B.6 LIVING WITH A STAR TARGETED RESEARCH AND TECHNOLOGY

Amended on August 13, 2010. 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-2010. The due dates have changed. Notices of Intent to propose are due September 30, 2010. Proposals are due October 30, 2010.

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 rerouted 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://www.nap.edu/catalog.php?record_id=12272);
- 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/2009_Roadmap.pdf);
- *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 typically subdivided into the three components described below: (1) Focused Science Topics, (2) Sun-Climate Theme and (3) Tools and Methods (TM). The maximum duration of these awards are four years, three years, and two years, respectively. Due to the launch of LWS Program's first mission Solar Dynamics Observatory (SDO), element (3) Tools and Methods has been replaced by a call for science topics focusing on SDO mission. Read the following sections carefully; there are significant changes, especially as related to compliance and element (3).

Proposals will be judged noncompliant and will not be reviewed if the Evaluation 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 Tools and Methods component this year. Given the resource constraints, the TM component has been replaced for at least this year with SDO focused science topics.

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 four 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" which must be identified in the proposal's table of contents. Failure to include this section or to identify it in the proposal table of contents will result in the proposal being judged noncompliant, 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; and
- 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):

1.2.1. (a) Low-To Mid-Latitude Ionospheric Irregularities and Turbulence

Target Description:

The ionosphere plays a major role in space weather due to its important influence on the propagation of electromagnetic waves. Changes in this propagation can significantly impact communication and navigation systems primarily through the development of electron density irregularities and plasma turbulence, often in the vicinity of large electron density gradients. Associated irregularities and turbulence can have a spatial range from tens of kilometer through centimeter scales and temporal scales from milliseconds to tens of minutes. A wide variety of physical processes occur on these separate scales and, for decades, this has posed a considerable challenge to the goal of a truly self-consistent, comprehensive model-based understanding of irregularity dynamics and morphology.

However, recent developments have presented new opportunities to make large advances in our understanding of irregularity physics. Large observational databases from ground based radar and satellite platforms (e.g. Jicamarca radar, SuperDARN HF radar, DMSP, C/NOFS, DEMETER, GPS TEC) are available for a wide range of appropriate irregularity scale sizes. For example, recent observations by the C/NOFS spacecraft provide unprecedented measurements of the equatorial ionosphere that enable timely, high-resolution studies of ionospheric irregularities. Total electron content (TEC) measurements between the CERTO beacon and a ground network of receivers near Jicamarca Radio Observatory provide the unprecedented opportunity of imaging the genesis of equatorial plasma instabilities and scintillation at high spatial resolution and study the onset, evolution, and propagation of these irregularities. Moreover, recent advances in modern computer technology; kinetic and fluid models with sophisticated, realistic boundary conditions; and high resolutions have recently become available. A focused team effort to apply these new tools, constrained appropriately by observations, is timely and has significant potential to transform our knowledge of irregularities and advance our predictive space weather capabilities for their presence and effects.

Goals and Measures of Success:

The goals of this FST are to provide an improved understanding and a predictive capability of ionospheric irregularities and turbulence, and specifically, to identify the causal mechanisms of the irregularities based on theoretical and computational studies in conjunction with comparison to experimental data.

Measures of success are the following:

- Development of improved models of E and F region plasma instabilities and turbulence;
- Establishment of the connection (if any) between E and F region irregularities;
- Identification of the causes of day-to-day variability of irregularities;
- Understanding of the connection between large-scale ionospheric processes and
- the development of electron density irregularities (e.g., equatorial spread F); and
- Development of a predictive capability for irregularity onset and evolution.

Types of Investigations:

- Theoretical studies of the linear and nonlinear development of ionospheric instabilities,
- First-principle modeling of ionospheric irregularities and turbulence in 2D and 3D (e.g., fluid, hybrid, PIC simulation models),
- Observational studies identifying regions of ionospheric irregularities and possible causal mechanisms, and
- Characterization of irregularities and turbulence as a function of geophysical parameters (e.g., latitude, longitude, altitude, F10.7, geomagnetic storm conditions etc.).

