A.30 LIVING WITH A STAR TARGETED RESEARCH AND TECHNOLOGY: NASA/NSF PARTNERSHIP FOR COLLABORATIVE SPACE WEATHER MODELING

1. Scope of Program

1.1 Overview

Space weather refers to conditions on the sun and in the solar wind, interplanetary medium, magnetosphere, ionosphere, and thermosphere that can influence the performance and reliability of space-borne and ground-based technological systems and can endanger human life or health. Mitigation of these adverse effects requires understanding of the fundamental physical processes that affect the state of the Sun, solar wind, interplanetary medium, magnetosphere, ionosphere, and upper atmosphere. This understanding is being achieved by a variety of ongoing programs that address research, observations, and modeling of the space environment.

The National Space Weather Program (NSWP) is a multiagency Federal research initiative seeking to mitigate the adverse effects of space weather. Its ultimate goal is to achieve timely, accurate, and reliable space environment observations, specifications, and forecasts. Information about the NSWP can be obtained from the National Space Weather Program Strategic Plan and the National Space Weather Program Implementation Plan, both available at http://www.ofcm.gov/homepage/text/pubs.htm. NSWP goals address a number of scientific and operational requirements. For example, NASA's Vision for Space Exploration, which provides a comprehensive plan to explore the solar system and beyond with an initial focus on the Moon and Mars, requires appropriate scientific knowledge to explore and support decisions about the destinations for human exploration.

Under the NSWP, the Upper Atmosphere Research Section of the Division of Atmospheric Sciences of the National Science Foundation (NSF), in coordination with the NSF Office of Polar Programs, the Air Force Office of Scientific Research (AFOSR), and the Office of Naval Research (ONR), solicits proposals in support of NSWP objectives. In addition to basic research, this proposal competition has emphasized the development of space weather models for specification and forecast of conditions throughout the space environment.

Similarly, a primary goal of NASA's Living With a Star (LWS) Program is the development of first-principles-based models for the coupled Sun-Earth and Sun-Solar System, similar in spirit to the first-principles models for the lower terrestrial atmosphere. Such models can act as tools for science investigations, as prototypes and test beds for prediction and specification capabilities, as frameworks for linking disparate data sets at vantage points throughout the Sun-Solar System, and as strategic planning aids for enabling exploration of outer space and testing new mission concepts. To begin the process of developing and integrating models for all the components of the Sun-Earth and Sun-Solar System chain, the LWS Targeted Research and Technology (TR&T) Science Definition Team identified these models and their integration as strategic capabilities that

are critical for the TR&T program and recommended that they be funded as a distinct program element within the TR&T.

Because of the common goals among the agency programs described above, the LWS TR&T steering committee (http://lws-trt.gsfc.nasa.gov/trt_steercom05.pdf) suggested a unique partnership between NASA and NSF to support large-scale research projects that are more ambitious than those typically supported by a single grant by either institution. This NASA/NSF Partnership for Collaborative Space Weather Modeling will support modeling collaborations between institutions, including Government laboratories and universities, on projects that require funding levels in the range of $300K to $500K per year. Collaborations among proposing institutions are not required, but it is anticipated that collaborations are more likely to meet the objectives of this solicitation.

Two strategic goals have been identified that are of immediate concern to both the NSWP and to NASA's LWS program:

1. The need for a comprehensive, coupled, quantitative three-dimensional model for the outer magnetosphere, inner magnetosphere (plasmasphere, ring current, and radiation belts), and the ionosphere, including polar regions; and
2. The need for a three-dimensional time-dependent model of the solar corona and the ambient solar wind.

The NASA LWS program has identified an additional strategic goal of immediate concern only to NASA and its Vision for Space Exploration:

3. The need for a predictive model for radiation exposure anywhere on the surface or in the atmosphere of Earth, on the Moon, on Mars, and in interplanetary space between Earth and Mars.

1.2 Strategic Goals Addressed by this Solicitation

1.2.1 A Comprehensive Magnetosphere-Ionosphere Model.

The first strategic goal is a comprehensive, coupled, quantitative 3D model that predicts plasma and magnetic field conditions for both inner and outer magnetosphere, including the plasmasphere, ring current, and radiation belts, and the ionosphere, including polar regions.

