Integrated Earth Systems (IES)

PROGRAM SOLICITATION
NSF 15-600

REPLACES DOCUMENT(S):
NSF 12-613

National Science Foundation

Directorate for Geosciences
Division of Earth Sciences

Full Proposal Deadline(s) (due by 5 p.m. submitter's local time):

November 16, 2015

November 14, Annually Thereafter

IMPORTANT INFORMATION AND REVISION NOTES

Readers are referred to additional information in the Frequently Asked Questions (FAQs) in section X. Appendix of this solicitation.

Other updates were minor editorial wording changes.

Any proposal submitted in response to this solicitation should be submitted in accordance with the revised *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) (NSF 16-1), which is effective for proposals submitted, or due, on or after January 25, 2016.

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

Integrated Earth Systems (IES)

Synopsis of Program:

Integrated Earth Systems (IES) is a program in the Division of Earth Sciences (EAR) that focuses on the continental, terrestrial and deep Earth subsystems of the whole Earth system. The overall goal of the program is to provide opportunity for collaborative, multidisciplinary research into the operation, dynamics and complexity of Earth systems at a budgetary scale between that of a typical project in the EAR Division's disciplinary programs and larger scale initiatives at the Directorate or Foundation level. Specifically, IES will provide research opportunities for the study of Earth systems that operate across components of the Earth encompassing the core of the Earth to the top of the critical zone with a specific focus on subsystems that include all or part of the continental, terrestrial and deep Earth subsystems at all temporal and spatial scales (NROES, 2012). IES will provide opportunities to focus on Earth systems connected to topics which include (but are not limited to) the continents; the terrestrial, surficial Earth systems including physical, chemical and biotic dimensions; linkages among tectonics, climate, landscape change, topography and geochemical cycles including core and mantle processes.

Cognizant Program Officer(s):

Please note that the following information is current at the time of publishing. See program website for any updates to the points of contact.

- Leonard E. Johnson, Program Director, telephone: (703) 292-8559, fax: 703-292-9025, email: lejohnso@nsf.gov

- Thomas Torgersen, Program Director, telephone: 703-292-8549, fax: 703-292-9025, email: ttorgers@nsf.gov

Applicable Catalog of Federal Domestic Assistance (CFDA) Number(s):

- 47.050 --- Geosciences

Award Information

Anticipated Type of Award: Standard Grant or Continuing Grant

Estimated Number of Awards: 4 to 10

4 to 10 new awards per year. The award size for IES projects is expected to range between $1,000,000 and $3,000,000 for projects of 3 to 5 years duration, although smaller awards may be made. The scope of IES projects is expected to be beyond that which can be supported in EAR's disciplinary programs.

Anticipated Funding Amount: $9,000,000

pending availability of funds.

Eligibility Information

Who May Submit Proposals:

> The categories of proposers eligible to submit proposals to the National Science Foundation are identified in the Grant Proposal Guide, Chapter I, Section E.

Who May Serve as PI:

> There are no restrictions or limits.

Limit on Number of Proposals per Organization:

> There are no restrictions or limits.

Limit on Number of Proposals per PI or Co-PI:

> There are no restrictions or limits.

Proposal Preparation and Submission Instructions

A. Proposal Preparation Instructions

- **Letters of Intent:** Not required

- **Preliminary Proposal Submission:** Not required

- **Full Proposals:**

    - Full Proposals submitted via FastLane: NSF Proposal and Award Policies and Procedures Guide, Part I: Grant Proposal Guide (GPG) Guidelines apply. The complete text of the GPG is available electronically on the NSF website at: http://www.nsf.gov/publications/pub_summ.jsp?ods_key=gpg.
    - Full Proposals submitted via Grants.gov: NSF Grants.gov Application Guide: A Guide for the Preparation and Submission of NSF Applications via Grants.gov Guidelines apply (Note: The NSF Grants.gov Application Guide is available on the Grants.gov website and on the NSF website at: http://www.nsf.gov/publications/pub_summ.jsp?ods_key=grantsgovguide)

B. Budgetary Information

- **Cost Sharing Requirements:**

    Inclusion of voluntary committed cost sharing is prohibited.

- **Indirect Cost (F&A) Limitations:**

    Not Applicable

- **Other Budgetary Limitations:**

    Not Applicable

C. Due Dates

- **Full Proposal Deadline(s)** (due by 5 p.m. submitter's local time):

    November 16, 2015

    November 14, Annually Thereafter

Proposal Review Information Criteria

Merit Review Criteria:

National Science Board approved criteria. Additional merit review considerations apply. Please see the full text of this solicitation for further information.

Award Administration Information

Award Conditions:

Standard NSF award conditions apply.

Reporting Requirements:

Standard NSF reporting requirements apply.

TABLE OF CONTENTS

I. INTRODUCTION

Earth science research involves the study of physical, chemical, and biological processes that interact and combine in many ways to produce a wide range of dynamic Earth systems. These Earth systems are characterized by their complexity, their non-linearity, and their continuous evolution. They interact with one another over a wide variety of space and time scales and can produce multiple and diverse outcomes. These characteristics present significant hurdles to our ability to understand and forecast the behavior of a complex and evolving Earth, including the human impact or impact on humans.

