B.6 LIVING WITH A STAR TARGETED RESEARCH AND TECHNOLOGY

Amendment 11 July 21, 2009. This version of Appendix B.6: Living With a Star Targeted Research and Technology replaces, in its entirety, the Draft version that was released with the ROSES-2009. The due dates remain the same. Notices of intent to propose are due September 18, 2009. Proposals are due October 16, 2009.

1. Scope of Program

1.1 Overview

The goal of NASA's Living With a Star (LWS) Program is to develop the scientific understanding needed for the United States to effectively address those aspects of Heliophysics science that may affect life and society. The LWS Targeted Research and Technology (TR&T) program element solicits proposals leading to a physics-based understanding of the integral system linking the Sun to the Solar System including the impact on the heliosphere, planetary magnetospheres, and ionospheres. The TR&T program's objectives can be achieved by data analysis, theory, and modeling, and the development of tools and methods (e.g., software for data handling). TR&T is a crosscutting initiative that addresses the LWS strategic goals relating to all aspects of NASA's Mission, namely (in no priority order):

1. Solar energetic particles and galactic cosmic rays pose major radiation hazards for space hardware and astronauts. Penetrating particle radiation adversely affects aircraft avionics and potentially the health of airline crews and passengers on polar flights. Communication and navigation systems are directly affected by impulsive changes in the solar particle and electromagnetic output leading to re-routed polar flights and GPS outages. In support of NASA's Vision for Space Exploration and the national communication, navigation, and transportation infrastructure, the TR&T program needs to deliver the understanding and modeling required for useful prediction of the variable solar particulate and radiative environment at the Earth, Moon, Mars, and throughout the solar system.

2. One of the major challenges facing humanity is global climate change. In order to gauge the response of the terrestrial climate system to natural and anthropogenic forcings, NASA through the TR&T program and Earth Science Division in conjunction with other national agencies such as NOAA and NSF needs to deliver the understanding of how and to what degree variations in the solar radiative and particulate output contribute to changes in global and regional climate over a wide range of time scales.

3. National infrastructures are increasingly dependent on satellites orbiting Earth. With increasing miniaturization these systems are ever more sensitive to variations in the near-Earth space environment. To protect these assets, the TR&T program needs to

deliver the understanding and modeling required for effective forecasting/specification of magnetospheric radiation and plasma environments.

4. The upper atmosphere and ionosphere is central to a host of space weather effects, including anomalous satellite drag, GPS position error, radio blackouts, radar clutter, and geomagnetically induced currents. In order to mitigate space weather's impact on life and society, NASA through the TR&T program in conjunction with other national agencies such as NSF and DoD needs to deliver understanding and predictive models of upper atmospheric and ionospheric responses to changes in solar electromagnetic radiation and to coupling above and below.

These strategic goals will guide the selection of focused science topics for this solicitation. The primary goal of the LWS Program is to make progress in understanding this complex system, focusing on the most critical interconnections.

The *Final Report of the LWS TR&T Science Definition Team (SDT)* (December 2003), located on the LWS TR&T homepage at http://lws-trt.gsfc.nasa.gov/trt_resources.htm, identified TR&T as a systematic, goal-oriented research program. The TR&T component of the LWS Program provides the theory, modeling, and data analysis necessary to enable an integrated system-wide picture of Heliophysics science with emphasis on societal relevance.

Significant progress toward quantitative understanding and predictive capability with respect to these problems will require large-scale, integrated modeling activities. Recognizing the need for activities that would be broader and more sustained than those that can be supported by a traditional NASA grants program, the *Final Report of the LWS TR&T Science Definition Team* recommended that "…large modeling activities that address coupling across traditional science domains in the Sun-Earth chain specifically be included as strategic capabilities." The TR&T SDT also recommended the formation of a TR&T Steering Committee in order to update periodically the designated strategic capabilities for future solicitations. The most recent report of this Steering Committee is available on the LWS TR&T homepage at http://lws-trt.gsfc.nasa.gov.

As a result of these studies and recommendations, the LWS TR&T program has defined a strategy with three program elements, namely, Strategic Capabilities, Targeted Investigations, and Cross-Disciplinary Infrastructure Building programs.