1.2.1. (b) Factors that Control the Highly Variable Intensity and Evolution of Solar Particle Events

Target Description:

It is widely believed that the largest solar energetic particle (SEP) events are caused by CME-driven shock acceleration (although other processes may also contribute). However, observationally, the efficiency of this process appears to be highly variable. As an example, a 2001 study found more than a thousand-fold spread in the intensity of >20 MeV protons accelerated by CMEs of the same velocity. On the other hand, a 2004 statistical study suggested that CMEs that erupt soon after a previous CME from the same active region are much more efficient in accelerating particles than those erupting into a pristine environment. Evidently, once a large eruption occurs, coronal and interplanetary properties play a key role, along with CME properties, in determining how intense the SEP event will be. This could be due to a stronger turbulence level or a larger population of seed particles at the second shock; other suggested explanations include differences in the open and closed field-line geometry, or a lowering of the Alfven velocity, leading to the formation of a stronger shock. Among the additional factors that likely affect acceleration and transport efficiency are shock geometry, global IMF structure, connection longitude, proton-amplified Alfven waves, and streaming limits.

This FST is timely. First, there are ~100 cycle-23 SEP events in the available database with broad SEP and solar-wind/ICME coverage (ACE, Cluster, GOES, SAMPEX, SOHO, Ulysses and Wind), and excellent near-Earth CME and other imaging (SOHO, RHESSI, TRACE, Hinode). With experience from these events as a guide, it will be possible to take full advantage of new, multispacecraft data from STEREO and near-Earth assets. For cycle-24 events there is a unique opportunity to make multipoint measurements of SEP, solar wind, and ICME properties, providing much greater detail on coronal/interplanetary initial conditions, and on the resulting longitudinal and temporal evolution of SEP events. In addition, for the first time, three-point CME imaging will provide higher precision and more detailed CME properties, along with multipoint coronal imaging. Finally, SDO will enable greatly improved capabilities to characterize the dynamic solar activity and its effects on the inner-heliosphere. Never before have such an array of distributed *in situ*, imaging, and modeling assets been available for this focused study.

Goals and Measures of Success:

The scientific goal of this FST is to identify the key properties that characterize when (a) SEP acceleration is efficient (large, intense events with rapid onsets) and when it is not (small, slowly developing events), and (b) to identify the conditions that facilitate efficient SEP radial and longitudinal transport; and develop a physical understanding of how these key properties function with theory, modeling, and simulations. The practical goal is to enable a forecaster, during the first one-two hours following an eruption, to use multipoint real-time data; knowledge of initial coronal and interplanetary conditions; models and experience to make more accurate predictions of how intense, long-lasting, and far-reaching the SEP event will (or will not) be. The goal here is *not* to predict how or when an active region will erupt. The primary measures of success of this work would be quantifying and then improving our current ability to combine real-time data (CME, radio, X and gamma-ray, and other imaging), along with data on initial conditions (IMF, solar wind, magnetic configuration), to forecast, within the first one-two hours following an eruption, the resulting peak intensity, fluence, composition, spatial evolution, and duration of accelerated particles, including the possibility of a large shock-spike event or the possibility of an early "all-clear" announcement.

Types of investigations:

- Studies of the effect of preconditioning of the interplanetary medium on the
- characteristics of an ensuing SEP event (particularly multipoint studies);
- Studies of the solar source and CME characteristics of large SEP events to
- identify key properties governing the efficiency of SEP acceleration;
- Modeling and theoretical studies of SEP generation and radial/longitudinal
- Transport; and
- Studies of the longitudinal variation of the characteristics of SEP events.

1.2.1. (c) Jets in the Solar Atmosphere and their Effects in the Heliosphere

Target Description:

One of the most striking features of the solar atmosphere is that it exhibits jetting activity at all size scales and at all temperature regimes; in fact, the upper chromosphere may well be nothing more than a collection of spicules. Consequently, developing predictive models for the coupling of the chromosphere to corona requires a comprehensive understanding of the origins and dynamics of jets. Although ubiquitous in the chromosphere and transition region, often identified as "explosive events," jets are also commonly seen in X-ray observations, especially in coronal hole regions where they may be playing an important role in the origin and properties of the solar wind. SOHO and STEREO have revealed that polar jets can extend out to beyond a solar radius and are related to plumes, which are ubiquitous in coronal holes. Hence, a deep understanding of jets may also be critical for modeling the coupling of the corona to the wind. Jets have long been proposed as a possible mechanism by which both coronal loops and prominences gain their mass. Furthermore, the recent results from Hinode and other spectroscopic instruments indicate that jets may be playing a central role in coronal heating. In addition, they have also been suggested to be sites of particle acceleration. Physical models for their origin have been proposed and range from magnetic reconnection to wave pressure driven mass lifting, but the underlying mechanisms for jet acceleration are still widely debated.