IES is a program in the Division of Earth Sciences (EAR) that focuses specifically on the continental, terrestrial and deep Earth subsystems of the whole Earth system. Overall, the goals of IES are to:

- provide opportunity for collaborative, multidisciplinary research into the operation, dynamics and complexity of Earth systems at a budgetary scale between that of a typical project in the EAR Division's disciplinary programs and larger scale initiatives at the Directorate or Foundation level;
- support study of Earth systems that builds on process-oriented knowledge gained from EAR programmatic research and enables systems-level hypothesis testing and analysis of coupled processes;
- provide a "bridge" among the EAR disciplinary programs in order to foster the exchange of questions, ideas, and knowledge between disciplinary discovery and system-level investigations.

Specifically, IES will provide research opportunities for the study of Earth systems that operate across components of the Earth encompassing the core of the Earth to the top of the critical zone with a specific focus on subsystems that include all or part of the continental, terrestrial and deep Earth subsystems at all temporal and spatial scales (NROES 2012). IES will provide opportunities to focus on Earth systems connected to topics which include (but are not limited to) the continents; the terrestrial, surficial Earth systems including physical, chemical and biotic dimensions; linkages among tectonics, climate, landscape change, topography and geochemical cycles including core and mantle processes.

II. PROGRAM DESCRIPTION

IES is a program to specifically involve the component disciplines of programs in EAR. The IES focus will be on the operation and evolution of continental, terrestrial and deep Earth systems over spatial scales that range from global to regional to local to grain scale, and on all timescales. Quantifying these complex systems requires extensive data on fluxes, structures, and evolution of the system as well as information on how such fluxes are interconnected within a specific system. Because of the rapid expansion of facilities to observe and monitor terrestrial properties and fluxes (sampling mechanisms, arrays, sensors, satellites, LiDAR, etc.), as well as evolving experimental techniques and capabilities, data volumes (especially at the Earth-system scale), will soon be measured in petabytes. Understanding the behavior and evolution of complex systems typically lies beyond the abilities and expertise of the single scientist and will require cooperative and integrated efforts in data collection (whether archived, legacy, or newly observed) and analysis as well as integrative studies that combine large, diverse data sets in the construction and testing of explanatory Earth systems models.

An effective organizational schema for multidisciplinary IES research is the concept of a system-level model. Constructing, testing and improving such models will require an iterative cycle of hypothesis forming, data gathering and analysis, hypothesis testing, and model improvement (not always in that order). An essential measure of how well a particular system or subsystem is understood will be the ability to extrapolate observed behaviors into new regimes and confirm them with additional data or observations. IES is a "bridge" among the EAR disciplinary programs and is intended to foster the exchange of questions, ideas, and knowledge between disciplinary discovery and system-level investigations. Existing EAR disciplinary programs provide key knowledge that feeds system-level understanding and IES will, in turn, provide the EAR disciplines with new hypotheses for testing and expose new needs for process understanding. The recent (2012) National Research Council (NRC) report *New Research Opportunities in the Earth Sciences* (NROES) has identified a number of areas of greatest near-term research opportunity that all involve integrative interdisciplinary efforts focused on specific dynamic Earth systems. IES thus presents an opportunity to integrate and amplify the outputs from disciplinary EAR program science in a coherent and holistic systems framework.

IES projects are expected to involve collaborations among investigators from different EAR disciplinary specialties. Inclusion of collaboration with other science fields is also welcome but the primary focus is on advancing EAR disciplines rather than advancing disciplines outside the EAR programmatic structure.

Readers are referred to additional information in the Frequently Asked Questions (FAQs) in section X. Appendix of this solicitation.

III. AWARD INFORMATION

Anticipated Type of Award: Continuing Grant or Standard Grant

Estimated Number of Awards: 4 to 10

4 to 10 new awards per year. The award size for IES projects is expected to range between $1,000,000 and $3,000,000 for projects of 3 to 5 years duration, although smaller awards may be made. The scope of IES projects is expected to be beyond that which can be supported in EAR's disciplinary programs.

Anticipated Funding Amount: $9,000,000 pending availability of funds.

IV. ELIGIBILITY INFORMATION

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> The categories of proposers eligible to submit proposals to the National Science Foundation are identified in the Grant Proposal Guide, Chapter I, Section E.

Who May Serve as PI:

> There are no restrictions or limits.

Limit on Number of Proposals per Organization:

> There are no restrictions or limits.

Limit on Number of Proposals per PI or Co-PI:

> There are no restrictions or limits.

V. PROPOSAL PREPARATION AND SUBMISSION INSTRUCTIONS

A. Proposal Preparation Instructions

Full Proposal Preparation Instructions: Proposers may opt to submit proposals in response to this Program Solicitation via Grants.gov or via the NSF FastLane system.

