

# Next Generation Software for Data-driven Models of Space Weather with Quantified Uncertainties (SWQU)

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## PROGRAM SOLICITATION NSF 20-519



### National Science Foundation

Directorate for Mathematical and Physical Sciences  
Division of Physics  
Division of Astronomical Sciences  
Division of Mathematical Sciences

Directorate for Geosciences  
Division of Atmospheric and Geospace Sciences

Directorate for Computer and Information Science and Engineering  
Office of Advanced Cyberinfrastructure



National Aeronautics and Space Administration

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

March 20, 2020

## IMPORTANT INFORMATION AND REVISION NOTES

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Any proposal submitted in response to this solicitation should be submitted in accordance with the revised *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) (NSF 19-1), which is effective for proposals submitted, or due, on or after February 25, 2019.

## SUMMARY OF PROGRAM REQUIREMENTS

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### General Information

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#### Program Title:

Next Generation Software for Data-driven Models of Space Weather with Quantified Uncertainties (SWQU)

#### Synopsis of Program:

This solicitation addresses the overlapping objectives of the [National Space Weather Strategy and Action Plan](#) (NSW-SAP) and the [National Strategic Computing Initiative \(NSCI\) Update](#) through a pilot program. The goal of this pilot program is to transform development of predictive modeling of the coupled evolution of the magnetized solar atmosphere and the solar wind, and their interaction with the Earth's magnetosphere and upper atmosphere. This requires advancing our understanding of the necessary and sufficient requirements of model complexity, computational performance, and observational inputs. The pilot program is also expected to directly contribute to the long-term goal of creating space weather models with quantifiable predictive capability.

#### 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.*

- Vyacheslav (Slava) Lukin, Program Director, Division of Physics, telephone: (703) 292-7382, email: [vlukin@nsf.gov](mailto:vlukin@nsf.gov)
- Bogdan Mihaila, Program Director, Division of Physics, telephone: (703) 292-8235, email: [bmihaila@nsf.gov](mailto:bmihaila@nsf.gov)
- Iliia I. Roussev, Program Director, Division of Atmospheric and Geospace Sciences, telephone: (703) 292-8519, email: [irussev@nsf.gov](mailto:irussev@nsf.gov)
- David A. Boboltz, Program Director, Division of Astronomical Sciences, telephone: (703) 292-2199, email: [dboboltz@nsf.gov](mailto:dboboltz@nsf.gov)
- Leland M. Jameson, Program Director, Division of Mathematical Sciences, telephone: (703) 292-4883, email: [lameson@nsf.gov](mailto:lameson@nsf.gov)
- Yong Zeng, Program Director, Division of Mathematical Sciences, telephone: (703) 292-7902, email: [yzeng@nsf.gov](mailto:yzeng@nsf.gov)
- Vipin Chaudhary, Program Director, Office of Advanced Cyberinfrastructure, telephone: (703) 292-2254, email: [vipchaud@nsf.gov](mailto:vipchaud@nsf.gov)
- James Spann, Space Weather Lead, NASA Headquarters, telephone: (202) 358-0574, email: [jim.spann@nasa.gov](mailto:jim.spann@nasa.gov)
- Jeff Morrill, Program Scientist, NASA Headquarters, telephone: (202) 358-3744, email: [jeff.s.morrill@nasa.gov](mailto:jeff.s.morrill@nasa.gov)

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

- 43.001 --- National Aeronautics and Space Administration (Science)
- 47.049 --- Mathematical and Physical Sciences
- 47.050 --- Geosciences
- 47.070 --- Computer and Information Science and Engineering

**Award Information**

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**Anticipated Type of Award:** Standard Grant or Continuing Grant

**Estimated Number of Awards:** 4 to 8

**Anticipated Funding Amount:** \$12,000,000

Subject to availability of funds and receipt of sufficient quality proposals; the anticipated total funding amount includes joint funding from NSF and NASA. The awards are expected to be at the level of \$500K-\$1M per year; a total award for three years is expected to be in the range of \$1,500,000 – \$3,000,000.

