A.28 INTERDISCIPLINARY RESEARCH IN EARTH SCIENCE

1. Scope of the Program

This solicitation is for new and successor interdisciplinary research investigations within NASA's Interdisciplinary Research in Earth Science (IDS) program. Proposed research investigations will meet the following criteria: a) offer a fundamental advance to our understanding of the Earth system; b) be based on remote sensing data, especially satellite observations, but including suborbital sensors as appropriate; c) go beyond correlation of data sets and seek to understand the underlying causality of change through determination of the specific physical, chemical, and/or biological processes involved; d) be truly interdisciplinary in scope by involving traditionally disparate disciplines of the Earth sciences; and e) address at least one of the five specific themes listed this solicitation:

- Understanding the Global Sources and Sinks of Methane
- Ecology at Land/Water Interfaces – Human and Environmental Interfaces
- Understanding the Linkages Among Fluvial and Solid Earth Hazards
- Life in a Moving Ocean
- Partitioning of Carbon Between the Atmosphere and Biosphere

The results of these investigations will improve our capability for both prognostic predictions and retrospective simulations of the Earth system. They will also advance our understanding of the vulnerabilities in human and biogeophysical systems and their relationships to climate extremes, thresholds, and tipping points. Meeting these goals requires approaches that integrate the traditional disciplines of the Earth sciences, as well as innovative and complementary use of models and data.

1.1 Context and History

Since its inception more than a decade ago, NASA's IDS program has advanced the goal of understanding the Earth system by promoting interdisciplinary research and exploiting the vast wealth of data from NASA satellite and airborne sensors. The program's focus has generally aligned with the goals of the U.S. Global Change Research Program (http://globalchange.gov/). Substantial contributions have also been made to Earth system model development, training the next generation of interdisciplinary scientists, and developing the necessary infrastructure to take full advantage of NASA satellite data.

The specific topics of the program have varied through time (see prior solicitations and awards at nspires.nasaprs.com), and this solicitation represents the development of new elements and the continuation of others.

2. Interdisciplinary Research Themes, Proposal Details, and Review information

Specific scientific topics and questions are identified as separate subelements within any given year's solicitation. These topics and questions constitute the complete set of scientific research topics solicited by the IDS program, and no priority should be construed from their relative order. Proposals submitted in response to this element must address at least one of these subelements, and proposals must identify clearly which subelement or subelements are addressed. Proposed research investigations must also meet all of the following criteria, and each of these should be specifically addressed in the proposal:

- offer a fundamental advance to our understanding of the Earth system;
- be based on remote sensing data, especially satellite observations, but including suborbital sensors as appropriate;
- go beyond correlation of data sets and seek to understand the underlying causality of change through determination of the specific physical, chemical, and/or biological processes involved;
- be truly interdisciplinary in scope by involving traditionally disparate disciplines of the Earth sciences; and
- address at least one of the specific subelements listed in the solicitation.

Proposals developing significant new datasets must include a data management plan.

NASA expects to have separate peer review panels for each subelement, and proposals will be assigned to one or more panels based on the proposer's identification of the appropriate subelement, as well as NASA's assessment of proposal content. While NASA expects to select proposals in each of the subelements, NASA reserves the right to select proposals in none, some, or all of these depending on the nature and distribution of proposals received and the outcome of the peer review process.

2.1 Subelement 1: Understanding the Global Sources and Sinks of Methane

Methane (CH_4) is an important greenhouse gas (GHG) with large natural and anthropogenic sources. It is responsible for 20% of the global warming produced by all well-mixed greenhouse gases, and constitutes 60% of the climate forcing by CO_2 since preindustrial times. It is an important driver of tropospheric ozone (O_3) and tropospheric OH, the primary atmospheric oxidant. Methane also contributes to water vapor (H_2O) in the stratosphere. Methane-induced cooling of the stratosphere (mainly due to increased water vapor) is a significant issue. However, the sources responsible for the methane trends during recent decades are poorly understood. The U.S. Global Change Research Program (USGCRP) has defined "Methane Cycling within the Carbon Cycle Framework" as a FY 2017 thematic interagency priority. The recent growth in atmospheric methane concentration (following a nearly ten-year plateau), the development of observational capability, the ability to build on advances from the combination of newly-available global data, and the evolving suite of global biogeochemical models all make methane a timely subject.