- Full proposals submitted via FastLane: Proposals submitted in response to this program solicitation should be prepared and submitted in accordance with the general guidelines contained in the NSF Grant Proposal Guide (GPG). The complete text of the GPG is available electronically on the NSF website at: http://www.nsf.gov/publications/pub_summ.jsp?ods_key=gpg. Paper copies of the GPG may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-7827 or by e-mail from nsfpubs@nsf.gov. Proposers are reminded to identify this program solicitation number in the program solicitation block on the NSF Cover Sheet For Proposal to the National Science Foundation. Compliance with this requirement is critical to determining the relevant proposal processing guidelines. Failure to submit this information may delay processing.

- Full proposals submitted via Grants.gov: Proposals submitted in response to this program solicitation via Grants.gov should be prepared and submitted in accordance with the NSF Grants.gov Application Guide: A Guide for the Preparation and Submission of NSF Applications via Grants.gov. The complete text of the NSF Grants.gov Application Guide is available on the Grants.gov website and on the NSF website at: (http://www.nsf.gov/publications/pub_summ.jsp?ods_key=grantsgovguide). To obtain copies of the Application Guide and Application Forms Package, click on the Apply tab on the Grants.gov site, then click on the Apply Step 1: Download a Grant Application Package and Application Instructions link and enter the funding opportunity number, (the program solicitation number without the NSF prefix) and press the

In determining which method to utilize in the electronic preparation and submission of the proposal, please note the following:

Collaborative Proposals. All collaborative proposals submitted as separate submissions from multiple organizations must be submitted via the NSF FastLane system. Chapter II, Section D.5 of the Grant Proposal Guide provides additional information on collaborative proposals.

See Chapter II.C.2 of the GPG for guidance on the required sections of a full research proposal submitted to NSF. Please note that the proposal preparation instructions provided in this program solicitation may deviate from the GPG instructions.

Except as modified below, full proposals should be prepared in accordance with the guidelines in the Grant Proposal Guide or NSF Grants.gov Application Guide.

Project Description:

The Project Description section should contain three parts, each with specific page lengths (28 pages total):

1. Proposed Research (**20 pages** maximum)
   - A description of the proposed system(s) to be investigated and interaction(s) with other Earth systems over relevant space and time scales.
   - A description of the integrative studies using diverse data sets to be used in the elaboration of explanatory systems models.
   - A plan to evaluate the validity of Earth system models (e.g. by forecasting the behavior of the system being modeled and comparing model outputs to observational data).
2. Management and Integration Plan (**4 pages** maximum - in addition to the 20 pages for research).

   The Management and Integration Plan should:

   - describe how the team effort will be coordinated;
   - describe how the leaders of the disciplinary components of the IES study will effectively integrate the science and the plan;
   - describe how data, models, ideas will be disseminated and shared within the research team and when appropriate across the research community;
   - provide a timeline of expected outcomes.
3. Results of prior Support: (**4 pages maximum** for **all** PIs, coPIs - in addition to the 20 pages for the project description).

Supplementary Documents:

Use of NSF Research Platforms and Facilities: Projects that will be utilizing NSF research platforms (e.g. ships, airplanes, etc) or other shared use facilities (e.g. field instrumentation, analytical or experimental facilities) are responsible for filing a copy of their Request for Facility Support as a supplementary document in their proposal. PIs should coordinate their requests with the appropriate facility to ensure that access is available to the facility and fits within the time line of the proposed research.

Computational Facilities: For projects that will be utilizing NSF computational facilities, a copy of the allocation request that would be submitted to the facility in question should be provided as a supplementary document.

Data Management: Proposals must include a data and information management plan that describes how access to quality controlled and fully-documented data and information by all researchers, and others, will be achieved at no more than incremental cost and within a reasonable time during the course of the award, e.g., via a recognized data repository. The plan should address, as appropriate, provisions for reuse and derivative use, archival plans, and preservation of access. The data plan should identify where and how data will be archived as well as identifying the catalogues used to register the data and the portals through which data are accessible.

Post doctoral Research Mentoring Plan: Proposals that request funding for postdoctoral researchers must include a one-page mentoring plan in accordance with guidance in the GPG.

Official letters of commitment and/or participation: Only official letters that verify specific institutional and other sector resource commitments or participants should be included as supplementary documents.

Single Copy Documents:

Proposals must include a conflicts of interest table, in the single copy documents section of FastLane, as a list in a single alphabetized table, with the full names and institutional affiliations of all people with conflicts of interest for all senior personnel (PI and co-PIs) and any named personnel whose salary is requested in the project budget. Conflicts to be identified are (1) Ph.D. thesis advisors or advisees, (2) collaborators or co-authors, including postdoctoral researchers, for the past 48 months, and (3) any other individuals with whom or institutions with which the senior personnel (PI, co-PIs, and any named personnel) have financial ties, significant other relations, including advisory committees (please specify type). (This list generally replicates information that should be provided in the biographical sketches, but it is collated into one alphabetized table to facilitate the identification of individuals who would have conflicts of interest in the review of the proposal.) If submitting via Grants.gov, complete the information and attach as a PDF file (see Field 5, Additional Single Copy Documents, on the NSF Grant Application Cover Page).

Each Project should submit ONE COI matrix table for their PROJECT: the COI matrix will include the names of all individuals associated (named) with that project and their COI according to the following template.

Column A: PI, coPI or Senior Personnel on project or any individual or organization providing a letter of collaboration (last name, first name).