Expected features of such a model include:

- The use of Interplanetary Magnetic Field (IMF) and solar wind data from L1 monitors or from heliospheric prediction models and F10.7 or some other EUV proxy as input;
- 3D magnetic and electric fields determined from the bow shock to the ionospheric E region at all latitudes (this implicitly requires proper kinetic treatment of the ring current);
- Determination of the electron density in the ionosphere and plasmasphere (this

implicitly requires a comprehensive ionosphere-thermosphere model that includes forcing from below through tides and gravity waves);
- Determination of radiation belt electron and ion populations;
- Determination of ionospheric currents and the resulting ground magnetic perturbations;
- The ability to handle the worst known magnetic storm conditions in a numerically robust manner;
- The ability to be executed in real time with reasonable computer resources;
- Use of established metrics and skill scores for the primary predicted quantities, in particular total electron content (TEC), radiation belt fluxes, and ground perturbations; and
- Ability to deliver a working version, with rigorous evaluation and validation procedures, to the CCMC and/or other NASA LWS or NSF centers within 3-5 years.

Desirable features of such a model include:
- Ability to employ input from several SW/IMF monitors;
- Ability to describe ionospheric ion outflow and multiple ion species in the outer magnetosphere, ring current, and plasmasphere;
- Ability to automatically assess output quality through concurrent real time data; and
- Ability to assimilate data.

1.2.2 Time-Dependent 3D Model for the Corona and Ambient Solar Wind

The second strategic goal is a 3D time-dependent model that provides the structure and properties of the slowly varying corona and the ambient solar wind.

Expected features of such a model include:
- A 3D quantitative description of the structure and properties of the large scale corona and heliosphere at any given instant in time;
- The ability to use both presently available and forthcoming line-of-sight (LOS) photospheric magnetic field data from ground- and space-based solar observatories as input;
- User-friendly interfaces and graphics for runs on demand by the general research community;
- The flexibility for quick-turn-around runs; and
- Ability to deliver a working version, with rigorous evaluation and validation procedures, to the CCMC and/or other NASA LWS or NSF centers within three to five years.

Desirable features of such a model include:
- The use of vector magnetic field observations as input;
- Predictions of time dependent solar wind parameters at point or object (Earth, Mars, spacecraft) in space;

- Ability to initiate simple transients (e.g., pressure pulses); and
- Modularity sufficient to include routines containing new or more sophisticated physics (e.g., improved energetics, erupting CMEs).

1.2.3 Earth – Moon – Mars Radiation Model

The third strategic goal is a comprehensive model capable of predicting radiation exposure anywhere on the surface or in the atmosphere of Earth, on the Moon, on Mars, and in interplanetary space between Earth and Mars. The model will provide deliverables of use to mission planners and space system designers for space exploration missions.

Expected features of such a model include:

- The ability to predict radiation exposure anywhere on the surface of Earth, the Moon, or Mars, in the atmosphere of Earth, and in the space between Earth and Mars given the energy spectrum, angular distribution, and elemental composition of the cosmic ray distribution in the solar wind; and
- A deliverable product in the form of a "Green function" for radiation exposure. The model should define clear procedures for integrating this Green function with an arbitrary specified cosmic ray distribution, to produce a prediction for radiation exposure.

Desirable features of such a model include:

- Error estimates on the predictions;
- Identification of the major sources of error;
- Recommendations concerning the research needed to narrow the error bounds (Illustration: Are uncertainties in nuclear cross-sections a major uncertainty in Earth's atmosphere? Is the atmosphere profile a limiting uncertainty on Mars?);
- Information concerning the implications of the results on critical electronic components;
- An evaluation of the effects of backscatter/albedo from lunar or Martian soils;
- An evaluation indicating whether soil composition is a significant factor;
- An evaluation determining whether magnetism from local surface features on the Moon or Mars is a significant factor;
- A determination of the relevance of magnetism from the induced magnetosphere of Mars; and
- An evaluation of shadowing from local landforms such as mountains or canyon walls.

2. Programmatic Information

2.1 NASA/NSF Partnership for Collaborative Space Weather Modeling

Given the unique nature of the NASA/NSF Partnership for Collaborative Space Weather Modeling, proposal reviewers will include both scientific peers and knowledgeable

representatives from the LWS/Space Weather user community. Proposals will be evaluated on the basis of their relevance, feasibility, intrinsic scientific merit, and compliance with requirements to provide public access to the models, tools, and value-added products developed.