**Eligibility Information**

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**Who May Submit Proposals:**

Proposals may only be submitted by the following:

- Institutions of Higher Education (IHEs) - Two- and four-year IHEs (including community colleges) accredited in, and having a campus located in the US, acting on behalf of their faculty members. Special Instructions for International Branch Campuses of US IHEs: If the proposal includes funding to be provided to an international branch campus of a US institution of higher education (including through use of subawards and consultant arrangements), the proposer must explain the benefit(s) to the project of performance at the international branch campus, and justify why the project activities cannot be performed at the US campus.
- Non-profit, non-academic organizations: Independent museums, observatories, research labs, professional societies and similar organizations in the U.S. associated with educational or research activities.
- Other Federal Agencies and Federally Funded Research and Development Centers (FFRDCs): Contact the appropriate program before preparing a proposal for submission.

**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: 1**

Any one individual may be the Principal Investigator (PI) or co-Principal Investigator (co-PI) for only one proposal. In the event that any individual exceeds this limit, any proposal submitted to this solicitation with this individual listed as PI or co-PI after the first proposal is received at NSF will be returned without review. Individuals may be listed as participating senior personnel on more than one proposal.

**Proposal Preparation and Submission Instructions**

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**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 (PAPPG)* guidelines apply. The complete text of the PAPPG is available electronically on the NSF website at: [https://www.nsf.gov/publications/pub\\_summ.jsp?ods\\_key=pappg](https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg).
  - Full Proposals submitted via Research.gov: *NSF Proposal and Award Policies and Procedures Guide (PAPPG)* guidelines apply. The complete text of the PAPPG is available electronically on the NSF website at: [https://www.nsf.gov/publications/pub\\_summ.jsp?ods\\_key=pappg](https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg).
  - 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: [https://www.nsf.gov/publications/pub\\_summ.jsp?ods\\_key=grantsgovguide](https://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:**

Other budgetary limitations apply. Please see the full text of this solicitation for further information.

**C. Due Dates**

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

March 20, 2020

## **Proposal Review Information Criteria**

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**Merit Review Criteria:**

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

## **Award Administration Information**

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**Award Conditions:**

Additional award conditions apply. Please see the full text of this solicitation for further information.

**Reporting Requirements:**

Additional reporting requirements apply. Please see the full text of this solicitation for further information.

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## **I. INTRODUCTION**

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The National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA) expect to make a small number of awards for developing next generation software for data-driven models of space weather with quantified uncertainties. Improvements in predictive modeling capabilities of space weather require an integrative approach to address the complete Sun-to-Earth geospace environment, including disturbances generated by the Sun, the solar wind, and the magnetosphere, ionosphere, thermosphere system. NSF and NASA recognize that there are research needs that can only be met appropriately by teams of researchers. The advantages of pooled insights, complementary expertise, diverse points of view, and shared tasks make a successful research team more than the sum of its parts. A dedicated mode of support for such scientifically-focused multi-investigator projects with an emphasis on early career research support is provided by this activity.

## II. PROGRAM DESCRIPTION

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This solicitation addresses the overlapping objectives of the [National Space Weather Strategy and Action Plan \(NSW-SAP\)](#) and the [National Strategic Computing Initiative \(NSCI\) Update](#) through a pilot program. The goal of this pilot program is to transform development of predictive modeling of the coupled evolution of the magnetized solar atmosphere and the solar wind, and their interaction with the Earth's magnetosphere and upper atmosphere. This requires advancing our understanding of the necessary and sufficient requirements of model complexity, computational performance, and observational inputs. The pilot program is also expected to directly contribute to the long-term goal of creating space weather models with quantifiable predictive capability.

It is expected that the proposing teams will seek to develop methodology, computationally scalable algorithms, and open-source software elements for one or more of the following:

1. On-the-fly reduction and assimilation of observational data from diverse and distributed sources — including sparse in situ and remote sensing ground and space-based data — into physics-based numerical models (e.g., numerical solutions of highly non-linear systems of spatially and temporally discretized partial differential equations (PDEs)).
2. Evaluation and propagation of uncertainties associated with the data assimilation and numerical solutions of the PDEs in the presence of large numbers of model parameters, as well as the model uncertainty of a reduced physical description.
3. Integrated modeling of the multi-physics and spatially and temporally multi-scale space plasma phenomena with uncertainty quantification and efficient implementation on heterogeneous computer architectures.