Column B: Institution of PI, coPI or senior personnel on project

Column C: name of person with whom there is a conflict for the person in column "A" (last name, first name)

Column D: institution of person in column "C"

Column E: type of COI

Please provide COI matrix alphabetized by Column A then Column C:

B. Budgetary Information

Cost Sharing:

Inclusion of voluntary committed cost sharing is prohibited.

Budget Preparation Instructions:

Budgets for Research Platforms and Facilities: Projects that will be utilizing NSF research platforms (e.g. ships, airplanes, etc) or other shared use facilities (e.g. field instrumentation, analytical or experimental facilities) are responsible for filing a copy of their Request for Facility Support as a supplementary document in their proposal. Any costs that will be associated with such facilities should be clearly documented, and PIs should coordinate their requests with the appropriate facility to ensure that access is available to the facility and fits within the time line of the proposed research. Costs for research platforms and facilities that are not covered by the facility must be included in the proposal budget.

This program will support the costs of US-based scientists and their students. International collaborators are encouraged to seek support from their respective funding organizations. Funding guidelines for involving international collaborators allow the following expenses to be included in the NSF budget: 1) Travel expenses for US scientists and students participating in exchange visits integral to the project; 2) Limited project-related expenses for international partners to engage in research activities while in the United States as project participants; 3) Project-related expenses for US participants to engage in research activities while abroad.

C. Due Dates

- **Full Proposal Deadline(s)** (due by 5 p.m. submitter's local time):

    November 16, 2015

    November 14, Annually Thereafter

D. FastLane/Grants.gov Requirements

For Proposals Submitted Via FastLane:

To prepare and submit a proposal via FastLane, see detailed technical instructions available at: https://www.fastlane.nsf.gov/a1/newstan.htm. For FastLane user support, call the FastLane Help Desk at 1-800-673-6188 or e-mail fastlane@nsf.gov. The FastLane Help Desk answers general technical questions related to the use of the FastLane system. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this funding opportunity.

For Proposals Submitted Via Grants.gov:

Before using Grants.gov for the first time, each organization must register to create an institutional profile. Once registered, the applicant's organization can then apply for any federal grant on the Grants.gov website. Comprehensive information about using Grants.gov is available on the Grants.gov Applicant Resources webpage: http://www.grants.gov/web/grants/applicants.html. In addition, the NSF Grants.gov Application Guide (see link in Section V.A) provides instructions regarding the technical preparation of proposals via Grants.gov. For Grants.gov user support, contact the Grants.gov Contact Center at 1-800-518-4726 or by email: support@grants.gov. The Grants.gov Contact Center answers general technical questions related to the use of Grants.gov. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this solicitation.

Submitting the Proposal: Once all documents have been completed, the Authorized Organizational Representative (AOR) must submit the application to Grants.gov and verify the desired funding opportunity and agency to which the application is submitted. The AOR must then sign and submit the application to Grants.gov. The completed application will be transferred to the NSF FastLane system for further processing.

Proposers that submitted via FastLane are strongly encouraged to use FastLane to verify the status of their submission to NSF. For proposers that submitted via Grants.gov, until an application has been received and validated by NSF, the Authorized Organizational Representative may check the status of an application on Grants.gov. After proposers have received an e-mail notification from NSF, Research.gov should be used to check the status of an application.

VI. NSF PROPOSAL PROCESSING AND REVIEW PROCEDURES

Proposals received by NSF are assigned to the appropriate NSF program for acknowledgement and, if they meet NSF requirements, for review. All proposals are carefully reviewed by a scientist, engineer, or educator serving as an NSF Program Officer, and usually by three to ten other persons outside NSF either as *ad hoc* reviewers, panelists, or both, who are experts in the particular fields represented by the proposal. These reviewers are selected by Program Officers charged with oversight of the review process. Proposers are invited to suggest names of persons they believe are especially well qualified to review the proposal and/or persons they would prefer not review the proposal. These suggestions may serve as one source in the reviewer selection process at the Program Officer's discretion. Submission of such names, however, is optional. Care is taken to ensure that reviewers have no conflicts of interest with the proposal. In addition, Program Officers may obtain comments from site visits before recommending final action on proposals. Senior NSF staff further review recommendations for awards. A flowchart that depicts the entire NSF proposal and award process (and associated timeline) is included in the GPG as Exhibit III-1.

A comprehensive description of the Foundation's merit review process is available on the NSF website at: http://www.nsf.gov/bfa/dias/policy/merit_review/.

Proposers should also be aware of core strategies that are essential to the fulfillment of NSF's mission, as articulated in *Investing in Science, Engineering, and Education for the Nation's Future: NSF Strategic Plan for 2014-2018*. These strategies are integrated in the program planning and implementation process, of which proposal review is one part. NSF's mission is particularly well-implemented through the integration of research and education and broadening participation in NSF programs, projects, and activities.

One of the strategic objectives in support of NSF's mission is to foster integration of research and education through the programs, projects, and activities it supports at academic and research institutions. These institutions must recruit, train, and prepare a diverse STEM workforce to advance the frontiers of science and participate in the U.S. technology-based economy. NSF's contribution to the national innovation ecosystem is to provide cutting-edge research under the guidance of the Nation's most creative scientists and engineers. NSF also supports development of a strong science, technology, engineering, and mathematics (STEM) workforce by investing in building the knowledge that informs improvements in STEM teaching and learning.