The problem of solar jets is now ripe for a focused team attack. We now have unprecedented new data from SDO and STEREO, which allow us to study the complete thermal evolution of jet material from chromospheric to hot coronal temperatures and spatial evolution from the chromosphere out to the wind. One of the major mysteries of the recently discovered type II spicules by Hinode is that much more mass is observed to accelerate upward than to fall back down. The most likely explanation is that the mass heats up to temperatures outside the Hinode temperature range. SDO, with its extensive temperature coverage and high time resolution, will be able to resolve the evolution of the jet material and, thereby, help determine the role of jets in coronal heating and in solar wind acceleration.

Goals and Measures of Success:

The goal of this FST is to advance our understanding of the origins, structure, and dynamics of chromospheric and coronal jets; their extension into the solar wind; and their role in accelerating charged particles. This Topic is focused on jets rather than on major dynamic events such as eruptive flares and CMEs; however, comparative studies of possible relationships between the jet phenomena and CMEs/eruptive flares would be appropriate to this Topic. The prime measure of success for this work would be the development of accurate models for the UV – X-ray emission from jets, their contribution to the mass and energy flux of both the closed field and the open field corona and wind, and for their role in particle acceleration.

Types of Investigations:

- Studies of the properties of chromospheric/coronal jets: their masses, velocities, magnetic field, temperature/density structure, and the time evolution of these quantities;
- Studies of the statistics of jets and their possible role in providing mass and energy to the corona and solar wind;
- Physical models of jet acceleration and heating and studies of particle acceleration by jets; and
- Studies of the signatures in the solar wind of coronal jets and plumes and to what extent they determine the properties of the fast and slow winds.

1.2.1. (d) Incorporating Plasma Waves in Models of the Radiation Belts and Ring Current

Target Description:

In the collisionless plasma of the magnetosphere, changes in the energetic particle populations are controlled by interactions with plasma waves. Our ability to understand and model the dynamic variability of the radiation belts and ring current requires improved knowledge of the spatial distribution and properties of the important plasma waves in the magnetosphere and their variability due to changes in either solar wind forcing or geomagnetic activity. Major uncertainties remain, for example, on the spatial distribution and properties of EMIC waves, the spectral properties of equatorial magnetosonic waves, and the wave normal distribution of chorus emissions. The purpose of this new focus group is to fill in the gaps in our understanding of the key plasma waves and to advance the development of improved codes to treat the dynamical evolution of the ring current and radiation belt populations, including both the generation and the effects of plasma waves.

Goals and Measures of Success:

The goal of this Focused Science Team is to advance our predictive capabilities of ring current and radiation belt dynamics by incorporating improved models of plasma waves into our large-scale plasma and field models. This effort is timely in that it will combine modeling and observations to develop tools that can be used with the Radiation Belt Storm Probe mission, scheduled for launch in May 2012.

Success of this team effort will be measured by: the improvement of our understanding of the spatial distribution and properties of waves in the inner magnetosphere from existing measurements; the development of empirical and physics-based models of the dominant wave modes; and the integration of new wave models with existing global MHD, ring current, and radiation belt models. The expected outcome of this effort is an improved understanding in the spatial distribution and important characteristics of the wave modes that affect radiation belt and ring current dynamics, as well as the ability to predict the regions of wave excitation and wave characteristics based on spatial characteristics of the modeled ion and electron distributions.