The total funding available in fiscal year (FY) 2006 for new proposals submitted in response to this solicitation is expected to be about $1.5M. This funding is expected to support approximately three to five awards. Proposals for efforts up to five years duration are allowed.

For proposals addressing strategic goals 1 or 2 (see Section 1.1), NASA and NSF intend to fund appropriate proposals received from collaborations involving institutions that span the community including universities, Federally funded research and development centers, NASA centers, and others; collaborations between institutions of different types are encouraged. NASA intends to fund appropriate proposals addressing strategic goal 3.

The recommendation for funding will be based on the peer evaluation and the scientific and technical merit of each proposal, as well as the broader impacts of the activity, and relevance to LWS and NSWP goals. NASA and NSF will jointly manage the review process, the selection process, and the administration of the program.

The NASA and NSF program officers will recommend for selection the proposals that best address the objectives of this solicitation within the resource constraints. The NASA and NSF program officers will also recommend the division of funding responsibilities between the two agencies. NASA and NSF intend to issue separate funding instruments for the research efforts that each agency supports. NASA and NSF reserve the option of funding co-investigator institutions either as a subaward of the principal investigator institution's award or as a separate award directly to the co-investigator institution. The NASA and NSF selections will be coordinated so that together they fund the selected research efforts through an appropriate combination of awards.

To facilitate the issuance of separate funding instruments by NASA and NSF, for each institutional partner that proposes a budget of $100K or more within a multiinstitutional collaboration, the proposal should identify a lead co-investigator, provide a statement of work, and provide a separate budget for that institutional partner.

The NASA Selection Official is the Director, Earth-Sun System Division, Science Mission Directorate. The NSF Selection Official is the Head, Upper Atmospheric Research Section, Division of Atmospheric Sciences, Directorate for Geosciences.

2.2 Proposal Requirements

Proposals to this solicitation are expected to satisfy the following requirements:

- The total award size for any proposal will not exceed $500K per year for a period of performance of up to five years.

- For each institutional partner that proposes a budget of $100K or more within a multiinstitutional collaboration, the proposal should identify a lead co-investigator, provide a statement of work, and provide a separate budget for that institutional partner.
- Proposals should provide a detailed (~1/2 page) description of how the proposed work will benefit the goals and objectives described in Sections 1.1 and 1.2 and the timetable over which these benefits will accrue.
- The proposal must provide a set of clearly defined milestones and a description how and when these milestones will be accomplished.
- All models and software modules produced as a result of an NSF/NASA Partnership award must be submitted to an appropriate NSF and/or NASA modeling center, such as the Community Coordinated Modeling Center (http://ccmc.gsfc.nasa.gov/).
- The Federal Government must be granted a license for full and unrestricted use of the software, including the possible transition to space weather operations centers, consistent with 14 CFR 1260.30 (see Section A of the *NASA Grant and Cooperative Agreement Handbook* at http://ec.msfc.nasa.gov/hq/grcover.htm). In addition,
    a) the source code must be fully functioning,
    b) the code must be clearly documented according to standard software best practices,
    c) the code must be capable of running on actual, real-time, data as input and produce useful output, and
    d) to be part of end-to-end modeling efforts, the code's interoperability should be demonstrated.
- The proposal must include a description of how the resulting model(s) or software module(s) will be validated, documented, and delivered to potential users.
- Awardees may request time on the NSF supported PACI supercomputer and/or NASA's Columbia supercomputer.
    - Information on applying for computer time at the PACI centers can be found at http://www.paci.org/.
    - Information on applying for computer time on NASA's Columbia supercomputer can be found in this NRA's *Summary of Solicitation*, Section 1(c). Please note that the description of the computing resources needed should include an estimate of the aggregated computing time per year (number of runs times number of processors per run times number of hours per run), as well as the associated storage capacity needed to support the investigation. Peer review panels will be asked to consider the realism and reasonableness of the computing request as a requirement for the science investigation and as an appropriate utilization of a highly constrained resource. Successful investigations selected for funding will be considered for an allocation of the requested computing resources, but the fully requested level cannot be guaranteed.

The program will provide links to the abstracts of all selected proposals and their annual

progress reports, including developed and tested software and/or refined data products, at http://lws-trt.gsfc.nasa.gov/.

