (Pub. L. 110-246) amends section 2(b) of the Competitive, Special, and Facilities Research Grant Act (7 U.S.C. 450i(b)) to authorize the Secretary of Agriculture to establish the Agriculture and Food Research Initiative (AFRI); a competitive grant program to provide funding for fundamental and applied research, education, and extension to address food and agricultural sciences. Grants shall be awarded to address priorities in United States agriculture in the following areas:

1. Plant health and production and plant products;
2. Animal health and production and animal products;
3. Food safety, nutrition, and health;
4. Renewable energy, natural resources, and environment;
5. Agriculture systems and technology; and
6. Agriculture economics and rural communities.

To the maximum extent practicable, the National Institute of Food and Agriculture (NIFA), in coordination with the Under Secretary for Research, Education, and Economics (REE), will make grants for high priority research, education, and extension, taking into consideration, when available, the determinations made by the National Agricultural Research, Extension, Education, and Economics Advisory Board (NAREEEAB) pursuant to section 2(b)(10) of the Competitive, Special, and Facilities Research Grant Act (7 U.S.C. 450i(b)(10)), as amended. The authority to carry out this program has been delegated to NIFA through the Under Secretary for REE.

AFRI encourages projects that coordinate with the USDA Climate Hubs (http://www.climatehubs.oce.usda.gov/). The mission of the Climate Hubs is to develop and deliver science-based, region-specific information and technologies, with USDA agencies and partners, to agricultural and natural resource managers that enable climate-informed decision-making, and to provide access to assistance to implement those decisions. This is in alignment with the USDA mission to provide leadership on food, agriculture, natural resources, rural development, nutrition, and related issues based on sound public policy, the best available science, and efficient management.

AFRI encourages projects that develop content and programs suitable for delivery through the Cooperative Extension System's eXtension Initiative. Funds may be used to contribute to existing Communities of Practice (CoP) such as the Climate Forests and Woodlands Community of Practice, or to form a new CoP focused on content relevant to sustainable bioenergy systems and water resource management. Projects that choose to include the delivery of products through eXtension must align with the eXtension vision, mission, and values, and a letter of acknowledgement from eXtension is required. In addition, a letter of support may be required from one or more of the Communities of Practice. For detailed guidance on how to partner with eXtension, go to http://create.extension.org/node/2057.

4.3.2 *Eligible Applicants for USDA-NIFA Awards*

Eligible applicants for the program implemented under this subpart include: 1) State Agricultural Experiment Stations; 2) colleges and universities (including junior colleges offering associate degrees or higher); 3) university research foundations; 4) other research institutions and organizations; 5) Federal agencies, 6) national laboratories; 7) private organizations or corporations; 8) individuals who are U.S. citizens, nationals, or permanent residents; and (9) any group consisting of 2 or more entities identified in 1) through 8). Eligible institutions do not include foreign and international organizations. For questions regarding USDA eligibility, please contact the USDA-NIFA point of contact listed in Part 5.

4.3.3 *Funding Restrictions for USDA-NIFA Awards*

Allowable indirect costs are not to exceed 30% of Federal Funds awarded, equivalent to a maximum of 42.86% of total direct costs. For FY 2013 and 2014 appropriated funds, see Section 720 of the Agriculture, Rural Development, Food and Drug Administration, and Related Agencies Appropriations Act, 2012 (Division A of Pub. L. 112-55).

Funds made available for grants under the AFRI program shall not be used for the construction of a new building or facility or the acquisition, expansion, remodeling, or alteration of an existing building or facility (including site grading and improvement, and architect fees).

4.4 Programmatic Information Specific to DOE

4.4.1 *Eligibility*

All types of entities are eligible to apply for funding from DOE, except Federally Funded Research and Development Center (FFRDC) Contractors, and nonprofit organizations described in section 501(c)(4) of the Internal Revenue Code of 1986 that engaged in lobbying activities after December 31, 1995.

4.4.2 *Collaborations*

Multidisciplinary and inter-institutional collaborations are strongly encouraged to enhance and strengthen research capabilities as needed. Collaboration could include institutions such as universities, industry, nonprofit organizations, Federal agencies, and Federally Funded Research and Development Centers (FFRDCs), which include the DOE National Laboratories. Collaborations involving the DOE National Laboratories are permitted; however, the efforts must reflect specific and unique capabilities/expertise at the collaborating DOE National Laboratory. These financial collaborations should show clear scientific leadership from the submitting institution and reflect an appropriate level of effort from the DOE National Laboratory and should not exceed 10% of the budget except for pay-for-use situations (i.e., sample analysis).

4.5 Programmatic Information Specific to NOAA

Eligible applications for the program implemented under this subpart (NOAA Ocean Acidification Awards) should be responsive to the research goals detailed within the *Strategic Plan for Federal Research and Monitoring of Ocean Acidification* that are consistent with the priorities of the USGCRP detailed in Part 2. These goals include but are not limited to: the development of comprehensive models to predict changes in the ocean carbon cycle, oceanic carbonate-buffer systems, and impacts on marine ecosystems, ensure the ability to measure all required carbonic acid system parameters with adequate data quality, improve interdisciplinary monitoring or both the chemical changes and biological impacts resulting from ocean acidification, and examine species-specific and multi-species physiological responses including behavioral and evolutionary adaptive capacities.

5. Summary of Key Information

Expected program budget for first year of new awards	NASA: $6.3 M; USDA: $1.67 M; DOE: $1 M; NOAA: $0.2M
Number of new awards pending adequate proposals of merit	NASA: 15-25; USDA: 5-7; DOE: 2-3; NOAA: 1-2
Maximum duration of awards	3 years

Due date for Notice of Intent to propose (NOI) proposals	See Tables 2 and 3 in the *ROSES Summary of Solicitation*.
Due date for Proposals	See Tables 2 and 3 in the *ROSES Summary of Solicitation*.
Planning date for start of investigation	January 1, 2017
Page limit for the central Science/Technical/Management section of proposal	15 pp; see also Chapter 2 of the *NASA Guidebook for Proposers*
Relevance to NASA, USDA, DOE, and/or NOAA	This program is relevant to the Earth Science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA. Proposals for other agency funding must address one or more of the agency-specific objectives listed in Section 2 of this Appendix.
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 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	NNH16ZDA001N-CARBON
NASA point of contact concerning this program	Paula Bontempi Earth Science Division Science Mission Directorate National Aeronautics and Space Administration Washington, DC 20546-0001 Telephone: (202) 358-1508 E-mail: paula.s.bontempi@nasa.gov
USDA point of contact concerning this program	Nancy Cavallaro Global Climate Change Program National Institute of Food and Agriculture U.S. Department of Agriculture Washington, DC 20250-2241 Telephone: (202) 401-5176 E-mail: ncavallaro@nifa.usda.gov

DOE point of contact concerning this program	Dan Stover Terrestrial Ecosystem Sciences Office of Science/Biological and Environmental Sciences U.S. Department of Energy Washington, DC Telephone: (301-903-0289) E-mail: daniel.stover@science.doe.gov
NOAA point of contact concerning this program	Dwight Gledhill Ocean Acidification Program National Oceanic and Atmospheric Administration 1315 East-West Highway, SSMC3 11355 Silver Spring, MD 20910 Telephone: (301) 734-1288 E-mail: dwight.gledhill@noaa.gov