A competitive proposal must present a compelling case that, if awarded, one or more of the above software elements or their algorithmic prototypes will be developed within a three-year time frame. It is expected that any software elements will be developed using sustainable software infrastructure best practices with a specific vision for integration of multiple software elements.

Successful proposals will be funded for the duration of three years with awards providing resources beyond those available to an individual investigator, so as to promote a collaborative transdisciplinary approach to a focused topic while encouraging participation of scientists at the beginning of their scientific careers. The pilot program is intended to motivate early-career scientists to integrate knowledge, techniques, and expertise from multiple fields towards the goal of a predictive space weather model via support for training, workshops, and collaboration meetings to be included in the proposed research effort. It is therefore strongly encouraged that the proposed research effort include early-career scientists and software engineers in substantive roles central to the completion of the proposed project. For this solicitation, early career scientists and engineers are defined as graduate students, post-doctoral scientists, and those otherwise within 5 years of receiving their terminal-level degree.

## III. AWARD INFORMATION

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**Anticipated Type of Award:** Continuing Grant or Standard Grant

**Estimated Number of Awards:** 4-8

**Anticipated Funding Amount:** \$12,000,000

Subject to availability of funds and receipt of sufficient quality proposals; the anticipated total funding amount includes joint funding from NSF and NASA. The awards are expected to be at the level of \$500K-\$1M per year; a total award for three years is expected to be in the range of \$1,500,000-\$3,000,000.

## IV. ELIGIBILITY INFORMATION

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### Who May Submit Proposals:

Proposals may only be submitted by the following:

- Institutions of Higher Education (IHEs) - Two- and four-year IHEs (including community colleges) accredited in, and having a campus located in the US, acting on behalf of their faculty members. Special Instructions for International Branch Campuses of US IHEs: If the proposal includes funding to be provided to an international branch campus of a US institution of higher education (including through use of subawards and consultant arrangements), the proposer must explain the benefit(s) to the project of performance at the international branch campus, and justify why the project activities cannot be performed at the US campus.
- Non-profit, non-academic organizations: Independent museums, observatories, research labs, professional societies and similar organizations in the U.S. associated with educational or research activities.
- Other Federal Agencies and Federally Funded Research and Development Centers (FFRDCs): Contact the appropriate program before preparing a proposal for submission.

### 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: 1

Any one individual may be the Principal Investigator (PI) or co-Principal Investigator (co-PI) for only one proposal. In the event that any individual exceeds this limit, any proposal submitted to this solicitation with this individual listed as PI or co-PI after the first proposal is received at NSF will be returned without review. Individuals may be listed as participating senior personnel on more than one proposal.

#### Additional Eligibility Info:

Multi-organization proposals are encouraged. However, a single organization must accept overall management responsibility for the project. The proposal must be submitted by one organization with funding provided to the other organizations through subawards; separately submitted collaborative proposals are not permitted.

## V. PROPOSAL PREPARATION AND SUBMISSION INSTRUCTIONS

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### A. Proposal Preparation Instructions

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**Full Proposal Instructions:** Proposals submitted in response to this program solicitation should be prepared and submitted in accordance with the guidelines specified in the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG). The complete text of the PAPPG is available electronically on the NSF website at: [https://www.nsf.gov/publications/pub\\_summ.jsp?ods\\_key=pappg](https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg). Paper copies of the PAPPG may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-8134 or by e-mail from [nsfpubs@nsf.gov](mailto:nsfpubs@nsf.gov).

See PAPPG Chapter II.C.2 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 PAPPG instructions.

For submissions involving multiple organizations, the proposal should be submitted from only one organization, with funding for participating organizations made through subawards. Proposals should not be submitted using the separately submitted collaborative proposal mode.

The instructions below supplement the guidelines in NSF PAPPG or NSF Grants.gov Application Guide.