In addition to the regularly scheduled annual reports expected for any proposal selected in response to this opportunity, the Program Officers in the NASA LWS TR&T program and the NSF Upper Atmosphere Research Section will conduct a comprehensive review of the milestones accomplished three years after award initiation. At that time, and as directed by NASA HQ and NSF, each principle investigator will submit a detailed report to the LWS TR&T Program Officer (copy to the NSF/ATM Cognizant Officer) describing (1) progress to date, (2) problems encountered, and (3) plans for the remaining two years of funding. Each principle investigator will present these results either on site or during a visit to NASA HQ and/or NSF. Consistent with their policy of routinely seeking council of the scientific community, NASA and NSF will invite appropriate members of the research and user community to review and comment upon this 3-year report. With the findings from these reviews, NASA and NSF will then provide opportunity to the PI teams to revise their plans when requesting continued funding for the fourth year.

2.3 Demonstration of Relevance to NASA Objectives

Proposals for all of NASA sponsored research programs are judged on three criteria: Scientific and technical merit of the proposed work, cost realism and reasonableness, and relevance of the proposed work to NASA missions and science goals (see also Appendix C of the *Guidebook for Proposers Responding to NASA Research Announcement – 2005* at http://www.hq.nasa.gov/office/procurement/nraguidebook/). To enable the NASA Science Mission Directorate to properly evaluate the relevance of proposals submitted to its programs, as well as track its progress toward achieving its goals as mandated by the Government Performance Review Act (GPRA), it is mandatory that all research supported by NASA's programs demonstrate its relationship to NASA's strategic goals and/or science objectives as stated in the latest version of its Strategic Plan; see the discussion in Section I(a) of the *Summary of Solicitation* of this NRA. Therefore, in addition to addressing the specific goals of this program, the main text of each proposal must provide a statement of the relevance of the proposed work to NASA's *Strategic Objectives* as given in Table 1 in the *Summary of Solicitation* of this NRA. This discussion need not exceed the order of a quarter page of text and is to be included in the introduction to the Science-Technical-Management section of proposal.

Note that this NRA references NASA's 2005 strategic objectives (see Section I(a) and Table 1 for references).

2.4 Demonstration of Relevance to NASA's LWS Objectives

Proposers are reminded that the evaluation criteria for this solicitation are given in the *NASA Guidebook for Proposers* (see below for reference). These criteria are intrinsic merit, relevance to NASA's strategic goals and objectives, and cost realism and

reasonableness. In addition to the factors given in the *NASA Guidebook for Proposers*, the evaluation criterion "intrinsic merit" specifically includes the following factors:

- The degree to which the proposed investigation is relevant to one of the three Strategic Goals listed in Section 1.1 and described in Section 1.3;
- The proposed investigation's feasibility, intrinsic scientific merit, and compliance with requirements to provide public access to any tools and value-added products developed; and
- The intellectual merit of the proposed activity including consideration of the following questions: How important is the proposed activity to advancing knowledge and understanding within its own field or across different fields? How well qualified is the proposer (individual or team) to conduct the project including, if appropriate, the quality of prior work? To what extent does the proposed activity suggest and explore creative and original concepts? How well conceived and organized is the proposed activity? Is there sufficient access to the necessary resources?

In addition to the factors given in the *NASA Guidebook for Proposers*, the evaluation criterion "relevance to NASA's strategic goals and objectives" specifically includes the following factor:

- The broader impacts of the proposed activity, including consideration of the following questions: How well does the activity advance discovery and understanding while promoting teaching, training, and learning? How well does the proposed activity broaden the participation of underrepresented groups (e.g., gender, ethnicity, disability, geographic, etc.)? To what extent will it enhance the infrastructure for research and education, such as facilities, instrumentation, networks, and partnerships? Will the results be disseminated broadly to enhance scientific and technological understanding? What may be the benefits of the proposed activity to society?
- The relevance to the proposed investigation to the goals of NSWP.

2.5 Demonstration of Relevance to the Objectives of the National Space Weather Program

An effective National Space Weather Program requires a strong commitment to basic research in many areas of space-related science. Emphasis will be placed upon understanding the fundamental physical processes that affect the state of the Sun, solar wind, magnetosphere, ionosphere, and upper atmosphere, while focusing on answering research questions that will improve the ability to specify and predict conditions in the space environment. Additional information about the NSF program for Research in Support of the NSWP can be found at http://www.nsf.gov/pubs/2005/nsf05508/nsf05508.pdf. Additional information about the NSWP itself can be found at http://www.ofcm.gov/nswp-ip/tableofcontents.htm.