NSF's mission calls for the broadening of opportunities and expanding participation of groups, institutions, and geographic regions that are underrepresented in STEM disciplines, which is essential to the health and vitality of science and engineering. NSF is committed to this principle of diversity and deems it central to the programs, projects, and activities it considers and supports.

A. Merit Review Principles and Criteria

The National Science Foundation strives to invest in a robust and diverse portfolio of projects that creates new knowledge and enables breakthroughs in understanding across all areas of science and engineering research and education. To identify which projects to support, NSF relies on a merit review process that incorporates consideration of both the technical aspects of a proposed project and its potential to contribute more broadly to advancing NSF's mission "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes." NSF makes every effort to conduct a fair, competitive, transparent merit review process for the selection of projects.

1. Merit Review Principles

These principles are to be given due diligence by PIs and organizations when preparing proposals and managing projects, by reviewers when reading and evaluating proposals, and by NSF program staff when determining whether or not to recommend proposals for funding and while overseeing awards. Given that NSF is the primary federal agency charged with nurturing and supporting excellence in basic research and education, the following three principles apply:

- All NSF projects should be of the highest quality and have the potential to advance, if not transform, the frontiers of knowledge.
- NSF projects, in the aggregate, should contribute more broadly to achieving societal goals. These "Broader Impacts" may be accomplished through the research itself, through activities that are directly related to specific research projects, or through activities that are supported by, but are complementary to, the project. The project activities may be based on previously established and/or innovative methods and approaches, but in either case must be well justified.
- Meaningful assessment and evaluation of NSF funded projects should be based on appropriate metrics, keeping in mind the likely correlation between the effect of broader impacts and the resources provided to implement projects. If the size of the activity is limited, evaluation of that activity in isolation is not likely to be meaningful. Thus, assessing the effectiveness of these activities may best be done at a higher, more aggregated, level than the individual project.

With respect to the third principle, even if assessment of Broader Impacts outcomes for particular projects is done at an aggregated level, PIs are expected to be accountable for carrying out the activities described in the funded project. Thus, individual projects should include clearly stated goals, specific descriptions of the activities that the PI intends to do, and a plan in place to document the outputs of those activities.

These three merit review principles provide the basis for the merit review criteria, as well as a context within which the users of the criteria can better understand their intent.

2. Merit Review Criteria

All NSF proposals are evaluated through use of the two National Science Board approved merit review criteria. In some instances, however, NSF will employ additional criteria as required to highlight the specific objectives of certain programs and activities.

The two merit review criteria are listed below. **Both** criteria are to be given **full consideration** during the review and decision-making processes; each criterion is necessary but neither, by itself, is sufficient. Therefore, proposers must fully address both criteria. (GPG Chapter II.C.2.d.i. contains additional information for use by proposers in development of the Project Description section of the proposal.) Reviewers are strongly encouraged to review the criteria, including GPG Chapter II.C.2.d.i., prior to the review of a proposal.

When evaluating NSF proposals, reviewers will be asked to consider what the proposers want to do, why they want to do it, how they plan to do it, how they will know if they succeed, and what benefits could accrue if the project is successful. These issues apply both to the technical aspects of the proposal and the way in which the project may make broader contributions. To that end, reviewers will be asked to evaluate all proposals against two criteria:

- **Intellectual Merit:** The Intellectual Merit criterion encompasses the potential to advance knowledge; and
- **Broader Impacts:** The Broader Impacts criterion encompasses the potential to benefit society and contribute to the achievement of specific, desired societal outcomes.

The following elements should be considered in the review for both criteria:

1. What is the potential for the proposed activity to
   a. Advance knowledge and understanding within its own field or across different fields (Intellectual Merit); and
   b. Benefit society or advance desired societal outcomes (Broader Impacts)?
2. To what extent do the proposed activities suggest and explore creative, original, or potentially transformative concepts?
3. Is the plan for carrying out the proposed activities well-reasoned, well-organized, and based on a sound rationale? Does the plan incorporate a mechanism to assess success?
4. How well qualified is the individual, team, or organization to conduct the proposed activities?
5. Are there adequate resources available to the PI (either at the home organization or through collaborations) to carry out the proposed activities?

Broader impacts may be accomplished through the research itself, through the activities that are directly related to specific research

projects, or through activities that are supported by, but are complementary to, the project. NSF values the advancement of scientific knowledge and activities that contribute to achievement of societally relevant outcomes. Such outcomes include, but are not limited to: full participation of women, persons with disabilities, and underrepresented minorities in science, technology, engineering, and mathematics (STEM); improved STEM education and educator development at any level; increased public scientific literacy and public engagement with science and technology; improved well-being of individuals in society; development of a diverse, globally competitive STEM workforce; increased partnerships between academia, industry, and others; improved national security; increased economic competitiveness of the United States; and enhanced infrastructure for research and education.

Proposers are reminded that reviewers will also be asked to review the Data Management Plan and the Postdoctoral Researcher Mentoring Plan, as appropriate.