#### 1. Project Description. The Project Description is **limited to no more than 20 pages**.

*Please note that per guidance in the PAPPG, the Project Description must contain, as a separate section within the narrative, a section labeled "Broader Impacts of the Proposed Work". You can decide where to include this section within the Project Description.*

- a. Executive Summary. Provide a clear rationale for and description of the proposed project and its potential impact. Briefly describe the institutional setting, the proposed scope and organization of the project, which software elements or their algorithmic prototypes are to be developed, integration of activities in research, training and education, links with related major research centers on or off campus, and management plan. **Limit: 2 pages.**
  - b. Results from Prior NSF and/or NASA Support. Describe achievements under prior NSF and/or NASA support that pertain to the present proposal. **Limit: 5 pages.**
  - c. Description of the Project: Provide a concise description of the long-term vision for creating a space weather model with quantifiable predictive capability. Describe the planned research activities in sufficient detail to enable their scientific merit and significance to be assessed. Discuss how the proposed software and/or algorithm development will enable achievement of the stated long-term vision. Describe the role and intellectual contribution of each senior participant in the project, and briefly outline the resources available or planned to accomplish the stated goals. Interactions with other groups and organizations should be described.
  - d. Software Sustainability: If applicable, provide descriptions of the following:
    - The architecture of the software and the software engineering process to be used for the design, development, documentation, testing, validation and release of the software.
    - How trustworthiness, provenance, reproducibility, and usability will be addressed by the project and integrated into the proposed software system and the software engineering process.
    - How adaptability to new technologies and changing requirements will be addressed by the project and built into the proposed software system.
    - Which software license will be used for the released software, and why this license has been chosen. (Note that the chosen software license has to permit modification and redistribution of the software free of charge for non-commercial use.)
    - Sustainability of the developed software beyond the lifetime of the award.
    - How the proposed software will leverage existing space weather community resources and national cyberinfrastructure investments (for example, the Community Coordinated Modeling Center, <https://ccmc.gsfc.nasa.gov/>).
  - e. Human Resources and Diversity. Describe the proposed activities in the development of early career scientists. Specifically address how these efforts will enable integration of knowledge and expertise from multiple fields and how they will impact the participation of traditionally underrepresented groups. Outline plans for training, workshops, and related activities, as appropriate.
  - f. Collaboration with Other Sectors. Describe any proposed interactions and collaborations with other organizations and sectors, including national laboratories and industry, as appropriate. Define the goals of the collaboration, and describe the planned activities. Describe the roles in these collaborations of any participants that have been listed as participating senior personnel. List the participating senior personnel, the mechanisms planned to stimulate and facilitate knowledge transfer, and the potential long-term impact of the collaborations. A letter of collaboration is required from external collaborators as supplementary information - for form of letter see 4. **Limit: 2 pages.**
  - g. International Collaboration. Describe the nature of any planned international collaboration and the expected international and scientific or engineering benefits to the research and education programs. **Limit: 1 page.**
2. **Budget:** This pilot program is intended to motivate early-career scientists to integrate knowledge, techniques, and expertise from multiple fields towards the goal of a predictive space weather model via support for training, workshops, and collaboration meetings to be included in the proposed research effort. It is therefore strongly encouraged that the proposed research effort include early-career scientists and software engineers in substantive roles central to the completion of the proposed project. For this solicitation, early career scientists and engineers are defined as graduate students, post-doctoral scientists, and those otherwise within 5 years of receiving their terminal-level degree.
3. **Facilities, Equipment and Other Resources.** In addition to requirements in the PAPPG, this section should outline organizational and other commitments to the project, for example, space, faculty and staff positions, capital equipment, access to existing facilities, commitments for

collaboration and outreach programs, and other commitments. The description should be narrative in nature and not include any quantifiable financial information.

**4. Supplementary Documentation.** In addition to the requirements in the PAPPG:

Letters of Collaboration – Letters of support should not be submitted, as they are not a standard component of an NSF proposal. On the other hand, letters of collaboration, limited to stating the intent to collaborate and not containing endorsements or evaluation of the proposed project, are allowed. Letters of collaboration should follow the single-sentence format:

"If the proposal submitted by Dr. [insert the full name of the Principal Investigator] entitled [insert the proposal title] is selected for funding by the NSF or NASA, it is my intent to collaborate and/or commit resources as detailed in the Project Description."