Further background material concerning relevant research objectives can be found in the following documents:

- The National Academy of Sciences Web tutorial, entitled "*Space Weather: A Research Perspective*" (http://www7.national-academies.org/ssb/SSB_Space_weather97.pdf);
- The Sun Earth Connection LWS web site (http://lws.gsfc.nasa.gov/);
- The LWS Science Architecture Team report to SECAS (http://lws.gsfc.nasa.gov/documents/sat/sat_report2.pdf);

- *The Sun-Earth Connection Roadmap Report* (http://sec.gsfc.nasa.gov/sec_2002_roadmap.pdf);
- The NRC Decadal Survey Report *The Sun to the Earth and Beyond* (http://www.nap.edu/books/0309089727/html/);
- *The Heliophysics Roadmap* (http://sec.gsfc.nasa.gov/sec_roadmap.htm);
- *The TR&T Science Definition Team Report* (http://lws-trt.gsfc.nasa.gov/TRT_SDT_Report.pdf); and
- *The latest TR&T Steering Committee Team Report* (http://lws-trt.gsfc.nasa.gov/trt_resources.htm).

1.2 Targeted Investigations

The stated goal of LWS, that of achieving an understanding of those aspects of the Sun-Solar System that have direct impact on life and society, poses two great challenges for the TR&T program. First, the TR&T program must tackle large-scale problems that cross discipline and technique boundaries (e.g., data analysis, theory, modeling, etc.); and second, the TR&T program must identify how this new understanding will have a direct impact on life and society.

This Targeted Investigations program element is subdivided into the three components described below: (1) Focused Science Topics, (2) Sun-Climate Theme, (3) Tools & Methods. The maximum duration of these awards are 4 years, 3 years, and 2 years, respectively. Read the following sections carefully; there are significant changes this year, especially as related to compliance.

Proposals will be judged non-compliant and will not be reviewed if the compliance criteria found in section 2.2 and detailed in sections 1.2.1 and 1.2.3 are not met.

Note that there is no Independent Investigations (II) component this year. The original intent of the II component was to enable the consideration of cutting-edge ideas that have a high level of both urgency and impact on LWS goals and objectives. The LWS program received a large number of proposal submissions in this category, but only a few met the criteria of timeliness and strategic impact. Given the resource constraints the II component has been eliminated for at least this year. See the latest TR&T Steering Committee Report (http://lws-trt.gsfc.nasa.gov/trt_resources.htm) for more details.

1.2.1. Focused Science Topics

A set of Focused Science Topics has been chosen for emphasis in this solicitation and these are listed below. The maximum duration of these awards is 4 years. NASA desires a balance of research investigation techniques for each Topic, including theory, modeling, data analysis, observations, and simulations. Any individual proposal does not need to include all techniques. Given the submission of proposals of adequate number and merit, up to eight selections will be made for each Focused Science Topic. Once selected, these investigators will form a team in order to coordinate their research programs. One of the PIs will serve as the Team Leader for the Focused Science Topic for which he/she proposed, and will receive supplemental funding as necessary to support costs associated with these duties. Proposers are encouraged to propose to act as a Team Leader and if they do so, should include a brief section in their proposal describing how they would lead the team effort. Up to one extra page in the proposal is allowed for this proposed effort. All proposers for Focused Science Topics should include sufficient travel funds in their proposed budgets to cover two team meetings per year to be held on the U.S. coast furthest from their home institutions. See Instructions for TR&T Focus Team Members and Leaders at (http://lws-trt.gsfc.nasa.gov/trt_focusteams.htm) for full details of responsibilities.

While the primary evaluation criteria remain unchanged (see *ROSES Summary of Solicitation*, Section V(a), and the *NASA Guidebook for Proposers*, Appendix C.2), the criterion for relevance includes relevance to one of the Focused Science Topics as an essential requirement for selection within this component. In addition, starting this year NASA is instituting a compliance check as follows:

In order to be compliant to this ROSES element, each proposal submitted must contain a section, entitled "Proposed Contributions to the Focus Team Effort" and identified in the proposal's table of contents. Failure to include this section will result in the proposal being judged non-compliant, and the proposal will be returned.

