Living With a Star TR&T Program
Abstracts of awarded Proposals
NNH05ZDA001N
March 2006

PI: Rashid Akmaev/University of Colorado
Title: A Data Analysis and Modeling Study of Secular Change in Thermospheric Density
Abstract:
We propose a data analysis and modeling study of long-term changes that have occurred in the upper atmosphere over the recent several decades. Interest in these trends has been stimulated by the classical modeling study of Roble and Dickinson (1989), who predicted a dramatic response to a hypothetical future increase of greenhouse gases: the upper atmosphere is expected to cool down by tens of degrees in response to the standard doubled-CO2 scenario. The search for signs of global change in upper-atmospheric and ionospheric historical data records has been inconclusive. While some parameters clearly reveal long-term trends in general agreement with the model predictions, other estimates have produced inconsistent and even contradictory results due, in part, to the scarcity of sufficiently long uniform observational records. Our ability to detect trends is also confounded by the enormous variability of the upper atmosphere driven primarily by solar and geomagnetic activity on various temporal and spatial scales. The "greenhouse cooling" is expected to result in a substantial thermospheric density decline that depends on the level of solar activity. Existing analyses of neutral density trends based on satellite drag data over the last 2 to 3 decades have provided perhaps the most robust evidence of global change in the upper atmosphere to date. These results inherently provide a global view and qualitatively agree with each other and with theoretical model predictions. More work is required to improve our confidence in the trend estimates, to delineate the contributions of solar activity and other parameters, to better understand the physical mechanisms, and to quantify their contributions to the observed changes. The science goal of this project is to advance our understanding of the mechanisms driving the long-term global changes in the upper atmosphere and the near-Earth space environment. Our approach is unique in that it synergistically combines two key components: (1) we will extend, in time and altitude coverage and in number of observations per year, our comprehensive analysis of the global satellite-drag database to delineate the contributions of solar activity and other sources of natural variation, and to detect anthropogenic and possible natural long-term trends; (2) we will use an updated global upper-atmospheric numerical model to study the natural and anthropogenic variability using the records of greenhouse gas concentrations and solar activity over the same period of time. A direct comparison of the results of theoretical modeling with the analysis of accurately determined trends in the upper atmosphere will be carried out for the first time. This will provide insights into the key physical mechanisms and their possible interactions and feedbacks, and will facilitate the attribution of the observed trends. A clearer understanding of the thermospheric "greenhouse cooling" will lead to development of meaningful long-term forecasting capabilities. This work is immediately relevant to the science goals of the NASA Living With a Star program and, in particular, to its Targeted Research science topic T3e. The ability to understand and predict the long-term density variability in the near-Earth space environment is also of enormous practical significance to any spacecraft operators, including the NASA's programs and missions.

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PI: Amitava Bhattacharjee/University of New Hampshire
Title: Heating the Corona and the Solar Wind by Magnetic Reconnection
Abstract:
Understanding the heating of the corona and the solar wind is a primary objective of the LWS TR&T program. We propose to investigate the role of magnetic reconnection as a fundamental heating mechanism of the global corona and the solar wind. Magnetic reconnection and solar wind acceleration and heating are identified, respectively, as Research Focus Area F1 and F2.3 in the most recent Sun-Solar System Connection Roadmap (May, 2005). Both of these areas are

objectives of several ongoing and future missions including SOHO, TRACE, RHESSI, RAM, Solar Probe, SDO, Solar-B, Solar Orbiter, SPI, STEREO and Doppler. The heating of the solar corona and the solar wind occurs continually, in regions of closed as well as open field lines (coronal holes), in the quiet as well as the active Sun. The magnetic carpet, which covers the entire surface of the Sun, holds the key to our understanding of this heating. It is estimated that 95% of the photospheric magnetic flux closes within the magnetic carpet in low-lying loops. There is significant observational evidence that strong coronal heating in active regions have much in common with the quasi-steady heating in quiet regions and coronal holes, and that the latter may occur due to scaled-down versions of explosive reconnection events in bipolar configurations in the network. We propose to use analytical techniques and time-dependent simulations based on resistive and Hall MHD equations to investigate the role of collisional as well as collisionless current sheets and reconnection in heating the corona and the solar wind. We will undertake the following tasks: (1) Coronal Heating Driven by Explosive Reconnection in Sheared Network Bipoles. We will begin with a simple 2.5D bipole configuration in which reconnection is driven by photospheric footpoint shear, and investigate current sheet formation and magnetic reconnection in resistive and Hall MHD regimes. We will follow up with configurations of increasing complexity leading up to the tectonics model which includes a myriad of bipoles with multiple separatrices, and quantify the amount of heating as a function of the dissipation mechanism. (2) Reconnection and Thin Current Sheets in 3D Line-Tied Geometries With and Without Nulls. We will consider 3D magnetic geometries of line-tied fields, both with and without nulls, and quantify their contributions to coronal heating. We will build on our recent rigorous results on the Parker model of tangential discontinuities, which is a prime example of a model without nulls, and explore connections with quasi-separatrix layer (QSL) models. We will also consider the build-up of current sheets and fast reconnection in models with nulls and null-null lines by a combination of exact analytical models and 3D simulations. (3) Generation of Alfvén Waves by Photospheric Reconnection. We will investigate the possibility of generating Alfvén waves in regions containing open field lines by photospheric reconnection in low-lying loops. In turn, these waves can produce producing an enhanced flow of wave energy into the solar wind. With this quantitative analysis, we will determine whether the energy flux in these waves is sufficient to explain the observed long-period power and can drive heating and solar wind acceleration in coronal holes. (4) Energetics, Scaling Laws for Heating, and Observational Tests. We will attempt to answer the following questions: What fraction of the magnetic free energy in a given network configuration is dissipated as heat by resistive and collisionless reconnection mechanisms? How does the heating scale as a function of the plasma parameters and system size? What are the corresponding scaling properties for Alfvén wave heating produced by photospheric reconnection? Are nanoflares and microflares, reflected in EUV emission, sufficient to account for coronal heating in regions of closed as well as open field lines?

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PI: Dieter Bilitza/Raytheon Technical Services Company
Title: TOPLA: A New Empirical Representation of the F-region Topside and Plasmasphere for the International Reference Ionosphere
Abstract:
We propose to develop a new data-based F-region TOpside and PLAsmasphere (TOPLA) model for the electron density (Ne) and temperature (Te) for inclusion in the International Reference Ionosphere (IRI) model using newly available satellite data and models for these regions. IRI is widely used for the specification of ionospheric conditions and is currently under consideration as the International Standardization Organization (ISO) standard for ionospheric parameters. IRI¿s great significance for LWS science lies in its role as the observation-based background ionosphere for theoretical coupling studies between different regions, for radio wave propagation studies, for the evaluation of tomographic and numerical techniques (GPS), and as benchmark against which the skill-level of physics-based forecast models is measured. Additionally, IRI helps to teach and popularize space science through its usage for college course work and for web interfaces that visualize and explain the space environment. Recently, a number of new data sets have become available that help to fill coverage gaps of earlier studies and that can provide the

database for a systematic improvement of the IRI topside model. Specifically our study will overcome the following shortcomings of the current IRI topside model: (1) overestimation of densities above 700 km by a factor of 2 and more, (3) unrealistically steep density profiles at high latitudes during very high solar activities, (4) no solar cycle variations and no semi-annual variations for the electron temperature, (5) discontinuities or unphysical gradients when merging with plasmaspheric models. Our topside Ne model will be based on Alouette 1, 2, and ISIS 1, 2 topside sounder data and will use a Chapman-function with a height-varying scale-height H(h) that allows merging the topside profile with the plasmasphere model. The Ne model for the plasmasphere will rely on IMAGE/RPI data and will be based on combining and further developing the modeling approaches introduced by CoIs Reinisch and Huang based on IMAGE data and by CoI Gallagher based on DE and ISEE data. For the electron temperature the goal is to develop the first empirical model that fully accounts for solar cycle variations based on a large volume of satellite in situ measurements. A special focus will be the correct representation of (a) altitudinal and latitudinal extent of the Equator Anomaly region, (b) latitudinal, diurnal, and seasonal differences in the solar cycle variation of temperatures and densities, and (c) diurnal, latitudinal, and solar and magnetic activity variations of the topside transition height. Results of this study will provide substantial improvements in characterizing the ionosphere/ plasmasphere environment in support of manned and unmanned space exploration. The enhanced IRI model will provide a key baseline for studying geomagnetic storm effects on the ionosphere and plasmasphere.

Living With a Star TR&T Program
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PI: Joseph Borovsky/Los Alamos National Laboratory
Title: Predicting the Spacecraft-Charging Environment in the Magnetosphere from Upstream Solar-Wind Parameters
Abstract:
A three-year project is proposed to determine how the solar-wind plasma drives the spacecraft-charging environment inside the Earth's magnetosphere. The project builds on a series of recent studies that have determined the correlations and time lags between the properties of the solar-wind plasma and the hot-ion plasmas of the magnetosphere. The present study will focus on the connection between the solar wind and (a) the hot-electron plasma, (b) the low-density cold-ion population, and (c) measured values of spacecraft potentials, all in the magnetosphere. The study will utilize approximately 20 million measurements of spacecraft charging and the charging environment taken around the Earth's dipole at geosynchronous orbit. The objectives of this project are (1) to establish which solar-wind parameters affect the charging environment in the magnetosphere and by how much, (2) to determine the time lags at various locations around geosynchronous orbit for the solar wind to affect the environment there, (3) to determine the functional forms of the best-fit expressions connecting solar wind parameters with magnetospheric-environment parameters, (4) to determine how substorms affect the coupling and time lags of the solar wind to the charging environment, (5) to determine whether dipole inflation by a stormtime ring current affects the coupling and time lags of the solar wind to the charging environment, and (6) to assess the ability of the best-fit expressions and time lags to predict the charging environment from solar-wind input. The data sets that will be used are uniquely suited to this project and techniques that have been successful in similar studies will be utilized. The primary data set resides at Los Alamos and the Investigators have sufficient expertise to perform the tasks and interpret the results. In support of NASA and the LWS Program, this project will greatly further the understanding of the origin and control of the spacecraft-charging environment and will provide the information needed to predict that environment with a few-hour lead time. The project will also significantly further our understanding of the entry and transport of plasmas in the Earth's magnetosphere.

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PI: Athanasios Boudouridis/University of California, Los Angeles
Title: Solar Wind Geoeffectiveness as a Function of IMF and Dynamic Pressure and its Effect on High-Latitude Ionospheric Energy Deposition
Abstract:
The electric field and particle precipitation patterns at high latitudes are two of the most significant considerations for determining the ionospheric state during steady or variable solar wind and Interplanetary Magnetic Field (IMF) conditions. It is therefore of primary importance to fully understand what drives the electric fields and particle precipitation at high latitudes. It is well known that the IMF is the major contributor to geomagnetic activity on Earth. Recent studies, however, have shown that solar wind dynamic pressure variations cause global effects when they encounter the terrestrial magnetosphere, strongly affecting the magnetosphere, ionosphere, and upper atmosphere. In particular, it has been shown that solar wind dynamic pressure enhancements significantly increase particle precipitation and cause global intensification of the aurora, thus significantly increasing the deposition of energy in the Earth's upper atmosphere. In addition, the extent of the enhanced energy deposition is dependent on the preexisting state of the magnetosphere, which is controlled by the IMF orientation. Further studies have demonstrated that solar wind pressure increases also affect the cross-polar-cap potential drop (CPCP), and thus the coupling efficiency between the solar wind and the Earth's magnetosphere in ways that cannot be accounted for solely by the existing solar wind electric field. It is rather the combined contribution of IMF and dynamic pressure, in ways that are yet to be determined, that controls the coupling efficiency between the solar wind and the magnetosphere. Therefore, the pressure enhancements and IMF variations affect both the solar wind geoeffectiveness and the energy input in the high-latitude ionosphere and upper atmosphere. We propose to study the relative contribution of solar wind dynamic pressure, IMF Bz, and IMF By to solar wind geoeffectiveness during steady and variable conditions, and investigate under which circumstances the correlation between solar wind geoeffectiveness and high-latitude energy deposition is the highest. For this purpose we will utilize a combination of solar wind measurements, low-altitude Defense Meteorological Satellite Program (DMSP) data, and results of the Assimilative Mapping of Ionospheric Electrodynamics (AMIE) technique. We will focus our research on the following scientific questions: 1) What is the effect of different IMF orientations and solar wind dynamic pressure levels on the solar wind-magnetosphere coupling efficiency under steady conditions? 2) How do variations of dynamic pressure and IMF modify the CPCP and the coupling efficiency? 3) How permanent or transient are these responses for step-like changes in the solar wind, and what are the relevant timescales? 4) What is the relative contribution of dynamic pressure and IMF orientation to the CPCP and solar wind geoeffectiveness under steady or changing conditions? 5) How do IMF orientation, dynamic pressure levels, and their changes affect high-latitude energy deposition as measured by the intensity of precipitating flux or ionospheric Joule heating?