It would be of benefit to the program, if the proposers also demonstrate the relevance of their scientific objectives to the goals of the international initiatives commemorating the fiftieth anniversary of the International Geophysical Year (1957-58), such as the International Polar Year 2007-08 (http://www.ipy.org/), International Heliophysical Year (http://www.ihy2007.org/), Electronic Geophysical Year (http://www.egy.org/), and the SCOSTEP Program "Climate and Weather of the Sun-Earth System" (http://www.bu.edu/cawses/).

2.6 Electronic Submission of Proposals Required

Submission of fully electronic proposals is required for this solicitation. The NASA proposal data base system at http://nspires.nasaprs.com/ has the functionality to accept fully electronic proposals through a combination of data-based information (e.g., the electronic Cover Page and its associated forms) and uploaded PDF file(s) that contain the body of the proposal. One hard copy proposal, complete with required original signatures on its attached Cover Page, is to be submitted in addition to the electronic proposal documentation. The web site will provide a list of all elements that make up an electronic proposal, and the system will conduct an element check to identify any item(s) that is (are) apparently missing or incomplete. Note that a failed element check will not preclude submission but rather it will serve as a warning that a proposal may be incomplete.

Proposers to this solicitation are particularly encouraged to begin their submission process early and to make use of the help desk (nspires-help@nasaprs.com or by telephone to (202) 479-9376 Monday through Friday, 8:00 AM 6:00 PM Eastern Time) for any questions that cannot be resolved with the available on-line help menus.

2.7 Option to Submit Proposals via Grants.gov

Proposers may opt to submit proposals in response to this solicitation via either Grants.gov at http://www.grants.gov or via the NSPIRES system at http://nspires.nasaprs.com/.

Submission via Grants.gov requires electronic submission of the proposal and all required forms and supporting documentation. If a proposal is submitted via Grants.gov, then no hard copy proposals are required. NSPIRES remains the only system through which Notices of Intent to propose (NOIs) can be submitted.

Instructions for submitting proposals to NASA via Grants.gov may be found on the Grants.gov portal at http://www.grants.gov/. The funding opportunity number required to download an application package from Grants.gov is given in Section 2.8.

2.8 Summary of Key Information

Expected total program budget for new awards	~ $1.5M
Number of new awards pending adequate proposals of merit	~ 3-5
Maximum duration of awards	5 years;
Page length for the central Science-Technical-Management section of proposal	20 pp; see also Chapter 2 of *Guidebook for Proposers Responding to NASA Research Announcement – 2005*
Submission medium and number of copies	Electronic proposal submission is required. For submission via NSPIRES, electronic submission is required for this proposal with one signed original hard copy (see Section 2.6). For submission via Grants.gov, no hard copy is required (see Section 2.7). See also Chapter 3 of *Guidebook for Proposers Responding to NASA Research Announcement – 2005*
NASA Strategic Objectives to which proposals to this program must state and demonstrate relevance	See Table 1 in the *Summary of Solicitation* of this NRA.
General information and overview of this solicitation	See *Summary of Solicitation* of this NRA.
Detailed instructions for the preparation and submission of proposals	*Guidebook for Proposers Responding to NASA Research Announcement – 2005* at http://www.hq.nasa.gov/office/procurement/nraguidebook/.
Web site for submission of proposal via NSPIRES	URL: http://nspires.nasaprs.com (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	URL: http://grants.gov
Funding opportunity number for downloading an application package from Grants.gov	NNH05ZDA001N-LWS2
Due Date for Notice of Intent to Propose	October 14, 2005
Due Date for delivery of proposals	December 2, 2005

Address for the delivery of proposals	NASA/NSF Collaborative Space Weather Modeling ROSES-2005 NRA Science Mission Directorate NASA Peer Review Services Suite 200 500 E Street, SW Washington, DC 20024 Telephone: (202) 479-9030
NASA point of contact concerning this program	Dr. Madhulika Guhathakurta Earth-Sun System Division Science Mission Directorate National Aeronautics and Space Administration Washington, DC 20546-0001 Telephone: (202) 358-1992 E-mail: Madhulika.Guhathakurta@nasa.gov
NSF point of contact for this program	Dr. Kile Baker Division of Atmospheric Sciences The National Science Foundation 4201 Wilson Boulevard Arlington, VA 22230 Telephone: (703) 292-8519 E-mail: kbaker@nsf.gov