This section must include the following three items:

- The relevance of the proposal to the scientific objectives of the Focused Topic
- The potential contributions (e.g., data sets, simulation results, novel understanding of physical mechanisms, etc.) from the proposed effort to the Focused Science Team's effort
- Metrics and milestones for determining the successful progress and outcome of the proposed research.

Since each Focused Science Team has to produce a joint statement of work (SOW) specifying its deliverables, success criteria, and milestones, the mandatory section described here can serve as a starting point for this SOW.

The *NASA Guidebook for Proposers* states that "NASA strongly encourages PIs to specify only the most critically important personnel to aid in the execution of their proposals." LWS further emphasizes that Focus Teams will be formed from individual proposals selected in a Focus Topic. Therefore, individual proposals do not need to tackle the whole problem, but can instead seek to solve a piece of the problem.

The Focused Science Topics (FST) appropriate as the objectives for proposals to this LWS TR&T solicitation are as follows (linked to the four goals above):

(a) Determine the Behavior of the Plasmasphere and its Influence on the Ionosphere and Magnetosphere

Target description: The plasmasphere is the cold light ion plasma which fills the inner magnetosphere. It is connected to the underlying ionosphere along geomagnetic field lines, and is typically bounded by a plasmapause layer. This boundary is characterized by significant coupled dynamical variations and plasma wave / particle activity, driven by the overlap of cool dense plasma with hot, tenuous plasma. In general, the plasmasphere provides a reservoir that helps maintain the night-side ionosphere. It interacts with radiation-belt particles and with plasma waves to scatter energetic particles into the atmosphere. As such, the plasmasphere boundary layer and its evolution are critical for radiation-belt dynamics. The plasmasphere is also a significant contributor to total electron content and its large scale variations, both of which directly affect transionospheric radio signals such as GPS. When magnetospheric sunward convection speeds up, the plasmasphere is drawn out into pronounced plumes that supply substantial amounts of plasma to the dayside reconnection region, changing its asymmetry, and loading the resultant boundary layer flows in ways that may influence global magnetospheric dynamics.

An improved understanding and description of plasmasphere and plasmapause behavior is required for significant cross-disciplinary advances across the entire coupled ionosphere-thermosphere-magnetosphere-heliosphere system. In particular, there is a timely community need to advance our ability to model coupled system responses and to predict plasmaspheric plasma distribution and motion both along and across the magnetic field as well as the plasma-wave environment. Coupled system effects of interest include subsonic and supersonic multi-species ion upflow events, their corresponding ionospheric electron density structures and enhanced radiation-belt particle losses, and particle-particle and wave-particle interactions leading to plasma heating and photoelectron transport. Observations of plasmaspheric behavior are available under a wide variety of conditions from various NASA missions, especially recently from IMAGE, and significant data also exists from ground-based instruments and integrated line-of-sight total electron content observations from GPS and other radio wave techniques. Models exist that simulate field-aligned multi-species plasma flows and energetics, as well as global plasmaspheric density and temperature, but many uncertainties remain.

Goals and measures of success: The goal of this FST is to produce improved descriptions of the plasmasphere and plasmapause and their dynamic variability. The primary measure of team success will be the ability to obtain agreement between observations and models of daily, seasonal, solar-cycle, and storm-time variability of plasmaspheric density, temperature, and composition, plasmapause location, and plasma-wave density. Other measures of success will be quantification of the influences of the plasmasphere on ionospheric electron density, total electron content, and on radiation-belt particle loss.

Types of Investigations:

- Analyses of in-situ and remotely sensed plasmaspheric electron densities to establish a three-dimensional, time-dependent picture of the behavior of the plasmasphere and plasmapause;

- First-principles modeling of plasmaspheric density, composition, and temperature that include particle filling and depletion processes and electrodynamic coupling with the ionosphere;
- Observational and modeling studies of plasma convection, plasmapause layer dynamics, and plasmaspheric plume formation and transport;
- Theoretical studies of interactions among cold plasma, photoelectrons, radiation-belt particles, and plasma waves relevant to plasmaspheric heating and pitch-angle scattering.