Living With a Star TR&T Program
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PI: Pontus Brandt/The Johns Hopkins University Applied Physics Laboratory
Title: Storm-Time Sub-Auroral Electric Fields: Ionospheric and Magnetospheric Control
Abstract:
The role of electric fields in the sub-auroral ionosphere have been underestimated for a long time largely due to the lack of understanding of their origin and global behavior. Solar irradiation, Joule heating and the ring current cause ionospheric electric fields. Separation of their different origins is inherently difficult due to limited spatial coverage of measurements (radars, low-latitude satellites). We propose to provide a realistic model of the sub-auroral electric field, produced by the ionospheric closure of the ring current, using observations and modeling, and investigate how it is controlled by magnetospheric activity and ionospheric conductance. The output electric fields is intended to be used as input by other thermospheric models investigating the transport and density of the ionosphere/thermosphere. Our work can be divided into the following tasks. TASK I - Perform a correlative statistical study of ionospheric electric fields. Three types of electric fields

will be investigated: (1) Penetration (or undershielding) electric fields; (2) Sub-auroral Polarization Streams (SAPS); (3) Midnight-dawnside, sub-auroral flow reversals. Observational parameters will include solar wind conditions, ionospheric conductance, Region-2 current intensity. TAKS II - The sub-auroral, ionospheric electric field of selected storm events will be modeled using the Comprehensive Ring Current Model (CRCM), which computes the electric field, self-consistently arising from the closure of the ring current through the ionosphere. TAKS III - The results from the observational and model study will be combined into a climatological model of the behavior of the sub-auroral, ionospheric electric fields. The most outstanding ionospheric effect is the uplift of plasma through penetration electric fields on the low-latitude dayside, causing storm enhanced densities (SED) in the F-layer. The SEDs corotate into the duskside ionosphere where ring-current driven electric fields transport plasma to mid-latitudes and sunward. The SEDs have far reaching consequenses for a number of technological systems over our heavily populated continent. For example, the Wide Area Augmentation System (WAAS) assists positioning of civil aircraft by providing time delay of Global Positioning System (GPS) signals from geosynchronous satellites. However, WAAS can only provide time delays from about a two dozen of stations over the North American continent, forcing aircraft to interpolate the time delay value between stations. At disturbed times, the ionosphere display very high densities in very confined regions which makes the position determination by interpolation invalid. The proposed work fulfills the NASA National Objective: ``Study the Earth system from space and develop new space-based and related capabilities for this purpose.'' and all of its sub-objectives. As recommended by the LWS TR\&T Science Definition Team, the proposed work relies on large-scale modeling work that addresses the coupling between the two traditional domains of the storm-time magnetosphere and ionosphere and offers to provide its output (large-scale, sub-auroral electric fields driven by the magnetosphere) to be used further by thermospheric models. We therefore believe that the proposed work will be a useful strategic capability in understanding the storm-effects on the global electrodynamics and the mid- and low latitude ionosphere/thermosphere system.

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PI: Robert Cahalan/NASA Goddard Space Flight Center
Title: Wavelength and Time Dependence of Solar Forcing of Earth's Atmosphere-Ocean System
Abstract:
The Sun's radiative input to Earth has characteristic temporal variations that depend on wavelength, as we have documented under previous funding. We propose to further analyze SIM (Spectral Irradiance Monitor) solar spectral irradiance (SSI) data, and compare with SSI synthesized from the SRPM model (Solar Radiation Physical Modeling), to estimate the statistical relations between SSI and total solar irradiance (TSI), to study the responses of atmosphere-ocean mixed layer to variations in solar spectral irradiance. Proposed research will include the analysis of existing solar spectral irradiances from SORCE SIM, with coincident ground-based and aircraft observations from the Solar Spectral Flux Radiometer (SSFR) to estimate spectral solar forcing in the troposphere and stratosphere, and to model the atmospheric response to variations in SSI, to advance our understanding of the wavelength and time dependence of solar forcing of Earth's atmosphere-ocean system. This proposal falls into the category of Independent Investigations, and has three tasks: (1) Variations in Spectral Solar Irradiance (SSI): Extend the analysis of SSI from SIM on SORCE to the fully calibrated time series and compare with synthesized solar spectrum from the SRPM model (Solar Radiation Physics Modeling). Estimate the statistical relations between of SSI and TSI. (2) Spectral Solar Forcing: Estimate the vertical profiles of spectral and total solar forcing by analyzing the existing SORCE SSI, with coincident ground-based and aircraft observations from the Solar Spectral Flux Radiometer (SSFR). (3) Modeling the response of the atmospheric and surface temperature to the variations of SSI: A simple radiative-convective model (RCM) will be used to study atmospheric and surface responses to variations in SSI. The 1-D RCM will be extended to account for time-dependence of both variation of SSI and response of atmosphere-ocean mixed layer.

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PI: Margaret Chen/Aerospace Corporation
Title: Solar-Wind Ion Entry into the Magnetosphere through the Magnetosheath
Abstract:
This is a proposal to investigate the physical processes that lead to the transport of solar wind ions from the magnetosheath and into the magnetosphere to form the plasma sheet. Ion distributions in the magnetosheath, tail lobes, tail flanks, and plasma sheet will thus be characterized for different Interplanetary Magnetic Field (IMF) and solar wind conditions. The study will address whether the transport of solar wind ions into the magnetosphere from different locations supply sufficient particles of different energies needed to form the quiescent and storm-time plasma sheet. The effect of changes in the solar wind population on the variance in the plasma sheet will also be examined. Our approach will be to develop and use kinetic simulations to study the relevant particle transport processes and to compare our simulation results with published observations such as from Geotail, ISEE, AMPTE, and DMSP. We will follow the full particle motion or (where appropriate) the guiding-center drifts of solar-wind ions from the magnetosheath into the magnetosphere. In the magnetosheath, we will use an analytical magnetic field model that reproduces quite well the shape of magnetosheath field lines obtained from gas-dynamic calculations. The magnetosheath electric field is proportional to the cross product of the solar-wind velocity and the magnetic field. Especially for southward IMF, the magnetosheath's magnetic field lines will reconnect with initially closed magnetospheric field lines. For the magnetospheric model, we will use the magnetically and electrically self-consistent Rice Convection Model (RCM-E) with a magnetic field boundary condition that includes the effect of a non-uniform penetration magnetic field. This magnetospheric model maintains internal force balance between the magnetospheric plasma and magnetic field. Use of the RCM-E will allow us to calculate self-consistent distributions of particle flux, plasma pressure, and current density within the magnetosphere (including the tail flanks and plasma sheet). We will study how these distributions evolve as we vary the solar-wind conditions, and we will compare the simulated results with observations. A significant outcome of this work will be a physical understanding of the relationship between properties of the solar-wind plasma (e.g., velocity and density) and the resulting plasma sheet, which is the main source for the ring current. This would provide a currently missing link for characterizing magnetic storms (and eventually accounting for variations of particle population in the inner magnetosphere) from solar-wind properties and IMF conditions. Such an achievement would be beneficial for understanding and forecasting space weather, and thus for society.

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PI: Christina Cohen/California Institute of Technology
Title: Understanding Energetic Particle Responses to Local Interplanetary Shocks through Observations and Theory
Abstract:
We propose to study the energetic particle increases associated with the passages of interplanetary shocks. Although such events, called energetic storm particle (ESP) events, have been studied since the 1960s and theories of particle acceleration by traveling shocks are well developed, previous surveys have repeatedly shown that the many of predicted relationships between the shock parameters and the ESP characteristics are not apparent in the spacecraft data. Exploring these discrepancies, identifying new relationships, and determining relationships that do hold (based on theoretical models) is crucial in the quest to fully understand shock acceleration as it is manifested in the interplanetary medium and to predict the particle response to shocks moving outward from the Sun towards Earth. The solar energetic particle (SEP) events created by shocks driven by coronal mass ejections (CMEs) are a concern for space operations

and we are far from being able to predict them. Fortunately, most SEP events are limited in intensity by the streaming limit imposed by the magnetic turbulence generated by the energetic protons. However, in the vicinity of a shock, this limit is typically exceeded by the ESP event, resulting in intensity increases that can be orders of magnitude in size and a significant space weather threat. Additionally, ESP events are our only opportunity to examine the particles accelerated by CME-driven shocks in situ where both the shock and particle parameters can be measured and correlated. More sensitive particle measurements are being made than ever before and by combining the data from the ULEIS and SIS instruments on ACE the energy spectra of heavy ions can be determined over more than 3 orders of magnitude in energy. Spectra of protons and helium are also available from the EPAM instrument and at higher energies from ULEIS and SIS and, when appropriate, GOES. Recently, analysis of interplanetary shocks observed by ACE and Wind has been expanded to routinely fit the plasma and magnetic field data with a variety of methods resulting in a more accurate determination of shock parameters. We propose to combine these improvements in particle measurements and shock analysis with theoretical expertise in shock acceleration to understand the physical reasons for the lack of correlations previously reported for shock parameters and ESP characteristics and to enable progress in constructing a predictive capability.

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PI: Pallamraju Duggirala/Boston University
Title: Daytime Multiwavelength Ground-Based Optical Investigations of Precursors to Low-Latitude Plasma Irregularities
Abstract:
We propose a 3-year project to carry out systematic investigations of the precursors to the ESF irregularities during daytime using a ground-based optical multiwavelength Echelle spectrograph to be built at BU. Equatorial Spread-F (ESF) refers to the presence of plasma irregularities at low- and equatorial latitudes in the nighttime ionosphere. Unlike substorms and geomagnetic storms, ESF is a form of space weather not controlled exclusively by the Interplanetary Magnetic Field (IMF). ESF irregularities severely impact radio communications and navigational systems at a wide range of frequencies that adversely affect commercial and defense applications. The development of these irregularities is highly unpredictable. Even during the ¿ESF season¿ when various onset parameters are nearly identical, ESF occurs on one night and is completely absent on the other. Scientifically, this is a key-missing element in our understanding of plasma instabilities at low latitudes. This proposed work will carry out daytime optical measurements to investigate the roles of neutral parameters, such as the meridional and vertical winds and waves that are known to be effective triggers to the ESF. For the first time in history, we will have a large field-of-view multiwavelength spectrograph that is most suited to answer these relevant issues. We will carry out daytime measurements using three emissions 5577, 6300 and 7774 Å, which originate around 100, 230 and 300 km, respectively. These large field-of-view measurements will enable us to investigate waves and their direction of propagation at three different altitudes. The results from this study will not only resolve issues surrounding the precursors to ESF but will substantially enhance our understanding of the interaction of daytime and nighttime phenomena of the low-latitude/ equatorial electrodynamics in upper atmosphere. We plan to operate the new instrument at Carmen Alto (23.1^o S, 70.6^o W; 10.2^o S dip lat.), in Chile. This data will be used in conjunction with the multi-diagnostics of the Multi-Instrumented Studies of Equatorial Thermosphere Aeronomy (MISETA) consortium operating in the American longitude sector as well as Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) satellite and Communicational/Navigational Outage Forecast System (C/NOFS) mission (scheduled to be launched in 1996). Furthermore, Jicamarca Unattended Long-term Investigations Atmosphere (JULIA) radar data, Jicamarca Radio Observatory (JRO) data, Global Positioning Systems (GPS) and Defense Meteorological Satellite Program (DMSP) data will be available for independent confirmation of the occurrence of ESF irregularities and for the information on the background thermosphere/ionosphere conditions in conjunction with our ground-based data. This dayglow data at multiple wavelengths will add to the rich database and a unique resource to the community.

Living With a Star TR&T Program
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PI: David Facloner/NASA Marshall Space Flight Center
Title: Development of Empirical Tools for Forecasting Safe or Dangerous Space Weather from Magnetograms
Abstract:
The overall objective is to further develop and evaluate empirical tools for forecasting from magnetograms whether an active region will or will not produce a coronal mass ejection (CME) in the next few days, and, as a byproduct, gain insight to the magnetic conditions that cause CMEs. The proposed investigation builds directly on results that we obtained with previous LWS TR&T funding. In particular, we found an empirical measure of whole-active-region nonpotentiality that can be measured from a line-of-sight magnetogram of the active region and is strongly correlated with the CME productivity of active regions. This allows us in the proposed work to (1) use the MDI full-disk line-of-sight magnetograms to obtain large sets of separate-day magnetograms (~200) of active regions, and (2) use the good sensitivity of these magnetograms to assess, for spotless active regions as well as for sunspot active regions, the accuracy of the nonpotentiality measure as a predictor of All Clear space weather (no strong CMEs) or dangerous space weather (strong CMEs likely). In addition, using the ~200 magnetograms of sunspot active regions, we will carry out a bivariate analysis of the dependence of CME productivity on the nonpotentiality and size of active regions. The results will contribute directly to the development of operational CME forecasting methods that can be applied to and further developed and tested by the active-region vector magnetograms from Solar-B and the full-disk vector magnetograms from SDO. Our results, in combination with other observations from SOHO, Solar-B, and SDO, will yield better understanding of the magnetic conditions that cause CME explosions. Thus, in addition, to advancing the LWS TR&T goal of developing empirical tools for CME forecasting, the proposed investigation will enhance the science payoff from SOHO, Solar-B, and SDO. The requested funding is for half-time support of the PI and half-time support of a graduate student research assistant.