Departure from this format may result in the proposal being returned without review. The Project Description should document the need for and nature of collaborations.

**5. Single Copy Documents.**

- a. **Project Personnel (a text-searchable single PDF document, to be submitted as an Additional Single Copy Document):** List all Senior Personnel in the project. For each person, provide the last name, first name, and institution/organization.

No other items or appendices are to be included. **Full proposals containing items other than those required above or by the PAPPG will not be reviewed.**

## B. Budgetary Information

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**Cost Sharing:**

Inclusion of voluntary committed cost sharing is prohibited.

**Other Budgetary Limitations:**

The total budget request for three years must be in the range of \$1,500,000 – \$3,000,000.

## C. Due Dates

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

March 20, 2020

## D. Fastlane/Grants.gov Requirements

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**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](mailto: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: <https://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](mailto: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 may use Research.gov 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

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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 PAPPG Exhibit III-1.

A comprehensive description of the Foundation's merit review process is available on the NSF website at: [https://www.nsf.gov/bfa/dias/policy/merit\\_review/](https://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 *Building the Future: Investing in Discovery and Innovation - NSF Strategic Plan for Fiscal Years (FY) 2018 – 2022*. 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

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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. (PAPPG 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 PAPPG 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 NSB approved merit review criteria, reviewers will be asked to use the following criteria.

A proposal to this pilot program must exhibit synergy or value-adding features aiming to achieve the overlapping objectives of NSW-SAP and NSCI Update beyond what an equivalent level of support for individual investigators may provide. Reviewers will be asked to assess the following criteria to evaluate this:

- Synergy and interconnections: Benefits of a multi-investigator, transdisciplinary approach; the synergy among the investigators; and the potential for cross fertilization.
- Evidence of clear scientific goals; evidence that the scientific goals can be achieved within the scope and duration of the pilot program; evidence that the developed software elements or their algorithmic prototypes will be extensible to enable future quantifiable predictive capability for space weather forecasters.
- Achievements under prior NSF and/or NASA support, where applicable.
- Software sustainability: If applicable,
  - To what extent has the software architecture and software engineering process been described, and how well does it support the goals of the project? How well does the proposal present and discuss proof-of-concept demonstrations of key software elements?
  - To what extent are issues of trustworthiness, provenance, reproducibility, and usability addressed and integrated into the proposed software and software engineering process?
  - How well does the software engineering plan ensure the software is responsive to new computing developments? To what extent is adaptability to new technologies and changing requirements addressed by the project and built into the proposed software system?
  - Does the proposal state the software license to be used and is the choice both suitably justified and appropriate, given the goals of the project?
  - How well does the project address the sustainability of the developed software beyond the lifetime of the award?
  - To what extent does the proposed project leverage existing space weather community resources and national cyberinfrastructure investments?
- Organizational setting and rationale: Relationship to existing and planned organizational programs and capabilities; potential for stimulating creative interaction and collaboration. Potential for organizational, national, and international impact.
- Potential effect on the infrastructure of science and engineering, particularly in fostering a broadly interactive approach to cutting-edge research and the development of early career scientists, fostering an open climate for students and postdoctoral researchers, and fostering increased participation in research and education on the part of women and members of underrepresented groups.

## **B. Review and Selection Process**

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Proposals submitted in response to this program solicitation will be reviewed by Ad hoc Review and/or Panel Review.

NSF is responsible for carrying out the review process. NASA Program Managers may recommend *ad hoc* and panel reviewers, assist in selection of reviewers, and may attend the review panel as observers. NSF retains final decision in selection of all reviewers and for compliance with the Federal Advisory Committee Act (FACA). After the panel review has concluded, NSF and NASA Program Officers will meet to determine a mutually acceptable list of proposals to be recommended for selection.

#### **NASA Process:**

For those proposals to be funded by NASA, instructions will be provided to the PI on how to submit to NASA a proposal with no changes beyond those required by NASA. A second NASA review will not be conducted. The proposals resulting in awards funded solely by NASA will be administratively withdrawn from NSF. Verbatim copies of the reviews, excluding the names of the reviewers, will be sent to the Principal Investigator by the NSF Program Officer.