A NASA Atmospheric Composition Focus Area workshop, held in 2014 (https://espo.nasa.gov/home/sites/default/files/documents/SMDWorkshop_report_final.docx), noted that satellite observations of methane combined with *in situ* observations of fluxes are making important contributions to quantifying anthropogenic emissions (fossil fuel extraction and use, agriculture, landfills) and natural emissions (in particular, from wetlands). The workshop report concluded that better validated space-based methane measurements could constrain top-down approaches to deriving emissions. Satellite observations of methane will also need support from suborbital measurements, including co-emitted species (e.g., hydrocarbon ratios and agricultural tracers) and isotopic methane.

Methane emissions from terrestrial ecosystems play an important role in the atmospheric methane budget. These emissions can be grouped into two categories: biogenic and pyrogenic. Biogenic sources contain methane-generating microbes in anaerobic environments, such as natural wetlands and rice paddies, oxygen-poor freshwater reservoirs, digestive systems of ruminants and termites, and organic waste deposits (such as manure, sewage, and landfills). Pyrogenic methane is produced by the incomplete combustion of biomass and soil carbon during wildfires and of biofuels and fossil fuels. There is a growing database on these various terrestrial and aquatic sources, but the ability of biogeochemical models to accurately and realistically estimate and predict methane emissions from these diverse sources is limited. Better understanding and differentiating the role of managed versus unmanaged ecosystems in the global methane cycle is an important scientific challenge that needs to be addressed. Improving the use of remote sensing of the biophysical states, land use, and land cover properties of the surface as input into biogeochemical models is encouraged.

The role of the ocean in the global methane cycle, and the corresponding role of methane in the broader oceanic carbon cycle, is in need of further research. Given the potential for changes in methane cycling processes as the ocean continues to absorb atmospheric heat, and the potential for large positive feedback effects on global warming, further research is warranted in these areas. A focus on understanding the role of methane in the oceanic carbon cycle and the associated processes (physical, chemical, and biological) that lead to atmospheric exchange of methane with the ocean is, therefore, warranted. Linking increased understanding of these processes with existing atmospheric methane and global carbon cycle models is also of interest. Of particular interest are studies examining the impact of changing oceanic heat content on production (e.g., anaerobic methanogenesis), cycling (e.g., uptake and/or catabolism), and stored inventories (e.g., methane hydrates). As the Earth system and climate warms, it is possible that methane hydrates could destabilize and release methane, a major greenhouse gas, to the atmosphere. The carbon cycle and climate impact of this outgassing is of interest, particularly if the capability to model the outgassing and fate of the methane output could be quantified.

In this subelement, NASA solicits proposals that address research issues relevant to the global methane cycle. Potential areas of interest include, but are not limited to:

- Improved understanding of the processes, source types, and fluxes responsible for natural and anthropogenic methane emissions and emission trends;
- Analysis of the global methane budget over the past 40 years to reconcile observed changes in the ambient atmospheric methane mixing ratio for various zonal regions;
- Integration of top-down and bottom-up approaches to obtain a better understanding of the processes controlling methane sources;
- Research that integrates some or all of terrestrial and aquatic methane sources and sinks into a mechanistic and predictive framework;
- Analytical approaches for separating the contributions and possible interactions of managed versus unmanaged ecosystems to overall methane emissions;
- Using satellites to detect oceanic methane release, from hydrates or other sources, with an eye towards tracking the oceanic release of methane into the atmosphere;

- Understanding, quantifying, and/or modeling methane in the ocean or methane that is transferred from ocean to atmosphere, including novel approaches to track a surface ocean or ocean to atmosphere signature of methane release; and
- Utilization of climate models to simulate the current evolving sources and sinks of methane and the evaluation of methane's near-term climate effects and feedbacks.

In addressing this subelement, proposers are expected to link several of the topics described above through the significant use of space-based remote sensing data (with preference given to NASA-produced data sets). Space-based data may be used, together with data from airborne sensors, surface-based instruments, and/or models of sufficient scope to address the coupled aspects of the problem. Proposed projects are expected to include primarily data analysis and modeling. However, some modest additional airborne and/or surface-based measurements are allowed. All costs for these measurements (e.g., flight hour costs, travel, etc.) must be included in the proposal budget. Proposals are expected to be interdisciplinary in scope and to specifically address the connections addressed in this subelement. Proposals that address only a single component (e.g., solely atmospheric composition) will be considered nonresponsive to this subelement. Multidecadal future climate simulations are not encouraged.