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PI: Bela Fejer/Utah Sate University
Title: Storm-Time Ionospheric Electric Fields
Abstract:
We propose to use a very extensive database of plasma drift observations made on-board the Republic of China satellite (ROCSAT-1), Dynamics Explorer (DE-2), and Atmosphere Explorers E and C (AE-E and AE-C) satellites, as well as detailed ground-based magnetic field observations to study the storm-time, latitude-, and longitude-dependent response of mid- and low-latitude ionospheric electric fields to solar wind and magnetospheric disturbances. We plan to complement our experimental studies with numerical simulations using recent and future upgraded versions of the Rice Convection Model (RCM). The first basic objective of this proposal is to use this extensive combined satellite database of perturbation electric fields (obtained by removing quiet-time values along satellite orbits) to develop a detailed understanding of the local and storm-time, season, solar cycle dependent response of prompt penetration electric fields (mostly at low latitudes) to various solar wind-magnetosphere-ionosphere driving processes for different storm and solar cycle phases and seasons. These driving processes include the interplanetary electric field, IMF clock angle, and solar wind dynamic pressure. The second objective is the study of the longitudinal and latitudinal variations of the prompt penetration and disturbance dynamo electric fields under different geophysical storm conditions. This includes the study of the longitude-dependent relationship of low-latitude prompt penetration electric fields and subauroral polarization streams (SAPS). The third objective is the use of our experimental results for detailed testing of longitude-dependent predictions from global convection models, particularly during large magnetic storms. These studies should significantly improve the understanding of

global characteristics of storm-time ionospheric electric fields and made a major contribution to future NASA missions, particularly to multi-spacecraft ionospheric missions.

Living With a Star TR&T Program
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PI: John Foster/MIT Haystack Observatory
Title: Multi-Instrument Investigation of Inner-Magnetosphere/Ionosphere Disturbances
Abstract:
Strong penetrating and SAPS electric fields perturb and redistribute the cold plasma of the low and mid-latitude ionosphere and plasmasphere during geomagnetic disturbances. The phenomena associated with plasmasphere erosion are a prime example of global M-I coupling and require a multi-technique and multi-disciplinary analysis approach to understand properly. Streaming cold plasma, as seen as storm enhanced density SED plumes, can be used to identify and trace the effects of the perturbation electric fields. At lower latitudes, plasma redistribution and prompt changes in TEC indicate the effects of the disturbance electric fields. A thorough understanding of the mechanisms, causes and effects of these disturbance electric fields are needed to support a predictive capability for these important ionospheric phenomena. Questions to address: 1) Does the SAPS E field exhibit seasonal or longitude dependencies? 2) What determines the duration and strength of penetration electric field? 4) How do the conjugate E and F-region conductivities influence SAPS formation? 4) How does wave structure in the SAPS/SED channel lead to ionospheric irregularities? 5) What are the causes and characteristics of the redistribution of the equatorial ionosphere in the American sector? Proposed Method: 1) Use ionospheric TEC observations to study the location, extent, and duration of perturbation electric fields at mid and low latitudes. 2) Combine space and ground-based (GPS) TEC observations, incoherent-scatter radar (ISR) profiles, and DMSP observations to characterize the conditions leading to severe low-latitude ionospheric perturbation. 3) Investigate the relationship of the plasma redistribution to ionospheric irregularities using coherent radar, HF radio scintillation, and passive radar arrays (ISIS). 4) Coordinated ISR experiments (Sondrestrom, Millstone Hill, Arecibo, and Jicamarca) will investigate penetration E fields. 4) Modeling collaboration (RCM and SAMI-II) to address the relationship of the observed features and their evolution to the predicted effects of ring current development and inner magnetospheric shielding. 6) Develop a multi-technique viewpoint of the coupled processes through workshops held at Haystack. 7) Coordinate a distributed working group to investigate storm phenomena using Access Grid and similar remote conferencing techniques. 8) TEC maps and merged datasets made available through the online Madrigal data system. This research program follows upon the considerable research that the PI institution has already undertaken on problems in this focused research area. The PI institution has organized a CEDAR working group on low-latitude electric field, and has designed and fielded instrumentation arrays (ISIS) to address electric-field structure, with continuous, spatially-distributed observations.

Living With a Star TR&T Program
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PI: Tim Fuller-Rowell/University of Colorado
Title: Modeling the Impact of Storm-time Electrodynamics on the Mid and Low Latitude Ionosphere
Abstract:
Project Summary: The goal of this research is to determine the circumstances leading to the massive restructuring of the mid and low latitude ionosphere and the development of large-scale bite-outs of electron density at low latitudes during geomagnetic storms. Good examples of these features occurred during the Halloween storm in October 2003. Maps of total electron content (TEC) showed a factor of four increase at mid latitudes, and measurements of electron density by the DMSP satellite at 850 km indicated the ionosphere had virtually disappeared over a wide latitude swath at low latitudes. The depleted region, or ¿bite-out,¿ was accompanied by smaller

scale ionospheric irregularities, or bubbles, on its flanks. It is expected that the dramatic plasma gradients were created by exceptionally large upward ExB plasma drifts, raising the ionosphere to higher altitudes, transporting plasma poleward, and driving the huge depletions at low latitude. This study will investigate the interaction and feedback between the two main sources of the plasma drift ¿ the prompt penetration (PP) and disturbance dynamo (DD) electric fields, and determine the cause of the massive restructuring of plasma at mid and low latitudes during storms. This project is a ¿linked¿ proposal between research teams at University of Colorado (PI Tim Fuller-Rowell) and Rice University (PI Stan Sazykin). The success of the project relies on the self-consistent coupling between physical processes in the thermosphere, ionosphere, and plasmasphere (as captured in the CTIPe model) and the inner magnetosphere (as captured in the RCM). Combining these two models includes both dynamo and penetration electrodynamics, and consistently handle the feedback between the two regimes. This study is therefore unique in its ability to couple the various domains and address the science questions in a rigorous mathematical approach. This study will: 1) Determine the physical processes leading to the large vertical plasma drifts and the interaction and feedback between the penetration and dynamo electric fields, 2. Determine the impact on the mid and low latitude ionosphere including the cause of the massive restructuring of plasma density, and 3) Investigate the possible causes of the strong longitude dependence in the storm-time response. The first phase of the study will perform the comprehensive coupling of the CTIPe and RCM models where the polar cap boundary, the neutral wind driven dynamo currents, and the field-aligned magnetospheric currents are consistent between the two codes. The effects of under and over shielding in the inner magnetosphere will be implicitly included in the field-aligned currents and the potential solver. Numerical experiment will be performed with a goal of understanding the complex interaction between the geophysical domains including the electrodynamic feedback between PP and DD. For validation, the coupled model will be used to simulate the recent storms targeted by the recent CDAW workshop. The chosen storms have good global and regional coverage for TEC, have reasonable measurement of the electric fields, and have well developed experimental/ observational databases. The potential benefit of this study for space weather is clear. Large-scale changes in the ionosphere impact GPS navigation signals and alter the propagation of HF radio-wave communication. The large-scale ionospheric changes are also associated with the generation of small-scale ionospheric irregularities responsible for scintillations on satellite communication signals. Understanding the physical processes will lead to the possibility of improvement in predicting and forecasting the storm-time plasma redistribution and the creation of irregularities. This proposal targets the specific research topic of the LWS TR&T Focused Science Topic ¿Storm effects on the electrodynamics and the middle and low latitude ionosphere¿.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Natchimuthuk Gopalswamy/NASA Goddard Space Flight Center
Title: Coordinated Data Analysis Workshops (CDAWs): Meeting of the LWS Minds
Abstract:
The primary scientific objective of this proposal is to characterize the solar eruptions that produce significant impact on the heliosphere in general, and on Earth in particular, so that a global understanding of the phenomenon can be developed. The specific impacts we are concerned with are the prompt arrival of solar energetic particles (SEPs) and the delayed arrival of the energetic plasma, known as the coronal mass ejections (CMEs). The multitude of effects that directly affect the day-to-day life of the human society arise from the geoeffectiveness and SEPeffectivess of the solar eruptions. To achieve the scientific objectives we propose a two-pronged attack: (1) to hold a series of three Coordinated Data Analysis Workshops (CDAWs) to pool data, models, and analysis tools together for end-to-end studies of solar eruptions, and (2) to perform a targeted investigation of the solar sources of complex geomagnetic storms that last for more than three days with high intensity. CDAWs have proved to be an excellent forum for bringing scientists together from various disciplines of the Living with a Star (LWS) community for an in-depth look at science issues that cross the traditional discipline boundaries. The CDAWs are relevant to the Cross-Discipline Infrastructure Building Programs, because they address the

timely and important topics of LWS. The CDAWs also create value-added data products and publications in refereed journals that become part of the LWS infrastructure. The targeted investigation of CGS is directly relevant to the Focused Science Topic (d): Storm effects on the global electrodynamics and the middle and low ionosphere. This proposal is highly relevant to many of NASA's exploration objectives because the results will help understand the space (radiation and plasma) environment along and at the path of robotic and human exploration.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Raymond Greenwald/Johns Hopkins University
Title: Understanding the Evolution and Impacts of Storm-Enhanced Electric Fields in the Mid-Latitude Ionosphere
Abstract:
The proposal is directed to the NASA LWS TR&T Targeted Investigation program element and addresses the Focused Science Topic, ¿Storm effects on the global electrodynamics and the middle and low latitude ionosphere¿, which is identified by program descriptor T3d. We seek a deeper understanding of the penetration of nominally high-latitude ionospheric electric fields into the mid and low-latitude ionosphere and accordingly into the inner magnetosphere. During quiet periods the electric field is largely confined to the high-latitude zone and is highly variable in both time and space. During geomagnetic storms the electric field penetrates into the inner magnetosphere where it produces significant changes in magnetosphere-ionosphere coupling and major changes in the subauroral ionosphere. Two of the major goals of LWS science are to understand the processes that lead to these disturbances and to predict when they will occur. Reaching these goals requires a significantly improved understanding of the spatial and temporal evolution of both ionospheric and magnetospheric electric fields during storms. We propose to analyze observations collected with a new HF radar operating at the Wallops Flight Facility (¿=50¿) for insight into the evolution of penetration electric fields. This radar, a joint project of JHU/APL and NASA/WFF, extends the capabilities of the existing Super Dual Auroral Radar Network (SuperDARN) for observing electric fields and ionization irregularities into the mid-latitude region. The Wallops radar began operations in early May of 2005 and has observed several types of subauroral electric field arising from geomagnetic disturbance. The fields and their effects are effectively imaged over large areas (~thousands of kilometers) with high spatial (~tens of kilometers) and temporal (~minutes) resolutions. We shall use data from the Wallops radar, the existing high-latitude SuperDARN network, and related space- and ground-based instruments to characterize the activity and to obtain a global-scale view of the structure and dynamics of disturbance electric fields and plasma convection in the magnetosphere-ionosphere system. Our research plan is specifically tailored to serve the research objectives of the Focused Research Topic T3d. Specifically, we will (i) compile and characterize a database of mid-latitude electric field events, (ii) characterize the occurrence of subauroral polarization electric fields including their spatial and temporal variability and effects on the ionosphere, (iii) describe the occurrence of penetration electric fields and their ionospheric effects, and (iv) specify the global electric field as a parameter that conditions the occurrence of subauroral electric fields. This latter task will draw on mapping ionospheric convection with SuperDARN modified by subauroral effects with projection into the magnetosphere using established codes. We will also provide critical data and supporting analysis to assist the efforts of the T3d Science Team, including the testing and development of comprehensive models. We further propose to have the PI on this proposal serve as Team Coordinator.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Lon Hood/University of Arizona
Title: Solar Induced Variations of Stratospheric Ozone: Improved Observational and Diagnostic Analysis
Abstract:

The objective of the proposed work is to more completely determine and interpret the observed stratospheric ozone response to solar variability on both the 11-year and 27-day time scales as a function of altitude, latitude, and season. On the 27-day time scale, we will apply correlative and regression methods to (a) determine the altitude dependence of 27-day ozone responses in the lower stratosphere using a combination of SAGE II, UARS MLS, and EOS Aura MLS data; (b) determine the dependence of the 27-day response on latitude, season, and QBO phase in the upper stratosphere using primarily Version 8 SBUV(/2) ozone profile data; and (c) distinguish statistically among possible solar forcing mechanisms (e.g., solar UV flux, solar and magnetospheric particle fluxes, Galactic cosmic ray flux). On the 11-year time scale, we will apply a multiple regression statistical model to re-evaluate the 11-year solar UV induced response of stratospheric ozone using three complementary and independent data sets: (1) the recently released Version 8 SBUV(/2) ozone profile data set extending from 1979 through 2003 (with anticipated updates); (2) the recently completed Version 19 UARS HALOE data set extending from October 1991 through August of 2005; and (3) the SAGE II ozone profile data set extending from 1984 through 2000. We will also explore use of the HALOE and SAGE II data as external calibrations for the SBUV(/2) data. In order to diagnose the physical causes of the observed 11-year ozone response, we will carry out statistical analyses of other HALOE measured quantities (e.g., NO + NO2, temperature) and will study the results of collaborative two- and three-dimensional model simulations. We will specifically collaborate with Drs. John McCormack of NRL and Dan Marsh of NCAR for this purpose. Preliminary comparisons of a recent 50-year simulation of the NCAR WACCM v. 3 model, which includes no QBO but incorporates the effects of energetic particle inputs and uses observed sea surface temperatures as a lower boundary condition, shows that the model 11-year ozone response is similar to the observed response. As stated in the LWS TRT Summary (Appendix A.21 of the ROSES-2005 NRA), ``LWS will provide understanding of the effects of solar variability on terrestrial climate change . . .''. The observed solar cycle variation of stratospheric ozone is a fundamental constraint on sun-climate models that include stratospheric effects of solar ultraviolet and energetic particle inputs. The observed ozone response to 27-day solar UV forcing is also a basic constraint on sun-climate models. In addition, the need for the proposed research in the near future and the expectation of a significant scientific impact are supported by: (a) the recent availability of improved long-term remote sensing data sets including the Version 8 SBUV(/2) and UARS HALOE data sets; and (b) preliminary comparisons of the observed 11-year ozone variation with a recent 3D model simulation showing a potentially very good agreement. The latter comparisons indicate that the planned approach toward using collaborative model simulations for a variety of solar inputs and boundary conditions to identify causal mechanisms will be fruitful.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Jack Ireland/L3 Communications Government Services Inc.
Title: Mapping the Inner Heliosphere: Implementing Ajax Technologies for LWS
Abstract:
Recent developments in web based client-server technologies have brought substantial innovation to commercial websites. A landmark application of this new approach known as Ajax, is the Google(TM) Maps website http://maps.google.com. The software driving Google(TM) Maps allows users to pan, scan and zoom at will over what appears to be a single, enormous image of the Earth in a natural and intuitively appealing way. We will take open source equivalent technology into the realm of Living With a Star (LWS) applications by creating a suite of image retrieval, processing, display and storage algorithms that will implement the functionality required to be able to view and monitor features on the Sun and inner heliosphere simultaneously. This core suite of algorithms will be the engine that will power new and natural ways of visualizing the Sun and the inner heliosphere for the LWS program.

Living With a Star TR&T Program

NNH05ZDA001N

PI: Jay Johnson/Princeton University
Title: Theory and Hybrid Simulations of Transport due to Kinetic Alfven Waves at the Magnetopause
Abstract:
Recent observations have placed observational constraints on plasma entry mechanisms for northward IMF conditions when the plasma sheet cools and densifies. In particular, both in situ and remote observations have found dawn-dusk asymmetries in the density and temperature of the ion populations, and in situ particle distributions show perpendicular ion heating of low energy ions on the dawnside associated with strong compressional wave activity in the magnetosheath. It is the purpose of this proposal to examine transport processes that would occur due to kinetic and nonlinear interactions associated with the large amplitude, low frequency waves that are nearly always observed near the magnetopause in the context of these observational constraints. We would address the following scientific questions: (a) What is the nature of the low frequency wave activity and how does it regulate plasma entry into the magnetosphere, (b) What are the observational signatures expected from these transport processes?, and (c) How do the observational signatures compare with simulation and theory? We will use a combined theoretical and computational approach to understand how kinetic Alfven waves develop near the magnetopause and contribute to transport. We will obtain wave solutions near the magnetopause using the kinetic-fluid model (that include finite Larmor radius effects and wave particle interactions) that we will use to understand transport and heating at the magnetopause using methods of nonlinear dynamics. We will compare these results with hybrid simulations in a simplified slab geometry to understand the nonlinear aspects of low-frequency MHD waves at the magnetopause. Using this insight, we will perform and interpret three-dimensional hybrid simulations in a realistic magnetospheric geometry. We will examine the dependence of transport on solar wind conditions and the location along the magnetopause where particle entry occurs. We will compare our theoretical models with observations of wave activity, particle distributions, and global asymmetries. This project is directly relevant to the Living with a Star Targeted Research and Technology program Focused Science Topic area (c) Solar Wind Plasma Entry and Transport in the magnetosphere because we will address the means by which plasma crosses the magnetopause and we will quantify the amount of solar wind entering the magnetosphere due to low frequency kinetic Alfven wave activity and identify where it enters along the boundary. This proposal is also relevant to NASA's national research objectives to explore the dynamic earth system because we will have improved understanding of space environmental conditions and their causes which will increase capabilities for space flight and exploration.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Vania Jordanova/University of New Hampshire
Title: International Symposium on Recent Observations and Simulations of the Sun-Earth System
Abstract:
We propose to organize an International Symposium on Recent Observations and Simulations of the Sun-Earth System (ISROSES) in Varna, Bulgaria, from 18 to 22 September 2006. The main purpose is to create an international forum for scientists from solar, heliospheric, magnetospheric, and earth sciences communities to present and discuss recent advances in our understanding of the structure and complex interactions of the Sun-Earth System. The focused discussions will include, but are not limited to: (1) Solar Cycle variations in the Sun-Earth system; (2) Solar dynamics and the response of geospace; (3) Production, transport, and loss of energetic particles; (4) Sun-Earth system modeling and prediction. The main emphasis will be put on the integration of these studies -- ranging from observations to related interpretation, theory and numerical modeling -- across different temporal and spatial scales of the Sun-Earth system. Participants should come away with a better realization of the dynamic nature of the space environment, while appreciating the benefits of interdisciplinary approaches to understanding the

dynamic Sun-Earth system. ISROSES will include four full days of presentations and discussions; each day will be devoted to a primary topic with invited, contributed, and poster presentations. The invited presentations will cover the solar, magnetospheric, and ionospheric aspects of the topic to accomplish the cross-disciplinary objectives of the conference. The Principal Conveners Vania Jordanova and Ilia Roussev will be aided by a Scientific Organizing Committee (SOC) consisting of twelve well-established international scientists who will organize and lead the four days of individual sessions. The on-site coordination of the technical aspects of the conference will be planned by a Local Organizing Committee (LOC) consisting of eight distinguished Bulgarian scientists. The Conveners, in collaboration with the SOC will prepare a report on the meeting for publication in the Space Weather Journal. We seek support for students and young scientists to attend the symposium. The proposed Symposium Themes are relevant to the NASA Strategic Objective to understand the effects of the Sun on Earth and the environmental conditions that will be experienced by astronauts, as defined in the NASA ROSES-2005. They mesh well with the Strategic Goals of the NASA Living With a Star (LWS) Program, and with the NSF Solar, Heliospheric, and INterplanetary Environment (SHINE) and Geospace Environment Modeling (GEM) Programs. Specifically, they address the NASA LWS Program Focused Topic T3c "Solar Wind Plasma Entry and Transport in the Magnetosphere". The third ILWS General Meeting on 24 April 2005 in Vienna, Austria, approved to sponsor ISROSES as an ILWS Workshop.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Homa Karimabadi/SciberQuest, Inc.
Title: A Novel Data Mining Tool with Autonomous and Analytical Capabilities for Space Weather Studies
Abstract:
This proposal describes a research and development plan aimed at the Tools and Methods component of the LWS Targeted Research and Technology program. Our main objective is to adapt and bring in a new technology in data mining called Relevant Input Processor Network (RIPNet), which has proven very effective in other fields, into space sciences. Our recent application of this technique to space physics has demonstrated superior performance metrics (speed, accuracy, etc.) compared to standard techniques such as artificial neural net. The great speed advantage of RIPNet over traditional techniques (minutes rather than many hours and days) makes it an ideal desktop application and will be a key to its widespread use among experimentalists. RIPNet also offers a powerful reverse engineering capability. By this we mean that the outcome of the algorithm (i.e., the predicted model) is an analytical function with proper dependencies on the input parameters. The culmination of this work will be customized data mining software that can be used as a stand-alone application or be integrated into existing and future space physics data assimilation infrastructures (e.g., the Virtual Observatory). Consistent with the notional areas of interest for NASA¿s Living With a Star (LWS), our new technology should significantly increase science return from the data and enable development of more comprehensive physics-based understanding of the integral system linking the Sun to the Solar System through advanced knowledge discovery techniques (e.g., autonomous event detection, reverse engineering of time series data, etc.) that our software will provide. Although the focus of this work is on the development of a new type of data mining software, our research task also includes use of this software for a problem of great relevance to the LWS program. That is modeling of relativistic electron enhancements at Geosynchronous and Low Altitude Orbits which poses potential hazard to Earth-orbiting satellites and cosmonauts. We, however, emphasize that our software will be of general applicability and we plan to use it in the future for detection and modeling of events in the solar wind (e.g., CMEs, shocks, etc.) among others Our use of intelligent data analytic tools, i.e., computer algorithms which probe more deeply into data than first generation methods, will constitute a key step in modernization of data analysis in space physics. This in turn will help expedite the march toward a mature model of the coupling between regions and the global response of geospace to solar variations. As such, our work addresses NASA¿s objective of exploring the Sun-Earth system to understand the Sun and its effects on Earth, the Solar System and the space environmental conditions that will be experienced by

human explorers.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Enrico Landi/Artep, Inc.
Title: Solar Wind Origin and Acceleration Over the Solar Cycle
Abstract:
The knowledge of the source region, acceleration mechanism(s) and evolution over the solar cycle are of fundamental importance to NASA's efforts to understand the Sun and its effects on Earth and on human exploration. Here we propose a three-year investigation on the origin and acceleration of the solar wind, and of their evolution over the solar cycle. We will study the physical properties of the solar coronal plasma from the limb out to 4 solar radii making use of spectra from UVCS and SUMER, and images from EIT, Yohkoh and LASCO C1. The observations were taken from 1996 to 2005 and cover nearly an entire solar cycle. The data allow a comprehensive physical description of streamers and coronal holes, where the solar wind originates, and tests of ion-cyclotron wave damping as a mechanism for solar wind heating and acceleration.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Benoit Lavraud/Los Alamos National Laboratory
Title: Formation of Earth's Low-Latitude Boundary Layer and Cold, Dense Plasma Sheet under Northward IMF
Abstract:
Observations have shown the occurrence of unusually cold and dense plasma in the near-Earth tail of the magnetosphere. This cold, dense plasma sheet (CDPS) is known to form during intervals of northward interplanetary magnetic field (IMF) and to be of solar wind origin. It is further often observed to penetrate close to Earth during conditions of enhanced convection. This proposal addresses the science topic of solar wind plasma penetration and transport through the magnetopause and subsequently into the inner magnetosphere in order to assess the potential role of the CDPS in magnetospheric dynamics and geomagnetic activity. It aims to answer the following specific scientific questions: A. How and where does solar wind plasma enter the low-latitude boundary layer (LLBL) and plasma sheet under conditions of northward IMF? B. How and when are the double high-latitude reconnection, Kelvin-Helmholtz instability and wave-particle diffusion processes operative? C. What is the contribution of each process in terms of plasma transfer as a function of solar wind conditions? D. How is the CDPS material subsequently transported inward and what is its effect on geomagnetic activity? E. Does the CDPS have an influence on solar wind/CME geoeffectiveness through a preconditioning of the magnetosphere? We will answer these questions through a combination of data from key magnetospheric science missions (Cluster, Geotail) and solar wind measurements (Wind, ACE), together with the large database of geosynchronous plasma observations from the Los Alamos instruments. We will additionally test the viability of specific processes by detailed data and model simulation comparisons. This proposal directly contributes to the 'Solar wind plasma entry and transport in the magnetosphere (T3c)' focused science topic of the 'Living with a star targeted research and technology' NASA ROSES 2005 research announcement.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Jakobus le Roux/University of California, Riverside
Title: Self-Consistent Solar-Energetic Particle Acceleration at Evolving Shocks Associated with Coronal Mass Ejections