(b) Plasma-Neutral Gas Coupling

Target Description: The coupling of ionized plasma to neutral material is a fundamental physical process of importance to many problems in Heliophysics and Astrophysics. It is a key to our understanding of magnetosphere-ionosphere-atmosphree interactions, of the solar chromosphere, and of prominences and spicules embedded in the corona, as well as our understanding of interstellar gas within the solar system, comets in the solar wind, and planetary satellites inside magnetospheres or exposed to the solar wind.

Heliospheric material spans enormous ranges in thermodynamic and magnetic conditions. Regimes of plasma dynamic beta, particle magnetization, and form of conductivity change dramatically between the base of the chromosphere or thermosphere and the corona and magnetosphere, respectively. Mixed plasma conditions occur at interface zones, such as the cool spicules ejected into the solar corona, or ionospheric plasma fountains. Coupling across interfaces is especially strong when a magnetic field linkage threads the transition: mass, momentum, and energy transfer are then highly efficient. Where ions are magnetized, ion-neutral collisions may be the dominant way to convert fast ordered motion into heat. This is a major source of heating for the ionosphere and thermosphere, and possibly for the chromosphere. If significant, this mechanism would place chromospheric UV emission (with its varying influence on the planets) on a firm physical basis. Weakly ionized material may also play a significant role in determining the hydromagnetic state in adjacent regions, such as the corona, as ion-neutral collisions modify the conductivity and magnetic field, and above the aurora, where heating has recently been found to greatly enhance densities. The role of plasma instabilities and irregularities in plasma-neutral coupling is likely to be important, but is not well understood. Plasma-neutral coupling is an area ripe for an inter-disciplinary initiative comparing first principles theory with both solar and ionospheric remote sensing and ionospheric *in situ* observations, and holds the potential to resolve diverse problems of Heliophysics.

Goals and Measures of Success: The principal goals are (1) establish a cross-disciplinary collaboration between the solar, magnetosphere, and the ionosphere/thermosphere communities to resolve strategically important questions concerning the transition from a weakly ionized dense gas to a fully ionized tenuous plasma with the linkage of the electromagnetic field, (2) enhance our physical understanding of such a system, and (3) encourage chromospheric observations that quantify magnetic and thermal conditions in the chromosphere, in particular, observations with the new generation of spectropolarimetric instruments, and (4) improve numerical modeling of the coupling in both the chromosphere and the ionosphere-thermosphere.

Measures of success include: (1) First-principles self-consistent numerical models of the chromosphere that describe available observations, (2) First-principles self-consistent numerical models that describe realistically the plasma-neutral interaction in the ionosphere-thermosphere, (3) Demonstrated understanding of heating rates produced by ion-neutral relative motions in magnetized regions. (4) Refinement of self-consistent numerical models of energetics in the ionospheric E region that incorporate the full range of ionosphere/thermosphere kinetic and wave effects.

Types of Investigations:

- Analytical and numerical investigations of chromospheric and ionospheric heating including plasma-neutral gas coupling.
- Observations and data analyses that provide critical information to test the predictions of models of chromospheric heating. Examples might include measuring the ordered motions and change in magnetic field through the chromosphere.
- Observations and data analyses that provide critical information to test the predictions of models of ionospheric heating and outflow into the magnetosphere.
- Theoretical investigations and numerical models that self-consistently describe and successfully predict the plasma, neutral wind, and electromagnetic field interactions, constrained by both solar and ionospheric observations.

(c) Predict the Onset and Space Weather Impacts of Fast CMEs/Eruptive Flares

Target Description:
It is now widely accepted that the energy for the most destructive forms of space weather, including strong SEP events and major geomagnetic storms, resides in the strongly sheared magnetic field of an active region filament channel. This energy is often released explosively in the form of a fast coronal mass ejection (CME) and/or eruptive flare. Although we can predict where such events will originate, we cannot yet predict when they will occur and the magnitude of the resulting space weather. Consequently, the prediction of CME/flare onset and impact is one of the major objectives of the LWS program and is a prime focus for its missions.