2.2 Subelement 2: Ecology at Land/Water Interfaces - Human and Environmental Pressures

Land/water interfaces, including coastal regions, hold tremendous economic, recreational, and commercial value, supporting extensive resources, such as fisheries and agriculture. Coastal areas and freshwater ecosystems are highly sensitive ecologically and among the most threatened environments on Earth. These regions will change if not properly managed and/or protected. For example, one of the major pressures on land/water interfaces affecting the availability of ecological resources is urbanization. Urban encroachment is affecting coastal areas and freshwater ecosystems worldwide. The extent of conversion of near-coastal and other wetland areas to farmland and the abandonment of historic farmlands to urban or peri-urban settlement are both increasing. Research and management communities must work together to understand the impact of environmental change, climate change, land use decisions, and human activities on dynamic ecosystems at the land/water interface. Managers must ensure ecosystem resilience through collaborative planning, using the results of basic research activities to enable informed decision making and the sustainability of natural resources.

Causes, drivers, and impacts of an expanding human population are reflected in land cover/land use practices, the terrestrial hydrology and ecology, and associated ocean biology and biogeochemistry. Therein, this announcement encompasses coastal areas traditionally defined as marine or saltwater, and it also includes ecosystems associated with streams, lakes, and other land/water interfaces where local ecosystems are subject to human and environmental pressures. NASA welcomes proposals that seek to understand and quantify the impacts and feedbacks of human and environmental influences on land/water interfaces (including coastal) ecosystems with a focus on the biology and ecology of these ecosystems. Locally-induced changes (e.g., due to urbanization or other land use change) do not occur independent of other changes, such as those coming from regional changes associated with global change (e.g., sea level rise, change in precipitation). Studies that take these broader-scale changes into account as part of studies addressing more locally human-induced changes in coastal (or other land/water interface areas) are of particular interest. The objective is to understand, quantify, and model how the specific effects of humans and environmental variability and change impact the ecosystems (structure, composition, function) at the land/water interfaces. One example might be to quantify the biological impact(s) and feedback(s) of human populations and urbanization to local wetlands. Incorporation of retrospective studies or data analyses is also welcome, specifically studies that may look at future ecosystem impacts based on knowledge of the past Earth system or environmental variability and change or human influence (using models whose application is verified by the observations). Any retrospective analyses should make a clear link to an assessment of future ecosystem changes and take into account different scenarios for environmental or human forcing in the future

Integrative research is sought to apply NASA remote sensing (satellite and/or suborbital) observations to the characterization of biological and ecological impacts of human pressures and environmental (including climate) variability and change on the land/water interface. For example, within the domains of coastal zone ecology or freshwater ecology, a wide variety of terrestrial and aquatic ecosystem impacts and vulnerabilities could be addressed in proposals submitted in response to this subelement of the solicitation, but not all will be equally important. Therefore, proposals must offer compelling rationales as to 1) the clear definition and "geographic" boundaries of the ecosystem(s) under study, 2) why the impacts and/or vulnerabilities of a given ecosystem(s) to be studied are expected to be highly significant, representing major perturbations to the Earth system, and 3) how the remote sensing data products to be utilized in the study provide unique and powerful information for addressing the ecosystem(s) research issues/questions posed. Ecosystem in this context could be defined on any number of scales, but the ecosystem under study and planned research must be compellingly defined and justified in the global context.

NASA seeks projects that combine existing (a) satellite data (including, but not limited to NASA's), (b) field observations, including suborbital remotely sensed data, and (c) observationally-driven models to address the challenges of understanding the impacts and feedbacks of environmental change and/or human pressures on ecosystems at the land/water interface. Proposals must include all three of these elements. Projects should use existing NASA satellite data, existing suborbital data, and/or existing field data, although new data collections (*in situ*, suborbital, or remote) may be proposed, if justifications for the new satellite and suborbital remote sensing data collection and/or field observations are compelling. Projects should delineate and justify the scientific basis for the proposed geographic region of study (the land/water ecosystem). The goal is to provide an understanding of and predictive capability for ecosystem organization and management, especially accounting for the drivers of human pressure and environmental variability and change

2.3 Subelement 3: Understanding the Linkages Among Fluvial and Solid Earth Hazards

2.3.1 *Background*

Extreme hazard events may trigger a series of cascading hazards that can collectively pose a greater societal risk than the initial source event. In this subelement, NASA would like to move beyond the study of individual and isolated major regional hazards and begin to understand the physical linkages between the initial trigger event and the subsequent hazards. Extreme hazards are infrequent, significant events often impacting a large geographic area (hundreds of square kilometers), have global implications, and/or have broad societal impact. The associated cascading hazards collectively have a similar scale or may be more significant than the initial trigger. This subelement focuses on the understanding the relationships, interdependencies, preconditioning parameters, triggering thresholds, and tipping points among fluvial and solid Earth hazards that can be ascertained with remote sensing data alone or when coupled with additional *in situ* data.