Additional Solicitation Specific Review Criteria

In addition to the National Science Board merit review criteria, reviewers will be asked to consider several specific criteria when reviewing IES proposals. These criteria include:

- Is the mix of principal investigators and their specialties appropriate and adequate for the proposed IES study? Does the research require a team approach that goes beyond the scope that can be addressed in the discipline programs of the Earth Sciences Division?
- Will the research outcome advance primarily EAR programmatic science as opposed to other Divisional/Directorate science?
- Is there meaningful integration of the various disciplinary components of the proposed research into a systems level analysis?
- Is there a realistic attempt to quantify how well the particular system(s) being studied is(are) understood (e.g. by comparing the output of system models to additional observational data).

B. Review and Selection Process

Proposals submitted in response to this program solicitation will be reviewed by

Ad hoc Review and/or Panel Review.

Reviewers will be asked to evaluate proposals using two National Science Board approved merit review criteria and, if applicable, additional program specific criteria. A summary rating and accompanying narrative will generally be completed and submitted by each reviewer and/or panel. The Program Officer assigned to manage the proposal's review will consider the advice of reviewers and will formulate a recommendation.

After scientific, technical and programmatic review and consideration of appropriate factors, the NSF Program Officer recommends to the cognizant Division Director whether the proposal should be declined or recommended for award. NSF strives to be able to tell applicants whether their proposals have been declined or recommended for funding within six months. Large or particularly complex proposals or proposals from new awardees may require additional review and processing time. The time interval begins on the deadline or target date, or receipt date, whichever is later. The interval ends when the Division Director acts upon the Program Officer's recommendation.

After programmatic approval has been obtained, the proposals recommended for funding will be forwarded to the Division of Grants and Agreements for review of business, financial, and policy implications. After an administrative review has occurred, Grants and Agreements Officers perform the processing and issuance of a grant or other agreement. Proposers are cautioned that only a Grants and Agreements Officer may make commitments, obligations or awards on behalf of NSF or authorize the expenditure of funds. No commitment on the part of NSF should be inferred from technical or budgetary discussions with a NSF Program Officer. A Principal Investigator or organization that makes financial or personnel commitments in the absence of a grant or cooperative agreement signed by the NSF Grants and Agreements Officer does so at their own risk.

Once an award or declination decision has been made, Principal Investigators are provided feedback about their proposals. In all cases, reviews are treated as confidential documents. Verbatim copies of reviews, excluding the names of the reviewers or any reviewer-identifying information, are sent to the Principal Investigator/Project Director by the Program Officer. In addition, the proposer will receive an explanation of the decision to award or decline funding.

VII. AWARD ADMINISTRATION INFORMATION

A. Notification of the Award

Notification of the award is made to *the submitting organization* by a Grants Officer in the Division of Grants and Agreements. Organizations whose proposals are declined will be advised as promptly as possible by the cognizant NSF Program administering the program. Verbatim copies of reviews, not including the identity of the reviewer, will be provided automatically to the Principal Investigator. (See Section VI.B. for additional information on the review process).

B. Award Conditions

An NSF award consists of: (1) the award notice, which includes any special provisions applicable to the award and any numbered amendments thereto; (2) the budget, which indicates the amounts, by categories of expense, on which NSF has based its support (or otherwise communicates any specific approvals or disapprovals of proposed expenditures); (3) the proposal referenced in the award notice; (4) the applicable award conditions, such as Grant General Conditions (GC-1)*; or Research Terms and Conditions* and (5) any announcement or other NSF issuance that may be incorporated by reference in the award notice. Cooperative agreements also are administered in accordance with NSF Cooperative Agreement Financial and Administrative Terms and Conditions (CA-FATC) and the applicable Programmatic Terms and Conditions. NSF awards are electronically signed by an NSF Grants and Agreements Officer and transmitted electronically to the organization via e-mail.

*These documents may be accessed electronically on NSF's Website at http://www.nsf.gov/awards/managing/award_conditions.jsp?org=NSF. Paper copies may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-7827 or by e-mail from nsfpubs@nsf.gov.

More comprehensive information on NSF Award Conditions and other important information on the administration of NSF awards is contained in the NSF *Award & Administration Guide* (AAG) Chapter II, available electronically on the NSF Website at http://www.nsf.gov/publications/pub_summ.jsp?ods_key=aag.

C. Reporting Requirements

For all multi-year grants (including both standard and continuing grants), the Principal Investigator must submit an annual project report to the cognizant Program Officer no later than 90 days prior to the end of the current budget period. (Some programs or awards require submission of more frequent project reports). No later than 120 days following expiration of a grant, the PI also is required to submit a final project report, and a project outcomes report for the general public.

Failure to provide the required annual or final project reports, or the project outcomes report, will delay NSF review and processing of any future funding increments as well as any pending proposals for all identified PIs and co-PIs on a given award. PIs should examine the formats of the required reports in advance to assure availability of required data.