There are two reasons why this problem is now ripe for a focused team attack. First, we will soon have unprecedented new data from the first LWS mission, SDO, which will deliver continuous high-resolution (spatial and temporal) observations of the vector magnetic field at the photosphere and of the resulting coronal dynamics. The combination of STEREO and SDO will allow us to measure the complete evolution of an explosive event, from its energy buildup at the Sun to its impacts at 1 AU. Second, we now have the capability to perform detailed 3D modeling of CMEs/flares for comparison with the observations. Given that the Sun is entering the rise to maximum, it is now time to address this outstanding problem of CME/flare onset and impact.

Goals and Measures of Success: The goal of this Focused Science Topic is to relate quantitatively solar structure and evolution to the onset of a CME/flare event and to the intensity of the space weather driven by this event. The prime measure of success for this work would be a substantial improvement in our ability to predict when a solar eruption leading to a CME will occur and to predict the evolution of the CME and its space weather consequences.

Types of Investigations:

- Studies of photospheric/chromospheric/coronal magnetic structure and evolution leading to CME/flare onset.
- Development and testing of models (theoretical and empirical) that predict the onset, initial velocity and density, and internal magnetic field of CMEs.
- Development and testing of models that predict the CME properties in interplanetary space to Earth, including the internal CME properties and the shock that is generated.
- Assessment of the data required to predict the initiation of CMEs and their properties, including an assessment of the limitations of different data types, and the prioritization of data needed to predict CME initiation and properties.

(d) Origin and Nature of the Slow Solar Wind, Associated Interplanetary Structures, and SEP Transport

Target Description: At all times, the heliosphere is filled with a combination of fast and slow solar winds. The fast solar wind, typically associated with speeds exceeding 600 km/s, originates primarily from coronal holes. It is also characterized by ion temperatures that far exceed electron temperatures in the inner corona, at least out to 10 R_S from the Sun, and by near photospheric-like composition. At least half of the time, however, a substantial fraction of the near-ecliptic solar wind that immerses the planets has characteristics that are distinct from the fast wind: its speed is typically < 500 km/s, and the ion temperature tends to be lower than the electron temperature in the inner corona. Furthermore, its ionic and elemental composition is much more representative of closed magnetic structures (e.g. loops) in the corona. The properties of the slow solar wind are far more dynamic and variable than those of the fast solar wind. The slow solar wind is generally found in the vicinity of the heliospheric current sheet emanating from streamers at the Sun, especially at the time of solar minimum. However, the sources for this slow solar wind have not been clearly established. Near solar maximum, the slow solar wind may not even be spatially limited to the heliospheric current sheet.

Fast-moving solar energetic particles (SEPs) propagate from the corona into the heliosphere and, consequently, are highly effective remote probes of solar-heliospheric structures. As such, they add much to our investigation of the slow wind. Moreover, to increase our understanding of the origin of SEPs, which is a central goal of the LWS program, a better understanding of the nature of the coronal and heliospheric magnetic fields in slow wind regions is required. Thus, it is natural to study the physics of SEP transport concomitantly with studies of the origin and nature of the slow solar wind.

Goals and Measures of Success: The goal of this FST will be to develop an understanding of the physical processes in the solar corona and inner heliosphere that determine the origin of the slow solar wind, its coronal and interplanetary plasma and magnetic field dynamics and structure, and the transport of SEPs through the slow wind. Measures of success would be a substantial advance in our understanding of the slow solar wind, especially, its source(s) at the Sun, the physical reasons for its similarities and differences to the fast solar wind, the mechanism(s) responsible for its temporal variability, and the origin(s) of the observed plasma composition and magnetic structures. Another important measure of success would be an improvement in our ability to model the slow wind accurately and achieve better agreement between solar wind models and in situ data. Improvement in models for the propagation of SEPs from their solar sources into the inner heliosphere is another important measure of success for this FST.