#### **NSF Process:**

Reviewers will be asked to evaluate proposals using the two National Science Board approved merit review criteria and additional solicitation specific review 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

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### A. Notification of the Award

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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

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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 [https://www.nsf.gov/awards/managing/award\\_conditions.jsp?org=NSF](https://www.nsf.gov/awards/managing/award_conditions.jsp?org=NSF). Paper copies may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-8134 or by e-mail from [nsfpubs@nsf.gov](mailto: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 *Proposal & Award Policies & Procedures Guide* (PAPPG) Chapter VII, available electronically on the NSF Website at [https://www.nsf.gov/publications/pub\\_summ.jsp?ods\\_key=pappg](https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg).

#### Special Award Conditions:

All software developed as a result of funding provided by awards made by NSF or NASA in response to this solicitation is to be made available by the awardee free of charge for non-commercial use. Further, the software license shall permit modification and redistribution of the software free of charge for non-commercial use.

For those proposals selected and funded by NASA, in keeping with the [NASA approach for Increasing Access to Results of Federally Funded Research](#), as-accepted manuscript versions of peer-reviewed publications that result from NASA-funded awards must be uploaded into NASA's part of the [PubMed Central \(PMC\)](#) repository called [NASA PubSpace](#). Data and higher order data products that result from NASA-funded awards must meet the mandatory minimum requirement that the data behind figures and tables in peer-reviewed publications be available electronically at the time of release, ideally in supplementary material with the article. Full data sets must be made public by the end of the award.

In accordance with restrictions in Appropriation Acts, NASA is prohibited from funding any work that involves the bilateral participation, collaboration, or coordination with China or any Chinese-owned company or entity, whether funded or performed under a no exchange of funds arrangement.

### C. Reporting Requirements

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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 *Proposal & Award Policies & Procedures Guide* (PAPPG) Chapter VII, available electronically on the NSF Website at [https://www.nsf.gov/publications/pub\\_summ.jsp?ods\\_key=pappg](https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg).

## NASA Reporting Requirements:

The NASA reporting requirements for awards made through this solicitation will be consistent with 2 CFR 1800.902.

NASA award recipients may also be subject to reporting requirements under the NASA Plan for Increasing Access to Results of Federally Funded Research. Such requirements include reporting of final peer-reviewed manuscripts in annual and final progress reports. In other words, award recipients should report on progress in archiving of data and manuscripts in their progress reports and especially in the final report. All requirements will be identified in the Notice of Award. If the total value of your currently active grants, cooperative agreements, and procurement contracts from all Federal awarding agencies exceeds \$10,000,000 for any period of time during the period of performance of this Federal award, additional reporting requirements will apply. See 2 CFR 200 Appendix XII—Award Term and Condition for Recipient Integrity and Performance Matters.

NASA award recipients are required to submit annual progress reports.

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## 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:

- Vyacheslav (Slava) Lukin, Program Director, Division of Physics, telephone: (703) 292-7382, email: [vlukin@nsf.gov](mailto:vlukin@nsf.gov)
- Bogdan Mihaila, Program Director, Division of Physics, telephone: (703) 292-8235, email: [bmihaila@nsf.gov](mailto:bmihaila@nsf.gov)
- Ilija I. Roussev, Program Director, Division of Atmospheric and Geospace Sciences, telephone: (703) 292-8519, email: [irussev@nsf.gov](mailto:irussev@nsf.gov)
- David A. Boboltz, Program Director, Division of Astronomical Sciences, telephone: (703) 292-2199, email: [dboboltz@nsf.gov](mailto:dboboltz@nsf.gov)
- Leland M. Jameson, Program Director, Division of Mathematical Sciences, telephone: (703) 292-4883, email: [lameson@nsf.gov](mailto:lameson@nsf.gov)
- Yong Zeng, Program Director, Division of Mathematical Sciences, telephone: (703) 292-7902, email: [yzeng@nsf.gov](mailto:yzeng@nsf.gov)
- Vipin Chaudhary, Program Director, Office of Advanced Cyberinfrastructure, telephone: (703) 292-2254, email: [vipchaud@nsf.gov](mailto:vipchaud@nsf.gov)
- James Spann, Space Weather Lead, NASA Headquarters, telephone: (202) 358-0574, email: [jim.spann@nasa.gov](mailto:jim.spann@nasa.gov)
- Jeff Morrill, Program Scientist, NASA Headquarters, telephone: (202) 358-3744, email: [jeff.s.morrill@nasa.gov](mailto:jeff.s.morrill@nasa.gov)