Abstract:
Under the National Objective to ¿Study the Earth System from space and develop new space-based and related capabilities for this purpose¿ the proposed work is specifically concerned with the NASA objective to ¿Explore the Sun-Earth System and its effects on Earth, the Solar System, and the space environmental conditions that will be experienced by human explorers. The proposal fits in with the Targeted Investigations element of the Living With A Star Targeted Research and Technology (LWST) Program under which it addresses the Focused Science Topic ¿Shock acceleration of solar energetic particles by interplanetary coronal mass ejections (CMEs) ¿. Time-dependent numerical solutions of the equations of fundamental kinetic focused transport and acceleration theory for energetic charged particles, kinetic wave excitation and transport theory, and MHD theory for CME shock evolution will be employed to achieve a fully self-consistent time-dependent model of solar energetic particle (SEP) acceleration at propagating interplanetary CME shocks from the Sun to Mars with the minimum number of simplifying assumptions. A few fully self-consistent SEP models that are based on transport and acceleration theory exist, but are either analytical, or semi-numerical such as the current University of California Riverside (UCR) model. The existing models are subject to a number of assumptions such as near-isotropic particle distributions at and downstream of the CME shock that need further investigation. The SEP model that we propose, which can be viewed as a logical extension of the current UCR model, will be used for this purpose, and for comparison of simulation results with specific SEP events. Thus we expect to achieve an enhanced understanding of the significant complexities of time-dependent SEP acceleration that arises at an evolving CME shock (e.g., self-consistent wave generation by SEPs streaming away from the shock and the role of quasi-perpendicular shocks), and how this relates to the formation of radiation hazards between the Sun and Mars.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Martin Lee/University of New Hampshire
Title: An Analytical Theory of Diffusive Shock Acceleration for Gradual SEP Events
Abstract:
The goal of this project is to develop an analytical theory for the shock acceleration of solar energetic particles (SEPs) at an evolving coronal/interplanetary shock. The theory should provide an effective framework for understanding the essential behavior of the large "gradual" SEP events which contribute to the most severe storms in space. Although the theory will be idealized in many ways in order to be amenable to analytical techniques, it will include the essential features which control the morphology of these events: shock acceleration by shock drift and the first-order Fermi process, wave excitation upstream of the shock by the energetic protons, diffusive transport of the ions in the turbulent sheath upstream of the shock, ion escape from the sheath by magnetic focusing, and injection from both solar wind and suprathermal/energetic ion seed populations. The theory will improve on previous analytical (and numerical) work in important ways, both in calculating the excited wave intensity and generalizing the injected populations. The theory will predict wave intensities, and particle energy spectra and anisotropy for all ion species, as functions of distance upstream of the shock. In particular the spectra of the escaping ions (which satisfy the "streaming limit") will be determined. The project will be critical to the success of Focused Science Topic (a) since it will provide analytical predictions which (i) can be compared with the detailed current and future observations of several spacecraft including ACE, STEREO, and Wind, and (ii) can be incorporated into numerical schemes which can be applied to more complex and realistic geometries and time variations.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Jon Linker/Science Application International Corporation
Title: MHD Modeling of Coronal and Heliospheric Magnetic Field Evolution
Abstract:

The "open" magnetic field is the portion of the Sun's magnetic field that stretches out into the heliosphere to become the interplanetary magnetic field (IMF). It plays a key role in the Sun-Earth connection. It defines the structure of the heliosphere, including the position of the heliospheric current sheet and the regions of fast and slow solar wind. Understanding of the topology and dynamics of the Sun's open magnetic field requires time-dependent modeling of the field response to changes in the photospheric magnetic flux. We propose a three-year program to investigate coronal and heliospheric magnetic field evolution with time-dependent MHD simulations. Specifically, we will: - Incorporate magnetic flux evolution into the SAIC/NOAA SEC coupled MHD model of the solar corona and inner heliosphere; - Study how the topological properties of the magnetic field evolve in response to different components of flux evolution, such as differential rotation; - Model the time-dependent response of the coronal and heliospheric field to the flux evolution specified by the Schrijver and DeRosa (2003) evolutionary model for several months of real time; - Use particle tracing techniques to investigate the contributions of initially closed field regions to the slow solar wind; - Compare the magnetic field topologies of the resulting solutions (expanding loops, disconnection and interchange reconnection events) with measurements from spacecraft to determine whether the simulated evolution is compatible with heliospheric observations. Results from our simulations will be provided to the space science community through journal publications and our web site (http://iMHD.net/mhdweb).

Living With a Star TR&T Program
NNH05ZDA001N

PI: Kan Liou/The Johns Hopkins University Applied Physics Laboratory
Title: A Photometry-based Model of Global Thermospheric Column O/N2 Driven by Solar and Magnetospheric Conditions
Abstract:
The principal goal of the proposed research work is to construct a photometry-based model of thermospheric atomic oxygen to molecular nitrogen column density ratios (O/N2) using satellite-based measurements of far ultraviolet (FUV) dayglow emissions. The proposed work will be carried out by processing and analyzing FUV images of OI 135.6 nm and N2 Lyman-Birge-Hopfield dayglow acquired by Polar ultraviolet imager (UVI), TIMED global ultraviolet imager (GUVI), and DMSP special sensor ultraviolet spectrographic imager (SSUSI). The multi-satellite image data sets provide unprecedented long term (one solar cycle) and simultaneous large spatial coverage not previously available and ensure the statistical significance of the planned result. The overall science objectives of the proposed research are (1) to characterize and quantify O/N2 column density ratios for both quiet and storm times, (2) to provide a tool for studying responses of thermospheric composition to geomagnetic disturbances, (3) to provide a tool for predicting (dayside) negative ionospheric storms, and (4) to provide validation for physics-based models. Images of dayglow emissions at 135.6 nm and LBH bands from different satellites will be cross-calibrated and converted to 2-dimensional maps of column density ratios of O relative to N2, referenced to a fixed N2 depth, using the updated empirical MSIS model of Hedin (NRLMSIS00) and the physics-based Atmospheric Ultraviolet Radiance Integrated Code (AURIC). The derived O/N2 column density ratios will be first resampled into regular bins and then assembled into a large historical database. Finally, an empirical O/N2 model will be obtained via a straightforward spherical harmonic fitting. Parameters that represent forcing from the polar latitudes (the auroral electrojet AE and/or the polar cap PC indices), the magnetosphere (the magnetic storm Dst index), and from the solar wind plasma and magnetic field will be included in the fitting. The unprecedented long term and large spatial coverage of the image data sets available for the proposed work ensure the statistical significance of the expected result. The proposal is aimed to support NASA LWS 2005 targeted investigation topic (T1): "Tools and Methods." The proposal directly addresses the science priority questions recommended by Geospace Mission Definition Team: "(2A) Determine the effects of long and short term variability of the Sun on the global-scale behavior of the ionospheric electron density" and "(3A) Determine the effects of solar and geospace variability on the atmosphere enabling an improved specification of the neutral density in the thermosphere." To a broader scope, this proposal addresses one of the NASA Strategic Objectives (IV): "Study the Earth system from space and develop new space-based and related capabilities for this purpose."

Living With a Star TR&T Program
NNH05ZDA001N

PI: Dana Longcope/Montana State University
Title: Solar Flare Forecasting Using Topological Energy Models
Abstract:
This is a proposal to develop tools for forecasting the severity of solar storms initiated from magnetic regions. The most severe storms occur when magnetic energy stored in these so-called active regions is suddenly converted to other forms such as radiation and outward moving material. Solar scientists still do not understand enough of the relevant physics to predict the instant this conversion will occur or the severity of the storm's effect on Earth. With the present understanding, however, it is possible to estimate the amount of energy currently stored in each region present, and how much of this energy is ready for release. This grant would fund the development of a set of programs to make such energy estimates continuously using routine photospheric magnetograms. The estimate is based on a simplification of the full set of magnetohydrodynamic equations known as the Minimum Current Corona, which places a rigorous lower bound on magnetic energy stored by slow motions of the complex photospheric field to which it is anchored. The energy is stored as field lines anchored to different photospheric regions interact with one another. This proposal would develop the methods for automatically identifying all photospheric regions and quantifying their sizes, locations and internal and external motions. These are translated into an energy estimate under the assumption that no reconnection occurs between field lines anchored to different regions. These steps are computationally simple enough to be performed continuously, automatically, in real time on a small computer. It is then possible to estimate the energy which would be released when any set of field lines were to reconnect at that instant. Such hypothetical reconnection scenarios can also be characterized by the amount of twist (helicity) which would be present in magnetic field ejected from the Sun --- a quantity which may be significant in predicting the consequences at Earth of the solar eruption. At the end of the funding the methods will be tested using observations of past flares, and then made publicly available. Since it delivers a method and software implementation useful in forecasting solar activity, this project is well suited to the Tools and Methods component of the Targeted Research and Technology program.

Living With a Star TR&T Program
NNH05ZDA001N

PI: John Lyon/Dartmouth College
Title: Plasma Transport from the Solar Wind to the Magnetosphere
Abstract:
The mechanism by which the solar wind plasma enters the magnetosphere remains an important and to a large degree unanswered question. A number of mechanisms have been proposed for this process. For example, there is direct entry along newly reconnected field lines, there is diffusive entry (perhaps drift mediated) along the magnetopause, there is impulsive penetration, to name a few. What does seem clear is that the amount of plasma within the magnetosphere is correlated with the density in the solar wind. This question of plasma entry has been called out in the current NRA as an important science question of interest to the NASA Sun-Earth Connection Program. We will attempt to determine the processes by which entry, energization and energy extraction take place through a number simulation codes, used singly and in concert. The simulation codes are: 1. A global MHD magnetospheric code which has been used successfully to model many of the aspects of magnetospheric structure and dynamics. This will be the workhorse for this project. It can be used to track fluid elements from, say, positions in the plasma sheet to their origins in the solar wind. 2. A particle tracking code that integrates the Lorentz orbits of particles within the system. In conjunction with the fields from the global MHD code, it can give ihe currentsnformation about the actual trajectories of the particles making up the collisionless plasma. 3. Two fluid and hybrid codes to model the boundary layers (magnetopause) of the

global system. One of the deficiencies of the MHD codes is that the boundary layers are both not resolved and deficient in physics. This makes the results of tracing particle trajectories through such layers problematic. Our approach will be two-fold. On one track we will use the global MHD model to set up idealized situations where the plasma enetry can be studied using the full array of tools listed above. Typically, then the MHD code would provide a base time-dependent configuration of electric and magnetic fields, as well as fluid flows. The results for plasma entry for the fluid model will then be compared against the results for the particle tracing. The kinetic codes will be used in conjunction with the particle tracing to develop ideas about the actual rates of particle penetration and reflection and energy gain or loss through the boundary layer. In the second track, we will try to validate the models by reference to actual data. This is generally easier with the MHD models than with the other simulations. Here we will rely on a combination of single event studies and upon statistical studies.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Ward Manchester/University of Michigan
Title: Modeling The 3D Density Structure and White-Light Appearance of CME Events
Abstract:

We propose to examine the propagation of solar eruptive events to 1 AU in a realistic heliosphere using a global magnetohydrodynamic (MHD) model. The main focus of this study will be the evolution of the 3D density structure of the CME and how it relates to Thomson-scattered white light images. The University of Michigan's BATSRUS code will used to perform the proposed simulations. CME initiation will follow from both flux ropes and (Gibson & Low, 1998) and imposed shearing motions. Our earlier simulations have produced many important results. We have shown that the mass of fast CMEs increases by as much as a factor of four as they propagate to Earth because of plasma swept up by the CME-driven shock. We have also shown that line-of-sight measurements of CME mass may significantly underestimate the mass swept up by a CME if a dense spherical shell encases a low density cavity. Expansion of the CME flux rope has also been shown to cause the dense core to evolve to a density depletion. These results have been published a series of papers: Manchester el al. (2004a, 2004b) Lugaz, Manchester and Gombosi (2005). This proposal seeks funds to significantly advance this research in 4 ways: (1) incorporate a more realistic MHD model of the inner heliosphere based on solar magnetograms, (2) investigate the pre-eruption conditions at the Sun based on magnetic data for chosen active regions and use this data to direct CME initiation, (3) comparing the CME synthetic white light images with LASCO observations near the Sun and images obtained near 1 AU with STEREO. We will examine the 3D model density structure of CME disturbances and line-of-sight images to determine what may be accurately inferred about the density, velocity and energy of CMEs from single and stereoscopic views. Understanding the CME morphology will allow us to separate the shock from the driver and will lead to more accurate measurements of the physical parameters such as the compression ratio, speed, mass, and location. In the case of shocks, the compression ratio and speed are necessary inputs in models of particle acceleration. Understanding how the various CME structures evolve through the heliosphere will enhance the scientific return from the numerous in-situ instruments. It will also help us investigate what causes some CME to be geoeffective. Obtaining realistic CME models throughout the heliosphere will greatly enhance the return from the SECCHI observations by (1) providing examples of how certain CME structures (shock, flux rope) will look at different heliocentric distances and perspectives, and (2) act as a controlled data set upon which to test the fidelity of the 3D reconstruction algorithms.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Anthony Mannucci/Jet Propulsion Laboratory
Title: Ionospheric Behavior During the First Few Hours of Intense Geomagnetic Storms
Abstract:

The impact of electric fields on the large-scale variation of plasma in the Earth's ionosphere is receiving increasing attention from the research community because it is of fundamental importance in understanding the structure and dynamics of the Earth¿s ionosphere during geomagnetic storms. Recent publications suggest that prompt penetration electric fields generated by the solar wind-magnetosphere interaction may have enormous consequences in changing the global structure of total electron content (TEC) in the dayside ionosphere, rapidly (within ~2-3 hours) after certain conditions in the solar wind are met. In earlier work, Foster et al., (2002) used a dense network of ground-based ionospheric measurements to detect mesoscale structures over North America that may be correlated with plasmaspheric structures known as drainage plumes, the latter widely believed to be due to storm-time electrodynamics in the inner magnetosphere. Both the dayside TEC increases, and the mesoscale mid-latitude structures, suggest the strong role of convection electric fields in determining ionospheric behavior during geomagnetic storms, but many questions remain about the origin of these fields and their ionospheric impact. The focus of this proposal are the large-scale and large-magntiude changes in TEC that occurs early on during intense geomagnetic storms. Significant gaps in understanding these changes suggest the need for establishing an empirical relationship between solar wind conditions that trigger geomagnetic storms, and the resultant ionospheric response. Such an empirical relationship has clear scientific value, because the magnitude and promptness of the ionospheric response is not being predicted, in general, with existing models of geospace. It also has practical value for predicting the severity of near-Earth space weather given an upstream monitor of solar wind conditions, as is available, for example, from the ACE spacecraft. Our approach will be to use a globally-distributed dataset of ionospheric measurements, obtained from the ground and from space, to relate the observed TEC behavior to upstream solar wind conditions. The dataset is available from Global Positioning System receivers on the ground and in orbit, and from dual-frequency ocean altimetry satellites. Our focus will be on dayside, large-scale plasma increases and re-structuring in the first few hours of intense storms. We will compare the observations to models to determine the degree and manner in which existing state-of-the-art models predict the observations and capture the physics.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Sergei Markovskii/University of New Hampshire
Title: Intermittent Heating of the Solar Wind in Coronal Holes
Abstract:
Much about the origin and nature of the solar wind, which is a key element of the Sun-Earth connection, depends on a detailed knowledge about the energy sources for the fast solar wind and the kinetic mechanisms responsible for its heating and acceleration in coronal holes. A broad consensus has emerged over the past decade attributing the solar wind heating to the cyclotron-resonant dissipation of ion cyclotron waves. Although a number of investigations of this mechanism have been carried out, two fundamental questions remain to be answered: What is the source and character of the necessary waves? and What is the detailed kinetic response of the ions? This proposal links small-scale magnetic reconnection events (microflares) at the coronal base to the generation of the fast solar wind. We explore the consequences of a new view that the microflares launch a highly intermittent electron heat flux up into the corona. These sporadic heat-flux bursts can excite highly-oblique ion cyclotron-resonant waves through a plasma microinstability and energize the ions. We have already developed a quantitative model of this process for the collision-dominated region near the base of the corona. The collisional relaxation of the proton distribution function in this region allowed us to simplify considerably the description of the solar wind evolution. With this model, we have shown that our mechanism is efficient enough to account for the initial acceleration of the fast solar wind. We now propose to extend our analysis to the rest of the solar corona. In the absence of collisions, a fully kinetic approach is required to describe the solar wind evolution. We will use both analytical and numerical techniques to develop and quantify this approach. When combined with our previous results, we will ultimately have a kinetic model that will work in the entire region of the solar wind acceleration. An essential goal of any coronal heating model is to explain the heating of the ions perpendicular to the magnetic field and the preferential heating of the heavy ions. For this

purpose, we will incude O5+ and Mg9+ ions in our analysis. The theoretically predicted behavior of these ions will be verified with the help of the UVCS/ SOHO observational data. To test our theory, we will further derive the amplitudes of the density fluctuations associated with the heat-flux generated ion cyclotron waves and compare them with the interplanetary scintillation measurements. Studying the solar wind energization helps prevent the potential exposure of humans to harmful effects of the solar activity in the outer space. Thus, this work is important for the success of the future space exploration mapped out in the new national program of prolonged human activity on the Moon and on the roundtrip to Mars. By guiding and enhancing the observational capabilities of the NASA missions, this research will provide the information for policy formulation of federal agencies coordinating the national program of space exploration.

Living With a Star TR&T Program
NNH05ZDA001N

PI: William Matthaeus/University of Delaware
Title: Turbulent Heating of the Corona, Origin of Solar Wind Fluctuations, and Boundary Conditions in the Inner Heliosphere

Abstract:
This proposal is to support collaborative work on the origins of the solar wind, and the boundary conditions for Space Weather effects in the inner heliosphere, to be carried out during a one year sabbatical that the PI has been granted by the University of Delaware for calendar year 2006. The University will supply 75% of the PI's salary in support of the sabbatical, and this proposal requests support for the remaining 25%. During the year the PI will spend approximately five months at the University of Florence to work collaboratively with Prof. Marco Velli. The PI and Prof. Velli both served on the Solar Probe Science and Technology Definition team and contributed substantially to the science component of that effort. The goals of this proposal are based on science issues that came up and became partially clarified while writing the solar probe Science and Technology Definition Team document, providing a unique opportunity to continue the momentum that was established in that series of meetings. The proposed research is: (1) to develop a better theoretical understanding of the behavior of Alfven waves and turbulence in the important regions between the sonic and Alfven points (approx. 5-20 Rs) in the corona, and between the Alfven point and 1AU in the solar wind. This includes study of observed 1/f noise, the development of anisotropy, and the nature of high latitude turbulence. These will be addressed through a combination of observational and numerical inputs, and analytical modeling; (2) to assemble a fully consistent model of the acceleration of the solar wind, using for the first time an accurate, consistent and tested nonlinear model for MHD turbulence starting in the lower corona. Unlike other similar models, we will include cross helicity and anisotropic cascade effects. These are issues that the PI has worked on in great detail with his collaborators, and in this new collaboration M. Velli will supply valuable expertise in wind equations and modeling of large scale coronal magnetic field. The further understanding of the plasma physics and turbulence theory of these regions will provide extremely valuable insights concerning the "inner boundary conditions" for space weather, and is therefore an essential underpinning of the LWS TRT science in general, directly addressing the 2005 targeted research area: "T3b. Determine the mechanisms that heat and accelerate the solar wind." This is a one year proposal, but the PI agrees to maintain participation in the associated working group.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Richard Mewaldt/California Institute of Tech
Title: Modeling and Observations of Solar Energetic Particle Spectral Breaks

Abstract:
Recent measurements show that in essentially all large solar energetic particle (SEP) events the energy spectra have a power-law component at low energies followed by a significant break in the spectra at higher energies (e.g., between ~5 to 50 MeV for protons). The spectra above the break sometimes are exponential in shape, but often a second power-law extends to hundreds of

MeV/nucleon. The location of spectral breaks and the spectral shape above the break play key roles in determining whether an SEP event represents a radiation hazard. We propose to combine a self-consistent, detailed model of shock acceleration and interplanetary transport with state-of-the-art SEP measurements to investigate why spectral breaks occur, which physical parameters affect their location, and what determines the spectral shape at high energies. The SEP data are from the EPAM, ULEIS, and SIS sensors on ACE and instruments on GOES and SAMPEX. These data will produce energy spectra from ~0.1 to ~100 MeV/nucleon for H, He, and heavy-ions from C to Fe. The observations already demonstrate that all ion species typically share a common spectral form, with spectral features that are organized by charge-to-mass ratio (Q/M). These spectra thereby provide critical information for investigating the physics of SEP acceleration and transport. To investigate SEP spectra theoretically we propose several improvements to the SEP acceleration and transport model of Li, Zank and Rice. This model produces SEP spectra very similar to those observed, with spectral breaks that are apparently related in part to the spectrum of Alfven waves generated by protons escaping upstream of the shock, a critical element of the shock acceleration process. Other aspects of the acceleration process that will be investigated include: the seed-particle energy spectrum; the level of pre-existing upstream turbulence; shock speed and strength; and the rate and rigidity dependence of particle escape from the shock. By systematically varying the initial conditions and model parameters and then comparing with observations of large SEP events, we will isolate the parameters and conditions that have the strongest effect on SEP spectral characteristics. This work will address several key scientific questions about SEP acceleration by CME-driven shocks, including: What seed-particle spectra and composition are needed to match the observations and how are they altered during the acceleration process? What conditions govern the acceleration rate, spectral slopes, break energies, intensity, and temporal evolution of SEP events? What combinations of these parameters result in very large SEP events like those on October 28, 2003 and July 14, 2000? Answering these questions is a prerequisite to building real-time models that can forecast when large SEP events will occur and how they will evolve - goals of both LWS and the 2005 S3C Strategic Roadmap.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Mari Paz Miralles/Smithsonian Astrophysical Observatory
Title: An Observationally-Driven Predictive Capability for the Acceleration and Heating of Fast and Slow Solar Wind Streams
Abstract:
We will combine: (1) measurements of plasma parameters in the acceleration region of the solar wind, made over the last decade of UVCS/SOHO observations, (2) measurements of in situ solar wind properties, and (3) ab-initio theoretical models of MHD turbulent heating in solar wind flux tubes, in order to understand the mechanisms that heat and accelerate the solar wind. The study will test and refine theories that propose that the geometry of coronal flux tubes is primarily responsible for the range of fast and slow wind speeds. Thus, this study will put new constraints on similarities and differences in the acceleration of fast and slow solar wind streams.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Mark Psiaki/Cornell University
Title: Development of a Limb Scanning Occultation Receiver for Ionospheric/Atmospheric Remote Sensing using Galileo and Modernized GPS Signals
Abstract:
New radio receivers will be designed and tested for acquiring and tracking weak GPS and Galileo signals during limb scans that occur just before or after occultation of the line-of-sight from the low-Earth orbit (LEO) receiver platform to the transmitting satellite. These receivers will be useful for global-scale remote sensing of the ionosphere and the neutral atmosphere from LEO

satellites. The receivers will be developed to use the existing GPS civilian L1 signal along with the new GPS civilian L2 and L5 signals. They will also use multi-frequency signals from the Galileo global navigation satellite system that the Europeans are building. These receivers will be specially designed to track very weak multi-frequency signals down to low minimum scan altitudes in the neutral atmosphere, and to return scientific data such as TEC, neutral atmosphere delay, and amplitude and phase fluctuations. One receiver will be designed using FPGA technology, and another will be designed using real-time software receiver technology. They will be capable of processing many occulting signals simultaneously from both GPS and Galileo satellites. One possible FPGA design will operate in a sequential batch mode on digital intermediate frequency data that is stored in a circular buffer. Batch operation allows a single-channel FPGA that implements a complex set of operations to function as a multi-channel device because it can perform its calculations many times faster than the rate at which data are logged. The goal of the design is to receive signals and produce science data for all GPS and Galileo occultations that occur in a typical LEO. The new receiver will be able to return 3 times as many limb scans per day as can current occultation receivers while using lower gain antennas and simpler radio-frequency processing. The use of newer high-quality GPS and Galileo signals will enable these goals to be achieved. The principal science advance of the project will be an increase by a factor of 3 or more of the global density of limb scan coverage for a given polar-orbiting LEO platform and an increased ability to field the new receivers on LEO platforms due to decreased cost and complexity. The net result will be a greatly improved ability to estimate dynamic global variations of ionospheric electron density, of neutral atmosphere temperature and pressure in the upper troposphere and the stratosphere, and of water vapor in the lower troposphere (if independent temperature measurements are available).