Types of Investigations:

- Studies of coronal structure and plasma properties, especially composition, with the goal of determining the source regions of the slow wind.
- Studies of the in situ magnetic and plasma properties of the slow wind, especially composition or other properties that allow us to distinguish source regions unambiguously.
- Studies of the relative properties of the fast and slow wind, focusing on identifying the clearly distinctive differences between the two winds and providing insights into the physical origins for these differences.
- Studies of SEP transport in slow wind regions.
- Studies of how SEPs can be used to connect the slow wind to its coronal sources.
- Development of improved models for the solar wind, especially models and physics-based procedures that can be delivered to the CCMC.
- Development of theories, models, and data analysis tools in anticipation of Solar Orbiter and Solar Probe Plus.

1.2.2 <u>The Sun-Climate Theme</u>

The LWS Sun-Climate strategic objective is to *"deliver the understanding of how and to what degree variations in the solar radiative and particulate output contribute to changes in global and regional climate over a wide range of time scales."* The new Sun-Climate Theme is established to address this objective. The maximum duration of these awards is 3 years. This theme represents a new opportunity to foster cross-disciplinary investigations of connections between solar forcing and climate. Particular emphasis is placed on coupling of the upper and lower atmosphere and the processes responsible for transmitting solar variations to the Earth's surface where they can affect regional climate. Only investigations of sun-climate issues will be considered compliant with this theme; climate investigations that are not directly relevant to solar forcing are not being solicited. Atmospheric responses on time scales of seasons to millennia are of primary interest.

It is anticipated that this new TR&T program element will be solicited on an annual basis over the next several years. Rather than aiming science contributions at a focused science team, proposers will submit individual investigations that must explicitly describe how the proposed work will lead to progress in achieving the prioritized goal quoted above. Contributions from a solar and upper atmosphere perspective will likely be on equal footing with those from a lower atmosphere climate dynamics and chemistry perspective. Exchange among diverse research foci within the Sun-Climate Theme is expected to grow through regular meetings (initially once a year), and individual collaborations are strongly encouraged.

Thematic Description: Proposals submitted to the new Sun-Climate Theme will target processes by which solar radiative and particulate forcing can impact the Earth's climate. Solar activity variations clearly influence the upper atmosphere, but signals diminish toward the surface. Nevertheless, in some locations climate-related parameters, such as the historical surface temperature or moisture records, exhibit variations that appear to be related to the solar cycle. Two key issues must be addressed to make progress in quantifying the solar contribution to climate variability and change: (1) Observed decadal to centennial-scale climate signals throughout the atmosphere and at the surface must be categorized as either systematically related to solar activity changes or as spurious because of internal climate system variations on similar time scales. (2) The emphasis of solar impact studies in climate research must be broadened beyond mean radiative forcing to include both direct and indirect atmospheric impacts of spectral irradiance and particle precipitation variations over the full range of spatial and temporal scales.

The intent of this Sun-Climate Theme is to initiate cross-disciplinary research that will develop a more solid mechanistic understanding of pathways by which solar variability affects the various levels of the atmosphere and how these effects are communicated toward the troposphere and surface where they modulate global and regional climate. It also targets the pathways by which ongoing climate change influences the atmospheric response to solar forcing, both directly and via upward coupling. Investigations that identify these processes and analyze variations over a wide range of time scales are necessary to reconcile observations and understanding of the natural modulation of climate by the Sun and to delineate the Sun's role in regional climate variability and current climate change. This information is crucial for testing climate models that are used for regional climate change prediction. Thus, this program component solicits investigations that seek to define and quantify the solar-induced changes in a "whole atmosphere" approach, emphasizing downward and upward coupling between the upper and lower atmosphere.