PIs are required to use NSF's electronic project-reporting system, available through Research.gov, for preparation and submission of annual and final project reports. Such reports provide information on accomplishments, project participants (individual and organizational), publications, and other specific products and impacts of the project. Submission of the report via Research.gov constitutes certification by the PI that the contents of the report are accurate and complete. The project outcomes report also must be prepared and submitted using Research.gov. This report serves as a brief summary, prepared specifically for the public, of the nature and outcomes of the project. This report will be posted on the NSF website exactly as it is submitted by the PI.

More comprehensive information on NSF Reporting Requirements and other important information on the administration of NSF awards is contained in the NSF *Award & Administration Guide* (AAG) Chapter II, available electronically on the NSF Website at http://www.nsf.gov/publications/pub_summ.jsp?ods_key=aag.

VIII. AGENCY CONTACTS

Please note that the program contact information is current at the time of publishing. See program website for any updates to the points of contact.

General inquiries regarding this program should be made to:

- Leonard E. Johnson, Program Director, telephone: (703) 292-8559, fax: 703-292-9025, email: lejohnso@nsf.gov

- Thomas Torgersen, Program Director, telephone: 703-292-8549, fax: 703-292-9025, email: ttorgers@nsf.gov

For questions related to the use of FastLane, contact:

- FastLane Help Desk, telephone: 1-800-673-6188; e-mail: fastlane@nsf.gov.

For questions relating to Grants.gov contact:

- Grants.gov Contact Center: If the Authorized Organizational Representatives (AOR) has not received a confirmation message from Grants.gov within 48 hours of submission of application, please contact via telephone: 1-800-518-4726; e-mail: support@grants.gov.

IX. OTHER INFORMATION

The NSF website provides the most comprehensive source of information on NSF Directorates (including contact information), programs and funding opportunities. Use of this website by potential proposers is strongly encouraged. In addition, "NSF Update" is an information-delivery system designed to keep potential proposers and other interested parties apprised of new NSF funding opportunities and publications, important changes in proposal and award policies and procedures, and upcoming NSF Grants Conferences. Subscribers are informed through e-mail or the user's Web browser each time new publications are issued that match their identified interests. "NSF Update" also is available on NSF's website.

Grants.gov provides an additional electronic capability to search for Federal government-wide grant opportunities. NSF funding opportunities may be accessed via this mechanism. Further information on Grants.gov may be obtained at http://www.grants.gov.

ABOUT THE NATIONAL SCIENCE FOUNDATION

The National Science Foundation (NSF) is an independent Federal agency created by the National Science Foundation Act of 1950, as amended (42 USC 1861-75). The Act states the purpose of the NSF is "to promote the progress of science; [and] to advance the national health, prosperity, and welfare by supporting research and education in all fields of science and engineering."

NSF funds research and education in most fields of science and engineering. It does this through grants and cooperative agreements to more than 2,000 colleges, universities, K-12 school systems, businesses, informal science organizations and other research

organizations throughout the US. The Foundation accounts for about one-fourth of Federal support to academic institutions for basic research.

NSF receives approximately 55,000 proposals each year for research, education and training projects, of which approximately 11,000 are funded. In addition, the Foundation receives several thousand applications for graduate and postdoctoral fellowships. The agency operates no laboratories itself but does support National Research Centers, user facilities, certain oceanographic vessels and Arctic and Antarctic research stations. The Foundation also supports cooperative research between universities and industry, US participation in international scientific and engineering efforts, and educational activities at every academic level.

Facilitation Awards for Scientists and Engineers with Disabilities provide funding for special assistance or equipment to enable persons with disabilities to work on NSF-supported projects. See Grant Proposal Guide Chapter II, Section D.2 for instructions regarding preparation of these types of proposals.

The National Science Foundation has Telephonic Device for the Deaf (TDD) and Federal Information Relay Service (FIRS) capabilities that enable individuals with hearing impairments to communicate with the Foundation about NSF programs, employment or general information. TDD may be accessed at (703) 292-5090 and (800) 281-8749, FIRS at (800) 877-8339.

The National Science Foundation Information Center may be reached at (703) 292-5111.

PRIVACY ACT AND PUBLIC BURDEN STATEMENTS

X. APPENDIX

Frequently Asked Questions:

What are Systems and System Dynamics?

A system is composed of diverse related components that function as a complex whole. A system is defined by the interaction and

feedbacks among two or more components arising from the interactions occurring via multiple connections among the components (e.g. mass and energy balances). Systems responses are typically complex phenomena (feedbacks, hysteresis, threshold crossings, etc.) that might not be predictable from simple component forcing and response analysis. System Dynamics refers to the spatial and temporal behavior of a system as it responds to various forcing functions.

How should my project be connected to an Earth systems dynamic model?

In many cases sophisticated, dynamic models exist of various subsystems of the Earth. One characteristic of the models is an ability to predict a temporal response to a change in forcing function or boundary condition. The temporal scale of these responses is governed by the internal processes that operate within the model. One means by which to connect your proposed IES scope of work to a model is to obtain ground truth data on the temporal response to an "event" and use your field observations and your proposed work to test/calibrate the process parameterizations within an existing model. Your proposed work should then emphasize how you will enhance or test the existing model. Alternatively, your proposed work could make, determine or collect (from the literature) process level rates and parameterize the operating principles that govern the Earth subsystem and build new models (or components) of specific Earth subsystems. Your proposed IES work should then emphasize how it will build new models or augment existing models and test the appropriateness of those new formulations. What IES seeks is an advance in knowledge of integrated Earth systems. Models are the means by which we most commonly enable that integration. Some areas of research are new and some areas are more mature. The focus of your IES project should be appropriate to the current community knowledge of that system and its operation.