Types of Investigations:

- Utilize existing wave data (Themis, Cluster, POLAR, IMAGE, CRRES, AMPTE, SCATHA, Akebono, DE1, etc.) to determine the spatial distribution and properties of the dominant wave modes,
- Model the spatial distribution and the power spectral intensity of plasma waves, including those driven by and affecting the ring current and radiation belt populations,
- Integrate the wave models with the models of ring current dynamics that provide self-consistent global background electric and magnetic fields and realistic ion composition,

- Evaluate quasi-linear diffusion rates, based on the modeled wave properties, and determine whether the effects of nonlinear scattering processes need to be included in the coupled models, and
- Utilize the new understanding of the plasma waves to improve the 3D and 4D transport codes to calculate the dynamic variability of the radiation belts.

1.2.2 The Sun-Climate Theme

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 three 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 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; (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 Science Analysis for the Solar Dynamics Observatory (SDO)

This topic challenges proposers to use the data from the Solar Dynamics Observatory (SDO) to characterize the properties, evolution, and terrestrial consequences of the solar magnetic field. SDO produces images of the Sun at wavelengths from the visible to the extreme ultraviolet and soft X-ray, full-disk Dopplergrams, as well as full-disk vector magnetograms at an unprecedented cadence and spatial resolution that span scales from the arc second resolution to the full diameter of the Sun. Data during the initial part of the SDO mission has shown the Sun at solar minimum has many interesting phenomena that require additional analysis to understand. Fast wave-like processes, distant interactions between solar regions, the thermal fine structure of the corona, and the sources of irradiance variations over a wide range of X-ray and (E)UV wavelengths are now routinely made. These observations can tell us more about the origins of solar variability and space weather. Below are some topics of interest.

Types of investigations:

- Investigate the linkage of subsurface features with magnetic fields above the surface,
- Investigate the physics and diagnostic potential of coronal wave-like phenomena made accessible by AIA's high cadence, high signal-to-noise ratio, or large field of view,
- Determine the impact of small events on larger-scale processes through the coupling of scales, including, for example, destabilazation of large filaments by ephemeral-region emergence, active-region evolution on the formation on coronal holes, or flaring triggered by processes external to the flaring active region,
- Determine the relationship between EUV radiance and the plasma properties of the corona; including how filaments evolve (takeoff velocity, twisting, non-'free-fall' velocities, failed escape/eruptions); why do coronal loops on one side of the

erupting filament/active region stay intact and just move out of the way during, then move back after an eruption or flare,

- Analyses of flare energetics by modeling the radiative cooling of small flares to understand the late phase seen in EVE irradiances and creating an understanding of the heating of the solar chromosphere and transition region during the impulsive phase of a flare,
- Use of observations to predict future solar activity, from short timescales to forecast of the properties of Solar Cycle 24.

This proposal opportunity is open to all interested parties, including Co-Investigators of SDO Science Investigations. A Co-I must show that the proposed research does not overlap with research currently funded by the SDO mission. Also, proposers should get a letter of acknowledgement from the PI/PIs to ensure that the latest data product described in the proposal will be available to them.

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. Most of these activities will be supported through formal proposals to the TR&T program as part of the regular proposal cycle. In all cases, an extra two pages will be allowed to the page limit for the science/technical/ management section of the proposal (see Section 3 below) for each of these activities.

(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 during the nominal four-year period of performance for the parent research proposal.

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) Science Analysis for SDO. The maximum duration of these awards are four years, three years, and three years, respectively. In addition there are Cross-Discipline Infrastructure Building Programs described in section 1.3. The maximum duration of these awards are two-three years.

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

2.2 Evaluation 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, in addition to the factors given in the *NASA Guidebook for Proposers*, the evaluation criterion for relevance specifically includes the following factor:

- 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 or to identify it in the table of contents will result in the proposal being judged noncompliant, and the proposal will not be reviewed. See section 1.2.1 for more details.

For the 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 evaluation criteria, other than those given in the *NASA Guidebook for Proposers*.

3. Summary of Key Information

Expected program budget for first year of new awards	~ $4.5 M/Yr
Number of new awards pending adequate proposals of merit	~ 35
Maximum duration of awards	Sun-Climate Theme: 3 years Focused Science Topics: 4 years Science Analysis for SDO: 3 years Cross-Discipline Infrastructure: 2-3 years
Due date for Notice of Intent to propose (NOI)	**September 30, 2010**
Due date for proposals	**October 30, 2010**
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 *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 *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 *NASA Guidebook for Proposers*.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH10ZDA001N-LWSTRT
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