Objectives and Metrics: The overall objective is to predict the climate response to solar variability on regional, as well as global scales. Metrics will be gauged for a number of tasks: (1) Identifying and quantifying the relevant pathways by which solar forcing causes variability in climate parameters, such as atmospheric temperature, circulation, and wave activity over a broad range of time scales; (2) Isolating the regional and global climate response to variations in these pathways; (3) Assessing the sensitivity of these pathways to long-term change in the troposphere and atmospheric composition; (4) Incorporating solar forcing effects into coupled chemistry climate models (CCMs) to produce verified simulations of these effects on atmospheric processes; and (5) Testing and improving the predictive capabilities of the CCMs and Earth System Models with regard to solar-induced forcing. Also of interest is identifying the minimum specifications of vertical extent, resolution, and process complexity that a lower atmosphere model would need in order to adequately simulate solar effects on surface climate and variability. It is expected that numerical modeling, theory, data analysis, and assimilation investigations will contribute to the Sun-Climate Theme, with studies addressing seasonal to millennial time scales. The following topics are examples of relevant areas of investigation; these are meant only to be illustrative and are not all-inclusive:

- Quantify wintertime constituent transport from the thermosphere to the stratosphere, and any subsequent effects on the troposphere, to investigate the influence on these processes of solar particle variability.

- Quantify stratospheric ozone variations caused by solar irradiance variability and the impacts of these variations on atmospheric circulation patterns.

- Explore the sensitivity of planetary-wave propagation and of large-scale circulation processes, such as the Brewer Dobson circulation, to solar variability.

- Develop and apply statistical procedures to climate data in order to quantify solar-variability signals on various time scales, tying these signals to radiative, chemical, or dynamical processes.

- Determine what regional climate variability is systematically influenced by solar variability.

- Develop an assimilation of meteorological data from the troposphere up to the lower thermosphere to identify the impact of solar variations.

- Investigate the sensitivity of interhemispheric coupling to wave activity variations induced by solar variability.

- Evaluate the spectral detail necessary for proper treatment of the radiative and photochemical response to solar spectral variability.

- Identify the dominant processes by which galactic cosmic rays can influence climate, including impacts on cloud condensation nuclei and thus cloud cover and cloud radiative forcing, as well as impacts on the global atmospheric electric circuit.

- Assess the influence of climate change on any of the above.

Note that this theme is ***not*** soliciting proposals for the development of solar irradiance proxies, unless they are specifically focused on improving the treatment of atmospheric coupling. Furthermore, this theme does not address day-to-day weather variability, unless it is connected to longer-term changes in tropospheric and stratospheric climate.

1.2.3 Tools and Methods

The Tools and Methods component supports studies that deliver tools and/or methods that enable critically needed science advances. The maximum duration of these awards is 2 years. Examples include (1) the development of new empirical methods or analysis techniques, such as local helioseismology, that can be used to forecast solar, interplanetary, and geospace activity, (2) the development of new feature recognition or artificial intelligence (AI) algorithms that can advance predictive capabilities for the LWS system, and (3) the development of software tools that can identify, retrieve, assimilate, and/or portray data in order to model results from different sources for LWS research and forecasting objectives. Tools that address the four LWS TR&T strategic goals will be especially welcome.

A deliverable product(s) and delivery site must be specified along with a delivery date. The deliverable product can be, for example, a stand-alone product or a web application, and must be delivered to a LWS approved repository/server such as the Community Coordinated Modeling Center (CCMC; http://ccmc.gsfc.nasa.gov/), an existing Heliophysics virtual observatory (VxO), solar soft repository, or a mission site. The delivery date must be during the final year of work with enough time left to support appropriate documentation and handover to the CCMC/VxOs/solar soft/mission to insure longevity and to enable its independent use by the scientific community. All tools will be listed with links from the LWS TR&T web site (http://lws-trt.gsfc.nasa.gov).

Furthermore, the Proposal Summary that is submitted at the NSPIRES website must include explicit language stating the following:
Deliverable: What will be the tool or method?
Delivery Site: Where will it be delivered (e.g., CCMC, data center, mission site, etc.)?
Schedule: When will it be delivered?
Proposals that do not include the Deliverable, Delivery Site and Schedule explicitly in the Proposal Summary will be deemed non-compliant and will not be reviewed.

1.3 Cross-Discipline Infrastructure Building Programs

One of the major challenges facing the LWS Program is the development of a research community that can cross traditional discipline boundaries and attack the system-wide problems that are central to understanding and modeling the Sun-Solar System connection. In order to address this challenge, proposals to this LWS TR&T program may include one or more of these infrastructure-building elements: cross-disciplinary workshops, and/or summer schools.