There have been several extreme hazard events in the past few decades that have triggered multiple cascading hazards. The 1991 eruption of Mount Pinatubo injected an estimated 20 million tons of sulfur dioxide and ash particles into the stratosphere, which circled the globe for weeks, influencing atmospheric chemistry and climate for the next several years. The eruption, in combination with monsoons and a typhoon that coincidentally followed, killed hundreds of people, sent ash, lahars, and mudflows across the landscape and into the ocean, thereby decimating regional ecosystems, rendering cropland unusable, killing corals, significantly impacting the fisheries, and altering watersheds. Another set of examples is the major woodland fires in the Western U.S. throughout the past two decades that have burned and sometimes reburned hundreds of thousands hectares. Following the fires, the denuded landscapes have an elevated time-varied susceptibility for fluvial driven hazards such as debris flow, landslides, flooding, and other dynamic topographic/fluvial hazards that often extended well beyond the boundaries of the initial burn area. A final example is the 2015 Gorkha earthquake in Nepal, which triggered over 3,500 landslides and avalanches in the Himalayas, many of them either partially or completely damming rivers in the valleys below, resulting in localized flooding and the potential risk of debris dam failures. Monsoon rainfall following the earthquake sequence triggered additional river crossing landslides and other mass wasting events, thereby putting communities upstream and downstream at an elevated risk.

2.3.2 *Scope of Program*

NASA’s Earth Science Division coordinates a series of satellite and airborne missions for long-term global observations of the land surface, biosphere, solid Earth, atmosphere, and oceans. This approach enables an improved understanding of the Earth as an integrated system. In this subelement, NASA requests proposals that move beyond the study of individual hazards and investigate the fundamental process, critical preconditioning parameters, and the tipping points that are associated with triggering either a secondary hazard or a series of cascading hazards through the integration of space-based remote sensing data with *in situ* observations and computer modeling. The goals of this solicitation are (1) to advance our fundamental understanding about the linkage between and among hydrology and solid Earth hazards, (2) to develop predictive models that identify possible solid Earth-hydrology related cascading hazards and estimate their scale, spatial magnitude, and location (as appropriate for the hazard) based on the initial trigger event and relevant preconditioning observations and, (3) to develop hydro-topography scaling parameters that transform our understanding of local processes and address regional and global sediment transport and mass wasting processes.

Successful proposals to this subelement will (1) develop an interdisciplinary research approach that incorporates representative members of the solid Earth, terrestrial hydrology, and modeling communities and (2) will exploit the unique role that satellite and airborne remote sensing data can play in understanding the causes and impacts of these "downstream" events.

Some of the science questions that NASA is interested in include, but are not limited to: What are the relationships, interdependencies, preconditioning parameters, triggering thresholds, and tipping points between hydrology and solid Earth hazards that can be ascertained with remote sensing data alone or when coupled with additional *in situ* data? How can these remotely sensed factors be used to understand the likelihood of triggering a secondary hazard or a series of cascading hazards and to understand how the likelihood evolves over time? How do changes in climatic patterns, such as precipitation regimes, influence the scale, magnitude, and location of both the initial event and the potential for triggered hazards that follows? How do changes in climatic patterns influence future hazard susceptibility? Potential linked hazards include, but are not limited to: understanding the significance that soil moisture, rainfall intensity/duration/direction, climatic and environmental variability, slope aspect, and topography parameters relate to mass wasting potential (landslides, lahars, debris flows, large-scale sediment transport) following volcanic eruptions, earthquakes, fires, or droughts; and understanding how these parameters can be scaled with remote sensing observations to address and forecast large-scale regional and global hazards.

Proposals to this subelement must:

- Make significant, but not necessarily exclusive, use of NASA produced remote sensing data and/or products.
- Be interdisciplinary in scope. Proposals must include substantive involvement of investigators from the solid Earth, terrestrial hydrology, and modeling communities
- Proposals may additionally include investigators from other disciplines, such as ecosystem and/or social scientists.
- Address the multihazards connections between a solid Earth hazard and a nonsolid Earth hazard component (e.g., hydrology). Proposals that address only a single hazard (e.g., just earthquakes or floods) will be considered nonresponsive to this subelement.
- Go beyond correlation of datasets and use models to connect observations and gain new insight into the physical processes and underlying causality.
- Develop approaches that can be broadly applied and are not tied to site-specific examples.