How big a research team should I be including in my proposal?

Most two component systems are amenable to research conducted within existing programs and would best be directed to individual EAR programs. When the system includes multiple disciplines, multiple separate components and multiple types of data/signals that typically cross between and among various EAR programs, the project is most suitable for IES submission. IES is intended to enable an enhanced definition, understanding and integration of EAR disciplinary science within systems level science and models that will advance the understanding of the continental, terrestrial and deep Earth systems of the planet. In that sense, your team should be adequate to this task.

How small a research team should I be including in my proposal?

Complex Earth systems typically involve multiple components that cross disciplinary boundaries. Understanding the complexity of the coupling or the nuances of the mechanisms and evidence of such coupling typically involves expertise across several disciplines. Your team should be adequate to provide the necessary sophistication in your interpretations, models or fieldwork to significantly and transformatively advance knowledge of the sensitivities, timescales and mechanisms of the Earth subsystem function.

This program sounds as if it is all mathematics of the Earth systems? How do I conduct fieldwork under this program?

The understanding of systems is most often presented in terms of couplings and feedbacks among components. In some cases, current understanding of one or more Earth subsystems has been expressed in terms of a conceptual coupling and/or a mathematical exploration of the coupling that defines the magnitude of response and the time-scale and time-delay of response. In other cases, current understanding is imbedded in complex computer models. Field work can be used to verify hypotheses generated from models, to provide greater detail for the model; OR fieldwork can be used to provide data for the construction of new and as yet undefined couplings not currently included in Earth systems models. A competitive project will use the field work to generate new process understanding and will assess the value of that new understanding within the scope of the project.

Understanding, exploring and enhancing knowledge of Earth systems might be rather vague. How should I be posing my questions and my hypotheses?

Hypotheses are typically generated from existing observations and theory most often rooted in the disciplinary research within Earth science. Coupling the driving science questions to specific hypotheses is always good practice. Your questions may be derived from conceptual component couplings that would then test the mechanisms and timescales of the conceptual couple through mathematical analysis or fieldwork. Alternatively, existing models may be used to pose questions for field evaluation or sensitivity evaluation that may then define the need or scope of further systems and disciplinary study. IES should provide a long term mechanism for tactical advancement of Earth science by enabling an exchange of hypotheses between (typically) process-level core programs and systems-level operation.

A suggested project budget of $1M to $3M is a large range. How should this be interpreted?

Larger systems with more components leave more complex signatures that require more diverse expertise to interpret. On the other hand, evaluation of system sensitivity and response function that are tested via mathematics and laboratory-only studies might be less expensive than projects that include more complexity and extensive fieldwork. Your budget should be appropriate to the complexity of the system under study, and the tools necessary to address that complexity.

What are some of the relevant documents issued by NSF and other Agencies?

1. New Research Opportunities in the Earth Sciences (NROES), National Research Council, the National Academies Press, 2012.
2. Basic Research Opportunities in Earth Science (BROES), National Research Council, The National Academies Press, 2001.
3. GEOVISION Report (Unraveling Earth's Complexities Through The Geosciences), NSF Advisory Committee for Geosciences, 2009. http://www.nsf.gov/geo/acgeo/geovision/start.jsp
4. National Academies Press, Washington, D.C., 2010. http://www.nap.edu/openbook.php?record.id=12700&page=R1
5. Grand Challenges in Geodynamics: Outstanding geodynamics problems and emerging research opportunities for the Earth Sciences, 2010. http://pages.jh.edu/~polson1/pdfs/GWPsmall.pdf
6. Origin and Evolution of Earth: Research Questions for a Changing Planet. National Research Council, National Academies Press, 2008. http://books.nap.edu/openbook.php?record_id=12161&page=R1
7. Banwart, Steven, 2012, Design of Global Environmental Gradient Experiments using International Networks of Critical Zone Observatories, International Critical Zone Observatory Joint Workshop, 9th-11th November 2011, EC SoilTrEC Project and NSF Critical Zone Observatory Programme, 33 pp.
8. National Research Council, 2012, Challenges and Opportunities in the Hydrologic Sciences, National Academy Press, Washington, D.C. 162 pp.

9. NSF Critical Zone Observatory Program: Panel Report, April 4, 2011
10. Freeman, Katherine and Goldhaber, Martin, 2011, Future Directions in Geobiology and Low-Temperature Geochemistry, A report based on presentations and discussions by participants of the Future Directions in Geobiology and Low-Temperature Geochemistry Workshop, 27-28 August 2010, 20 pp.
11. Brantley, Susan, and 26 others, 2011, Twelve testable hypotheses on the geobiology of weathering. Geobiology, Vol. 9, pp. 140-165. Results of workshop on the Biological Aspects of Weathering; Oct. 3-5, 2009

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