(a) Support of LWS Workshops/Campaigns: Given the goals of the Infrastructure Building Program, there are several guidelines that successful requests for workshop/ campaign support must satisfy:

- The workshop must address a science or technology topic that is both timely and important to the goals of LWS.
- Workshops must focus on comparing and validating tools that have already been developed. Examples of possible workshops include 1) predicting all clear forecasting, 2) comparison of helioseismic techniques, and 3) velocity estimation methods.
- Other workshop topics must be cross disciplinary in nature and bring together researchers from different disciplines in LWS science.
- Although there are no restrictions as to where the workshop will be held, it will clearly be advantageous to hold it at a location that is convenient and cost-effective for LWS researchers and students.
- Workshops that encourage the training of new researchers in LWS system science are strongly encouraged.
- Workshops that leverage funding from other institutions and agencies are strongly encouraged.

(b) Support of LWS Summer Schools for Graduate Students: The details of the summer school (e.g., format, location, duration, etc.) are left to the proposer to define. However, proposals should provide convincing evidence concerning the breadth of the topics to be considered, the means to be taken to assure participation by recognized research/ education authorities, and any institutional support that may be forthcoming (note: shared support of this activity is strongly encouraged). One or two such proposals may be selected for summer school activities not to exceed more than two years.

2. Programmatic Information

2.1 Types and duration of investigations

This program element contains three components described in section 1.2: (1) Focused Science Topics, (2) Sun-Climate Theme, (3) Tools and Methods. The maximum duration of these awards are 4 years, 3 years, and 2 years, respectively. In addition there are Cross-Discipline Infrastructure Building Programs described in section 1.3. The maximum duration of these awards are 2 years.

Read the preceding sections carefully; there are significant changes this year, especially as related to compliance. Proposals may be judged non compliant and not be reviewed if certain criteria are not met.

2.2 Compliance Criteria

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, and cost realism and reasonableness.

For Focus Science Topics (only) described in section 1.2.1, the compliance check will include the following :

- Each proposal submitted must contain a section, entitled "Proposed Contributions to the Focus Team Effort" and it must be identified in the proposal's table of contents. Failure to include this section will result in the proposal being judged non-compliant, and the proposal will not be reviewed. See section 1.2.1 for more details.

For Tools and Methods, described in section 1.2.3, compliance includes the following criteria:

- The Proposal Summary that is submitted to the NSPIRES website must include explicit language stating the Deliverable, Delivery Site, and Schedule. Proposals that do not include this information explicitly in the Proposal Summary will be deemed non-compliant and will not be reviewed. See section 1.2.3 for more details.

For the new Sun-Climate Theme component, described in section 1.2.2, and the Cross-Discipline Infrastructure Building Program described in section 1.3, there are no additional compliance criteria.

3. Summary of Key Information

Expected annual program budget for new awards	~ $4 M/Yr
Number of new awards pending adequate proposals of merit	~ 30
Maximum duration of awards	Tools and Methods: 2 years Sun-Climate Theme: 3 years Focused Science Topics: 4 years Cross-Discipline Infrastructure: 2 years
Due date for Notice of Intent to propose (NOI)	See Tables 2 and 3 in the *ROSES Summary of Solicitation*.
Due date for proposals	See Tables 2 and 3 in the *ROSES Summary of Solicitation*.

Planning date for start of investigation	~6 months after proposal due date.
Page limit for the central Science-Technical-Management section of proposal	15 pp; see also Chapter 2 of the *2008 NASA Guidebook for Proposers*
Relevance	This program is relevant to the heliophysics strategic goals and subgoals in NASA's *Strategic Plan*; see Table 1 and the references therein. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	See the *2008 NASA Guidebook for Proposers* at http://www.hq.nasa.gov/office/procurement/nraguidebook/.
Submission medium	Electronic proposal submission is required; no hard copy is required or permitted. See also Section IV of the *ROSES Summary of Solicitation* and Chapter 3 of the *2008 NASA Guidebook for Proposers*.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	Option not available
Funding opportunity number for downloading an application package from Grants.gov	Option not available
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