Substantive connection to NASA-conducted remote sensing data or distributed products is required in all proposals; proposals may include use of non-NASA data in addition to that from NASA. Proposers are encouraged to utilize existing or planned ground, airborne, and space-based observational capabilities and their associated data sets. This solicitation will support limited purchase of new satellite data and limited collection of new airborne imagery – see below for requirements. This solicitation will focus on scientific linkages of cascading hazards and will not consider real-time or near real-time disaster management and disaster response proposals that directly support disaster decision support systems. Large area floods that are only initiated by large storms or hurricanes/typhoons will not be considered in this solicitation.

2.4 Subelement 4: Life in a Moving Ocean

Upcoming NASA missions (e.g., SWOT) will resolve energetic scales of motion in the ocean that have never been sampled globally. The planned Pre-Aerosol, Cloud, ocean Ecosystem (PACE) mission will make unprecedented observations of ocean ecology. These missions will provide an opportunity to make available global high-resolution observed ocean currents for co-registration with ocean ecosystem data. Delineation of the associated physical and biological fronts in conjunction with finer-scale data on the movements of organisms will enable tracking of marine fish and mammal species and patches of marine debris patches. It will also promote efforts to understand better the dynamics of marine biogeographic provinces, which regularly reconstitute themselves temporally and spatially across the global ocean.

NASA seeks proposals to enable preparations for future space missions by improving its current ability to integrate remote sensing of ocean motion at approximately 10km spatial scale with similar or finer scale data on the movement of marine fish, mammal, and other species, as well as the movement of marine debris. Coupling existing ocean current information from sources such as the Ocean Surface Current Analyses Real-time (OSCAR) and GlobCurrent data sets with the aforementioned types of biological movement information builds a foundation for improving understanding of how life moves in the world's oceans. Doing so has significant implications for ecosystem-based management.

Phytoplankton, the ocean's primary producers, and zooplankton, the ocean's primary consumers and the larvae of many higher-level consumers, make up plankton. Plankton health supports all levels of marine life, including commercial fish species and protected marine mammals. Plankton are distributed in the global ocean by surface currents, as well as by the impacts of surface currents on the vertical and horizontal movement of the ocean. Surface ocean currents can strongly influence the location of nutrients that support phytoplankton growth and transfer heat across ocean basins. Thus, currents are key mediators of global ocean ecosystems, as well as climate. Furthermore, currents are primary distributors of marine debris. Finally, through the physical formation of oceanic fronts, marine currents are first-order organizers of marine biomes, provinces, and ecosystems—the organizational components of marine biogeography.

This subelement seeks proposals to address the following high-level question:

How can the coupling of physical ocean current and ocean ecosystem data improve either: the ecosystem-based management of the ocean or our understanding of the organization of the dynamic biogeography of the marine realm?

All proposals to this subelement must use existing satellite and *in situ* observations, as well as models.

The evolution of smaller and more robust electronic devices to track the movement of fish, marine mammals, and other ocean species is driving new research in the expanding field of movement ecology. To date, these tools are rarely used in conjunction with satellite imagery in a manner that places the fine-scale organismal movement information into its broader and also dynamic environmental context. Aligning movement information with global ocean current data establishes a cause and effect framework that provides critical information about physical drivers of the geography of marine ecosystems. The union of these different types of data is required if we are to make progress in establishing a much more dynamic science of marine biogeography, i.e., a complex predictive science of life in motion within a fluid medium.

Proposals to this subelement must involve interdisciplinary teams of satellite oceanographers, marine biologists, and those with modeling expertise appropriate to the science questions proposed. Proposals must also include remote sensing information on ocean currents from satellite and/or airborne instruments, for example Advanced Very High Resolution Radiometer (AVHRR), the Jason series, QuikSCAT/SEAWINDS, and MODIS along with other satellite and airborne platforms. They must also include *in situ* field measures of the movement of marine fish, mammals, other organisms, or marine debris.

Proposals to this subelement should also include physical and ecological models that integrate the ocean physical and biological observations to address the science questions proposed. Proposals may incorporate a range of methodologies for resolving the complex dance of the geophysical and ecological elements of a given study area.

Here are some notional examples of specific proposal topics—meant only to be exemplary and not definitive or exhaustive.