For questions related to the use of Fastlane, contact:

- FastLane Help Desk: 1-800-673-6188  
FastLane Help Desk e-mail: [fastlane@nsf.gov](mailto:fastlane@nsf.gov).
- Ramona Winkelbauer, IT Specialist, telephone: (703) 292-7390, email: [rwinkelb@nsf.gov](mailto:rwinkelb@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](mailto:support@grants.gov).

### NASA Contacts:

- James Spann, Space Weather Lead, NASA Headquarters, telephone: (202) 358-0574, email: [jim.spann@nasa.gov](mailto:jim.spann@nasa.gov)
- Jeff Morrill, Program Scientist, NASA Headquarters, telephone: (202) 358-3744, email: [jeff.s.morrill@nasa.gov](mailto:jeff.s.morrill@nasa.gov)

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## 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 <https://www.grants.gov>.

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## 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* (FASSED) provide funding for special assistance or equipment to enable persons with disabilities to work on NSF-supported projects. See the *NSF Proposal & Award Policies & Procedures Guide* Chapter II.E.6 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.

The National Science Foundation promotes and advances scientific progress in the United States by competitively awarding grants and cooperative agreements for research and education in the sciences, mathematics, and engineering.

To get the latest information about program deadlines, to download copies of NSF publications, and to access abstracts of awards, visit the NSF Website at <https://www.nsf.gov>

- **Location:** 2415 Eisenhower Avenue, Alexandria, VA 22314
- **For General Information** (NSF Information Center): (703) 292-5111
- **TDD (for the hearing-impaired):** (703) 292-5090
- **To Order Publications or Forms:**
  - Send an e-mail to: [nsfpubs@nsf.gov](mailto:nsfpubs@nsf.gov)
  - or telephone: (703) 292-7827
- **To Locate NSF Employees:** (703) 292-5111

## PRIVACY ACT AND PUBLIC BURDEN STATEMENTS

The information requested on proposal forms and project reports is solicited under the authority of the National Science Foundation Act of 1950, as amended. The information on proposal forms will be used in connection with the selection of qualified proposals; and project reports submitted by awardees will be used for program evaluation and reporting within the Executive Branch and to Congress. The information requested may be disclosed to qualified reviewers and staff assistants as part of the proposal review process; to proposer institutions/grantees to provide or obtain data regarding the proposal review process, award decisions, or the administration of awards; to government contractors, experts, volunteers and researchers and educators as necessary to complete assigned work; to other government agencies or other entities needing information regarding applicants or nominees as part of a joint application review process, or in order to coordinate programs or policy; and to another Federal agency, court, or party in a court or Federal administrative proceeding if the government is a party. Information about Principal Investigators may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See [System of Record Notices](#), NSF-50, "Principal Investigator/Proposal File and Associated Records," and NSF-51, "Reviewer/Proposal File and Associated Records." Submission of the information is voluntary. Failure to provide full and complete information, however, may reduce the possibility of receiving an award.

An agency may not conduct or sponsor, and a person is not required to respond to, an information collection unless it displays a valid Office of Management and Budget (OMB) control number. The OMB control number for this collection is 3145-0058. Public reporting burden for this collection of information is estimated to average 120 hours per response, including the time for reviewing instructions. Send comments regarding the burden estimate and any other aspect of this collection of information, including suggestions for reducing this burden, to:

Suzanne H. Plimpton  
Reports Clearance Officer  
Office of the General Counsel  
National Science Foundation  
Alexandria, VA 22314

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