- What was the impact of the 2011 Japan Tsunami debris on North Pacific fisheries?
- How are ocean circulation patterns moving abandoned fishing gear (e.g., ghost nets), widely distributed plastic particles, oil spills, or other oceanic hazards and what are the resulting impacts on marine ecosystems and organisms?
- Based on the movement of organisms and nutrients, how are biogeographic provinces organized within the vast pelagic realm and can we track their movement through time?
- Can information on surface currents and patterns of organismal movement inform better management in a time of changing climate?
- Can we bridge the current gap between our ability to remotely sense and model the distribution and abundance of phytoplankton taxa and our *inability* to remotely sense and model the distribution and abundance of zooplankton taxa?

2.5 Subelement 5 – Partitioning of Carbon Between the Atmosphere and Biosphere

An important feature associated with the continuing emission of carbon dioxide into the Earth's atmosphere from human activity is that, on average, only about half of the increased emissions remain in the atmosphere; the reminder are taken up by biophysical processes in Earth's biosphere (land surface and ocean). While these biophysical processes might continue to take up a significant fraction of fossil fuel and land use change emissions, it is also possible that they might diminish, disappear, or reverse direction in the future as human activities influence environmental and climate change. This is one of the major sources of uncertainty that must be reduced if scientists are to improve predictions of future climate. Thus, accurate representation of the processes that govern the longer-term exchange of carbon between the atmosphere and the biosphere is critically needed. If the strength of the biospheric carbon sink changes, then the sensitivity of climate to fossil fuel and land use change emissions also changes. This has potentially large implications as scientific input to public policy decisions.

The complexity of the carbon-climate system has been clearly demonstrated through existing observational evidence that the fraction of emitted carbon dioxide that is taken up by the biosphere can fluctuate significantly from one year to the next. Indeed, in certain years, the terrestrial carbon sink has essentially disappeared. Interannual and seasonal variability represent both a scientific challenge and an opportunity to our understanding of the biosphere response to environmental change and its feedback to the climate system.

In this subelement, proposals are sought that address the issue of the temporal variability of the uptake of carbon dioxide by the biosphere. While there is a particular interest here in addressing this phenomenon over a multidecadal time frame, studies that make use of the interannual variability to gain insight into decadal and longer-term variability are encouraged.

Studies proposed to this subelement must include coupled analyses of both atmospheric carbon dioxide and the terrestrial and/or marine biophysical processes that contribute to emissions and uptake, as well as the distribution of carbon stocks on land and/or in the ocean; studies that fully integrate the global carbon cycle to include atmosphere, land, and ocean are preferred. However, while studies should be global in extent, zonal, regional, and continental scale analyses that help determine the contributions and sensitivities of smaller scale phenomena to the global scale are also pertinent. All studies must make significant, but not necessarily exclusive, use of NASA-produced satellite data; use of NASA-produced or other airborne data is encouraged, but not required. Studies must use models that provide a representation of the relevant processes to integrate disparate data sets; studies that are based simply on empirical relationships, or correlation will be considered nonresponsive and returned without review.

Studies that both use existing data sets and address how data sets that NASA is looking to make available in the next few years (e.g., ICESat-2, GEDI, ECOSTRESS, NISAR, PACE) are of particular interest, but all studies must make use of existing data to test quantitatively the hypotheses based on currently available atmospheric and surface data.

While the expectation is that proposals to this subelement will make use of existing data, the opportunity exists for acquisition of small amounts of additional airborne data. The full cost of such data acquisition must be included with the proposal, and appropriate input based on discussion with the Airborne Science Program must be provided.

3. Requirement for Proposals Requesting Acquisition of New Airborne Data

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 and 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 https://airbornescience.nasa.gov/. If the instrument or aircraft 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. Summary Table of Key Information

Expected program budget for first year of new awards	~$10.5M Total ~$2.5M/year each for subelements 1, 2, and 5; ~$1.5 M/year each for subelements 3 and 4
Number of new awards pending adequate proposals of merit	~ 4-6 each for subelements 1, 2, and 5; 3-5 each for subelements 3 and 4
Maximum duration of awards	3 years
Due date for Notice of Intent	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	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.
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	NNH16ZDA001N-IDS

Main NASA point of contact concerning this program. See below for points of contact specific subelements.	Overall: Jack A. Kaye Earth Science Division Science Mission Directorate National Aeronautics and Space Administration Washington, DC 20546-0001 Telephone: (202) 358-2559 E-mail: Jack.A.Kaye@nasa.gov

General questions about the IDS Program should be directed to the point of contact above. Questions about specific subelements should be directed to those listed below, all of whom share the same mailing address, listed below.

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