Living With a Star TR&T Program
NNH05ZDA001N

PI: Cora Randall/University of Colorado
Title: Implications of Energetic Particle Precipitation for the Stratosphere
Abstract:
We propose to combine satellite data analysis and global modeling to investigate the effects of solar cycle variations in energetic particle precipitation (EPP) on the stratosphere. Precipitating particles continually penetrate the earth's upper atmosphere, producing odd nitrogen. During the polar night, if dynamical conditions are appropriate, the odd nitrogen so produced can descend to the stratosphere where it participates in the catalytic cycles responsible for controlling ozone distributions. While this has been known for decades, the implications for stratospheric ozone have never been quantified, and these effects are routinely neglected in three-dimensional global models. Nevertheless, observational evidence suggests that even under moderate levels of solar activity, EPP affects stratospheric ozone. The goal of this proposal is to investigate the effects of EPP on stratospheric ozone distributions, variability, and trends, and the resulting implications for studies of long-term change in the upper troposphere and stratosphere. To accomplish this, the proposed work has two main objectives: (1) Analyze the historical and continuing data base of stratospheric ozone and NOy satellite measurements to correlate variability in these constituents with solar cycle variations in EPP; and (2) Incorporate EPP into a global chemistry climate model to quantify EPP effects on stratospheric NOy and ozone distributions, and to investigate corollary effects on atmospheric composition and dynamics. Through the combined use of satellite data and modeling, the proposed work is directly responsive to the current NASA ROSES Research Announcement and Living With a Star (LWS) program objectives. It targets the NASA exploration objective "To understand and protect our home planet" by addressing "the role of solar variability in climate and stratospheric chemistry", one of the primary focus topics designated by the LWS Targeted Research and Technology Science Definition Team.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Edward Rhodes/University of Southern California
Title: The Study of the Changing Solar Interior Using Global and Local Helioseismology
Abstract:
The research we are proposing has the main goal of improving our knowledge of the temporal changes which are occurring in the structure and dynamical motions of the solar interior. Within the past few years, several hints of possible temporal changes that have occurred during the current solar cycle have been obtained through the application of helioseismic techniques to observations made with the Michelson Doppler Imager (MDI) experiment onboard the SOHO spacecraft. These hints have included the discovery of the Solar Subsurface Weather (SSW), and the confirmation of the existence of the torsional oscillations in the sub-photospheric layers. The discovery of the SSW has included a reversal in the meridional circulation beneath the solar surface in the northern hemisphere during the years 1998 through 2001. We have recently verified that the torsional oscillations can be seen in cotemporaneous ground-based observations taken at the Mt. Wilson Observatory (MWO) 60-Foot Solar Tower after the SOHO launch as well as in observations obtained prior to the SOHO mission. We have verified the existence of the torsional oscillations in our 60-Foot Tower data by first transferring two and one-half years of these observations to the MDI Science Center and by then computing the frequency splittings of the solar f-mode oscillations. We have also verified that these same MWO observations can be employed in the generation of the ring diagrams of local helioseismology. We have generated maps of sub-photospheric flows from MWO Dopplergrams obtained during three different Carrington Rotations in 1995, 1996, and 2001. We propose to search for changes in both the meridional flow and in the torsional oscillations during Solar Cycle 22 using earlier MWO observations since our 60-Foot Tower observations are the only suitable data available during that solar cycle. We also propose to improve the radial resolution of the measurements of the shallow sub-surface layers by incorporating measurements of the frequency-splitting coefficients of the high-degree p-mode oscillations now that we have been able to remove the contamination introduced into those measurements by solar differential rotation. Since the high-degree p-modes are confined to the shallow layers just below the photosphere, the inclusion of their frequency splittings should allow us to improve upon the depth resolution available from the use of the intermediate-degree f-mode splittings alone. We also propose to invert the high-degree frequency splittings in order to provide an independent verification of the zonal velocities which are measured by the ring-diagram methodology. During the first 28 months of this project we have transferred 1118 days of 60-Foot Tower Dopplergrams containing in excess of one terabyte of data to the MDI Science Center. All of these images are currently available for use by the entire solar community. During our planned continuation of this project, we expect to transfer all of our remaining archive of 60-Foot Tower Dopplergrams to the MDI Science Center. This transfer and our other planned tasks will all extend research which has been supported by NASA Living with a Star Program Grants NAG5-13510 and NNG04GM01G.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Jim Roeder/Aerospace Corporation
Title: Relativistic Electron Acceleration and Transport: CRRES and SCATHA Observations in the Inner Magnetosphere
Abstract:
Observations by the NASA/USAF SCATHA and CRRES satellite missions will be used to test candidate mechanisms for the acceleration and transport of radiation belt electrons in the energy range 0.05-6 MeV. Radial profiles of the measured energetic electron phase space density will be constructed at constant first and second adiabatic invariants. The profiles at a range of values for the second invariant, from near zero to large values, will help determine whether local wave particle interactions actively contribute to the electron acceleration. Electron and wave data from SCATHA and CRRES will also be used to test diffusion models of the wave-particle interactions in pitch angle and energy. The effect of magnetic and electric shell splitting will be investigated by examining the local time asymmetries of SCATHA and CRRES electron observations of in comparison with other available satellites.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Ilia Roussev/University of Michigan
Title: A Self-Consistent Investigation of SEP Production in Gradual Events Based on Realistic Models of Turbulence and IMF
Abstract:
We propose to study the shock acceleration of solar energetic particles (SEPs), and their transport, coupled to the dynamics of CME-driven turbulent shock waves in the heliosphere. Our goal is to develop a self-consistent model, which integrates the best theories developed for every aspect of the SEP production and transport problem. This will include a realistic model of turbulence near the shock front and effects of SEP spectrum anisotropy. The new SEP-turbulence model will be coupled with a realistic model of CME evolution to enable the LWS community to tackle important problems related to the shock acceleration of SEPs by CME shocks. Our research studies will target fundamental features of gradual SEP events, such as formation and evolution of CME-driven shocks, particle injection at the shock, excitation of turbulence by the self-generated Alfvén waves, particle diffusion due to the enhanced turbulence, and particle escape upstream of the shock, among other phenomena. The strength in our integrated approach is that it will enable us to quantify the particle acceleration and scattering by the self-excited Alfvén turbulence, and particle transport along and across the interplanetary magnetic field (IMF). We will extend the capability of the kinetic code of the University of Arizona to include a realistic model of self-excited turbulence, since this code is well suited to handle a finite particle spectrum anisotropy. The particle transport upstream of the shock wave will be studied using a newly developed statistical code based on the Monte-Carlo approach. All the models coupled together will allow us to account for the acceleration and transport of charged particles in realistic 3D turbulent IMF. The results of our studies will be compared with available data from SoHO, ACE, and other satellites in order to improve the CME-SEP-turbulence model accordingly. The whole research effort is expected to contribute towards better understanding, predicting, and mitigating the exposure of human explorers to harmful radiation of solar origin. The proposed self-consistent investigation of SEP production in gradual events based on realistic models of turbulence and IMF directly relates to Focused Science Topic T3a of the LWS TR&T solicitation. We are also devoted to contributing significant time and effort towards improving science education, particularly in solar-heliospheric physics, and we offer an Initiative for a Novus-Seculorum Program in solar Research and Education (INSPiREd). We propose to organize specialized summer schools, which will introduce and involve students in an integrated-system perspective of the Sun-Earth system. The schools will also provide a venue for teaching and research faculty to improve the scope, impact, and outreach of the existing academic programs. These objectives will make the INSPiREd an important complementary addition to the existing education and public outreach activities at NASA, NSF, and US academic institutions.

Living With a Star TR&T Program
NNH05ZDA001N

PI: James Ryan/University of New Hampshire
Title: Summer School in High-Energy Solar Physics at the University of New Hampshire
Abstract:
We propose to organize a summer school for graduate students and new postdocs in high energy solar physics. The material presented will cover the instrumentation related to, the observations of, and the associated fundamental physics of solar flares, coronal mass ejections, and solar energetic particles. The school will be held in New Hampshire from 14 ~ 24 June, 2006, immediately prior to the American Astronomical Society Solar Physics Division meeting at the same location. We request funding to support the travel and per diem costs for some 45 students and ~10 faculty, and to cover the publication of refereed versions of the lectures in a single volume. This Solar Physics Division of the American Astronomical Society has approved this event as its sponsored summer school for 2006. Financial support from NSF has also been

promised.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Stanislav Sazykin/Rice University
Title: Modeling the Impact of Stormtime Electrodynamics on the Mid and Low Latitude Ionosphere

Abstract:
The goal of this research is to determine the circumstances leading to the massive restructuring of the mid and low latitude ionosphere and the development of large-scale bite-outs of electron density at low latitudes during geomagnetic storms. Good examples of these features occurred during the Halloween storm in October 2003. Maps of total electron content (TEC) showed a factor of four increase at mid latitudes, and measurements of electron density by the DMSP satellite at 850 km indicated the ionosphere had virtually disappeared over a wide latitude swath at low latitudes. The depleted region, or "bite-out," was accompanied by smaller scale ionospheric irregularities, or bubbles, on its flanks. It is expected that the dramatic gradients were created by exceptionally large upward ExB plasma drifts, raising the ionosphere to higher altitudes, transporting plasma poleward, and driving the huge depletions at low latitude. This study will investigate the interaction and feedback between the two main sources of the plasma drift -- the prompt penetration (PP) and disturbance dynamo (DD) electric fields, and determine the cause of the massive restructuring of plasma at mid and low latitudes during storms. This project is a "linked" proposal between research teams at University of Colorado (PI Tim Fuller-Rowell) and Rice University (PI Stan Sazykin). The success of the project relies on the self-consistent coupling between physical processes in the thermosphere, ionosphere, and plasmasphere (as captured in the CTIPe model) and the inner magnetosphere (as captured in the RCM). Combining these two models includes both dynamo and penetration electrodynamics, and consistently handle the feedback between the two regimes. This study is therefore unique in its ability to couple the various domains and address the science questions in a rigorous mathematical approach. This study will: 1) Determine the physical processes leading to the large vertical plasma drifts and the interaction and feedback between the penetration and dynamo electric fields, 2. Determine the impact on the mid and low latitude ionosphere including the cause of the massive restructuring of plasma density, and 3) Investigate the possible causes of the strong longitude dependence in the storm-time response. The first phase of the study will perform the comprehensive coupling of the CTIPe and RCM models where the polar cap boundary, the neutral wind driven dynamo currents, and the field-aligned magnetospheric currents are consistent between the two codes. The effects of under and over shielding in the inner magnetosphere will be implicitly included in the field-aligned currents and the potential solver. Numerical experiment will be performed with a goal of understanding the complex interaction between the geophysical domains including the electrodynamic feedback between PP and DD. For validation, the coupled model will be used to simulate the recent storms targeted by the recent CDAW workshop. The chosen storms have good global and regional coverage for TEC, have reasonable measurement of the electric fields, and have well developed experimental/ observational databases. The potential benefit of this study for space weather is clear. Large-scale changes in the ionosphere impact GPS navigation signals and alter the propagation of HF radio-wave communication. The large-scale ionospheric changes are also associated with the generation of small scale ionospheric irregularities responsible for scintillations on satellite communication signals. Understanding the physical processes will lead to the possibility of improvement in predicting and forecasting the storm-time plasma redistribution and the creation of irregularities. This proposal targets the specific research topic of the LWS TR&T Focused Science Topic "Storm effects on the electrodynamics and the middle and low latitude ionosphere".

Living With a Star TR&T Program
NNH05ZDA001N

PI: Peter Schuck/Naval Reseach Laboratory
Title: Tracking Photospheric Magnetic Footpoints with the Magnetic Induction Equation
Abstract:

We propose a three-year program to develop techniques for accurate and precise estimation of solar surface flows from magnetogram data. Local Correlation Tracking (LCT) is the de-facto standard for estimating motion in solar image sequences. However, this technique has many documented limitations. Perhaps the greatest limitations of LCT are the absence of demonstrated accuracy, precision and a quantifiable local uncertainty associated with the velocities derived from this technique, and the introduction of artificial scales. This program will develop new techniques that are less susceptible to these limitations. The proposed techniques determine the optical flow by applying the magnetic induction equation and an affine velocity model statistically to a windowed subregion of the magnetogram sequence producing an overdetermined system that can be solved directly by standard least squares or total least squares techniques. These subspace methods are inherently statistical. Consequently, the optical flow estimates can be assessed for reliability and for resolution of the aperture problem. The result is a point-by-point optical flow field that is consistent with the magnetic induction equation. Our new algorithms will be benchmarked against synthetic data to establish the accuracy of the technique and compared against the accuracy of previously developed optical flow techniques such as LCT, Inductive Local Correlation Tracking (ILCT), Minimum Energy Fit (MEF). Our new techniques will make full use of high-resolution, high-cadence vector magnetogram data and line-of-sight magnetograms for the dual purposes of scientific analysis and and to augment space-weather prediction through real-time monitoring of photospheric activity. The output of this program with be the new methods and the extensively documented performance characteristics of the algorithm. Furthermore, magnetograms will be analyzed and the estimated velocity fields and associated uncertainties will be provided to the solar physics community for the purpose of driving realistic MHD simulations. The prime measure of success for this work would be the widespread use of these ``tools'' for the determination of solar surface flows from observational data. Therefore, the library of tools developed under the program will be accessible to the solar physics community. This program addresses the goals of the ``Tools and Methods'' component of the Living with a Star (LWS) Targeted Research and Technology Program (TR & T). The goal of our program is to develop the tools and scientific understanding needed for the United States to effectively address those aspects of the Sun-Earth System that may affect life and society. The proposed work will provide the necessary tools to deliver significant new understanding of solar eruptions and resolve persistent controversies concerning the spatial scales and flow velocities.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Yuri Shprits/University of California Los Angelos
Title: Quantifying Losses and Sources of Relativistic Electrons Using Kalman Filtering
Abstract:

In this study we propose to create tools and develop methods which will enable critically need science advances (A. 21_1.2.1 LWS TR&T announcement) in the radiation belt research and may be applied in other fields. The created tools will optimally assimilate and portray data from different sources for LWS research and forecasting objectives (A. 21_1.2.1 LWS TR&T announcement). The developed software will be capable of globally reconstructing equatorial radiation belt fluxes with high time resolution for future use in analyzing results from the future LWS RBSP mission. We will use satellite data from CRRES, HEO, SAMPEX, Polar, LANL and GPS combined by means of Kalman filtering with a radial diffusion model. The results will provide an insight into the physics of the acceleration and loss mechanisms in the outer radiation zone (a key Objective 5.14 of the NASA Strategic Plan, Understanding the fundamental physical processes of space plasma physics) and can be also used to develop new empirical models (A. 21_1.2.1 LWS TR&T announcement) of the radiation belts. Our estimation of the accurate initial conditions may be used for advancing radiation belt nowcasting (NASA report TM-2002-211613 Section 3.2.2 of the LWS mission Definition Team). Using these tools we will be able to estimate the errors of the various detectors on the various satellites which will be used for the parameter estimation of the model. We will apply extended sequential Kalman filtering techniques to find

unknown parameters of the system and thus compensate for missing or misrepresented physics in the model. The data from different satellites will sequentially change the parameters of the system and drive them to their true values. This study will deliver tools and methods for understanding and quantifying the high energy electron radiation belt fluxes. The methodology developed in this study can be also used for advancing other areas of LWS research, where sparse and low resolution data can be combined with physics based model to globally reconstruct observations and to find the unknown physical parameters of the system. The proposed research is central for the LWS objectives as suggested in the NASA report TM-2002-211613 Section 3.1 of the LWS mission Definition Team: Data assimilation models combine measurements, empirical models, and mathematical optimization methods and first principles models to provide the most realistic possible picture of the present condition or updates and corrections to the propagation of conditions forward in time. In this way these models improve nowcasting and forecasting.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Mikhail Sitnov/University of Maryland
Title: Dynamical Data-based Modeling of the Magnetospheric Magnetic Field with Enhanced Spatial Resolution
Abstract:
This project will advance empirical models of the geomagnetic field, making it possible to systematically increase their spatial resolution and to take into account the variable solar wind driving on the timescales involved in storms and substorms. The existing empirical models are global in space, time, and in the amplitude of field variations, and they are fitted to observations using a limited set of custom-tailored basis functions representing each magnetospheric current system. They do not properly reproduce a wide difference in the response of the individual field sources to solar wind driving. Removing these limitations is the main goal of the proposed project. It will be achieved in three steps. First, we will explore the timescales of the response of the main magnetospheric field sources to solar wind density, speed, ram pressure and the interplanetary magnetic field variations. The response functions will be parameterized using simple loading-unloading equations with respect to the solar-wind input. Second, we will implement a spectral technique, in which the fields of individual current systems are expanded into a series of basis functions, taking into account geometrical constraints, imposed on a given current system via its specific boundary conditions. The number of those basis functions can be made sufficiently large, providing the desired flexibility to the model. Combined with a progressive extension of the spacecraft database, that will improve the spatial resolution, maximize the information derived from observations, and minimize the number of a priori assumptions on the structure of the magnetosphere. Third, we will explore the possibility to replace the global time and amplitude fitting with the local one, using the dynamical system approach and modern techniques of the local fitting of data in the phase space, based on the concepts of time delay embedding, nearest neighbors, and conditional probability. An important technical improvement will be the parallelization of the existing and newly developed codes, providing a much faster update of the model using supercomputers. The proposed study will be based on the largest available amount of spacecraft data, using interplanetary and magnetospheric observations and covering more than 50 major storms. The final product, high-resolution dynamical empirical models of the geomagnetic field will serve as a backbone for many applications aimed to quantify the particle entry and transport in the magnetosphere, being particularly useful and efficient for tracing energetic particles from the magnetopause to the ring current and radiation belt regions for different solar wind and geomagnetic activity conditions, including storm and substorm effects. Thus, the proposed project is directly relevant to the Focused Science Topic T3c of the LWS TR&T program.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Elsayed Talaat/The Johns Hopkins Universtiy Applied Physics Laboratory

Title: Sub-Auroral Polarization Streams Effects on the Ionosphere and Thermosphere

Abstract:

The coupling processes within the magnetosphere/ionosphere/thermosphere system are a key area of research in the Sun Earth Connections theme. One dramatic manifestation of this coupling is enhanced sub-auroral electric fields, labeled sub-auroral polarization streams (SAPS) or sub-auroral ion drifts (SAID) (Galperin et al., 1973; Spiro et al., 1978, respectively). These events are of great importance in determining the temporal evolution of the ring current and thermal plasma distribution in the magnetosphere, ionosphere and plasmasphere. In this proposal we will create a climatological picture of SAPS/SAID, including their conjugacy, frequency, and intensity. We will also investigate the mechanisms behind their formation and duration and the effect that SAPS/SAID have on ionospheric density and thermospheric composition through analysis of multi-satellite observations and simulations using the NCAR Thermosphere Ionosphere Electrodynamics General Circulation Model (TIE-GCM).

Living With a Star TR&T Program
NNH05ZDA001N

PI: Lawrence Townsend/University of Tennessee

Title: Advanced Forecasting Methodologies for Solar Particle Event Radiation Exposures

Abstract:

This proposal is a successor to our previously funded proposal, Advanced Warning Methodologies for Solar Particle Event Radiation Exposures (NAG5-12477). The previous work focused on the development of methods using Bayesian inference and artificial intelligence for reliably predicting proton flux, dose and dose rate versus time profiles for use in predicting ionizing dose effects in humans, electronics or other components due to solar energetic particle (SEP) event protons. That work was successful in that the methods developed were shown to be capable of providing reasonably accurate ¿nowcasts¿ of doses from SEP events that are independent of the magnitudes of the events. The methodology is also unaffected by shielding configurations since it depends only upon the magnitudes of the local dose values used as input and is independent of their sources. The work proposed herein would extend our current methodology in two areas: (1) improving numerical techniques to permit faster and more robust calculations and (2) making a connection between our work and ongoing work in the space physics community. The goal of these parallel efforts is to make faster and more reliable forecasts of flux, dose, and dose rate versus time profiles through the use of more efficient numerical methods and the connection to applicable solar observables. We also propose to deliver a prototype dose forecasting software package with an associated user and training manual at the completion of this investigation. This would be the first step in transferring a research product to a user. The proposed work supports the goals and objectives of the Sun Earth Connection (SEC) Living With a Star (LWS) program through the development of knowledge of advanced warning capabilities for SPE radiation exposures to human in space, thus linking to the goals of the NASA Vision for Space Exploration. Predicting the occurrence and magnitude of SEP events prior to coronal mass ejection (CME) and/or flare occurrence is presently beyond the space science community¿s capabilities. While our currently funded project has made significant progress towards providing a reliable warning system capable of accurately predicting particle fluxes and doses shortly after SPE particles begin to arrive, we see two urgent needs: (1) the investigation of more efficient numerical techniques and (2) the investigation of connections between our work and ongoing work in the space and solar physics communities. The proposed work involves investigations of solar energetic particle effects in human radiation exposures and therefore is directly relevant to human exploration missions in deep space including extended human expeditions to the lunar surface and Mars. The methods could also be used for missions in low-Earth orbit, such as the International Space Station. The methods are also applicable to radiation exposures of spacecraft electronics, for both human and robotic missions.

Living With a Star TR&T Program

NNH05ZDA001N

PI: Tycho von Rosenvinge/NASA/Goddard Space Flight Center
Title: Study of SEP Events and Shocks in the Inner Heliosphere
Abstract:
We propose a number of observational studies that will address goals of the LWS Focused Science Topic ¿Shock acceleration of solar energetic particles by interplanetary CMEs¿. Although a number of shock acceleration models of increasing sophistication exist, they must be driven by, and tested against, observations. Our studies will use an extensive database of energetic particle observations from current and previous missions that extends over more than three solar cycles. In particular, the Helios 1 and 2 spacecraft provide crucial information about SEP events and shocks within heliocentric distances of 0.3 ¿ 1 AU. One goal of the studies will be to characterize intensity-time profiles of SEP events as a function of radial distance and azimuth relative to the related solar event. We will also investigate the global properties of the related shocks using in-situ solar wind plasma and field data from multiple spacecraft, and determine the relationship between shock parameters and properties of the SEP events. In addition, the speeds of shocks moving out through the inner heliosphere will be investigated by tracking the frequency drifts of the radio emissions that they produce. A particular aim is to better characterize the speeds of CME-driven shocks near the Sun since, at present, various assumptions are made by modelers of this important parameter. We will also investigate the properties of the earliest-arriving particles in order to understand more fully the production of the highest energy particles that are seen early in such events, and the influence of factors such as magnetic connection to the solar event, solar wind structures, and interplanetary particle scattering. In the process, we will investigate whether or not all the particles in so-called ¿gradual events¿ are indeed accelerated at CME-driven shocks. These studies will build on previous work using more limited 1 AU observations in which we have determined the large-scale structure of interplanetary shocks and how they evolve as they propagate out from the Sun.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Angelos Vourlidas/Naval Research Laboratory
Title: Search for Shocks Ahead of LASCO CMEs
Abstract:
We propose a research plan designed to contribute to the first of the Focused Science targets identified in the LWS TR&T program: Shock acceleration of solar energetic particles by interplanetary Coronal Mass Ejections We will attack a fundamental component of this problem; namely, the formation and evolution of CME-induced shocks using a combination of observations, MHD models and analysis tools. Our goal is to provide a clear understanding of the shock structure in white light coronagraph images. Our objectives are: (1) to establish whether CME-driven shocks are detectable in white light coronagraph images, (2) to derive methods to reliably identify these shocks, and (3) to provide tools for extracting the physical parameters of the shock for inputs to particle acceleration models. We will also attempt to compile metrics and/or rules for the easy identification of the shocks for operational applications. Our analysis will be based on calibrated white light images from the SOHO/LASCO C2 and C3 coronagraphs. To achieve our objectives, we will use the high dynamic range and fidelity of calibrated LASCO images to search for faint emissions/fronts ahead of fast CMEs. We will then use two new tools, raytrace and magnetosonic speed maps, to identify and measure the physical parameters across the shocks. We will also use synthetic white light maps from recent 3D MHD models to guide us in the interpretation of the various white light features and to investigate the expected visibility/ morphology of the shock under varying viewing angles This work and its potential applications relate directly to the new vision of NASA as it applies to both human and robotic exploration. Knowledge of the shock conditions in the corona/heliosphere and in extension of the likelihood of SEP events will be crucial ¿extending human presence across the Solar System¿ (a National Objective) and in particular for successfully conducting Lunar and Martian manned expeditions (NASA Objectives). Our proposal relates directly to the NASA Objective of "exploring the Sun-Earth system to understand the Sun and its effects on Earth, the Solar System, and the space

environmental conditions that will be experienced by human explorers, and demonstrate technologies that can improve future operational Earth observation systems". Our work also contributes to increased understanding of CME and coronal physics through the better determination of density profiles in CMEs, shocks and the extended corona, and to better models of the CME phenomenon through the validation of such codes. In that sense, our work contributes to the objectives of the Solar and Heliospheric Physics program.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Stephen White/University of Maryland
Title: The Green Bank Solar Radio Burst Spectrometer: A Resource for LWS Studies
Abstract:
We propose to make available high quality dynamic spectra of solar radio bursts to the LWS community from the Green Bank Solar Radio Burst Spectrometer (GBSRBS), and to carry out science studies of the connection between radio bursts and space weather phenomena using these data. GBSRBS will operate from 14 to 1000 MHz in the radio-quiet zone around Green Bank, WVa, with 1 second time resolution and excellent spectral resolution. The site is particularly important for low frequency studies, close to the ionospheric cutoff and the upper limit of the WIND/WAVES and STEREO/SWAVES instruments, because of the very low interference environment allowing us to see phenomena undetectable from other sites. GBSRBS will greatly enhance studies of solar radio bursts and their connection to events that impact the Earth, including coronal mass ejections, flares and acceleration of solar energetic particles. GBSRBS's wide frequency range and extension down to 14 MHz is particularly valuable for providing a continuous connection between phenomena in the low corona and the phenomena seen by the radio detectors on the WIND and STEREO satellites. This proposal is for support of the data archive and software development to make the data freely available to the community, as well as science studies carried out with the data. This project fits into both the Tools and Individual investigation programs.

Living With a Star TR&T Program
NNH05ZDA001N

PI: Simon Wing/The Johns Hopkins University
Title: Plasma Sheet Ion Properties, Sources, and Transport for Different Solar Wind, Geomagnetic, and Solar Cycle Conditions
Abstract:
Overall Objectives: We have developed a technique for inferring plasma sheet ion density (n), temperature (T), and pressure (p) from ionospheric observations. Using this method and DMSP data, we were able to create 2D images of plasma sheet n, T, and p, which show that the plasma sheet is colder and denser during periods of northward IMF than southward IMF. This proposal outlines a study to (1) complement our remote sensing technique with in situ measurements; (2) construct 2D/3D plasma sheet n, T, and p profiles as functions of plasma sheet location, geomagnetic activity, solar wind conditions, and solar cycle; (3) investigate the roles of reconnection, Kelvin-Helmholtz instability, and kinetic Alfven waves in transporting magnetosheath particles to plasma sheet; (4) the causes of the dawn-dusk asymmetry in the plasma sheet flanks; (5) ion and electron heating; (6) electron dynamics; and (7) plasma sheet injection into the inner magnetosphere and radiation belt/ring current. Research Plan: To carry out our proposed study, we will use ionospheric and in situ observations as well as 2D simulations that include full ion and electron dynamics and non-MHD processes. We will construct 2D plasma sheet profiles of location, geomagnetic activity, solar wind conditions, and solar cycle using DMSP and in situ observations for almost two solar cycles. We will also link an inner magnetospheric model with plasma sheet profiles. We will pool NASA Geospace SR&T, NASA LWS TR&T, and non-NASA resources. A team member, Jay Johnson, has just received a Geospace SR&T grant to carry out electromagnetic simulations to investigate magnetosheath

particle transport across the magnetopause boundary. Another team member Mei-Ching Fok will link her radiation belt/ring current model with the proposed plasma sheet profiles. The proposed project can stand alone, but it will achieve greater goals if done in coordination with simulations. Rather than comparing observations with fortuitous published simulation/modeling results, we will actually be able to design joint observation-simulation studies. Relevance to NASA LWS TR&T Program: The proposed efforts directly address the topics of interest to the 2005 NASA LWS TR&T Focused Science Topic C (T3C) that solicits "investigations that predict and quantify: (1) the amount of solar wind plasma entering the magnetosphere as a function of location on the magnetopause; (2) the processes by which plasma is transported from the magnetopause into the magnetosphere to form the plasma sheet; and (3) the mechanisms by which plasma is injected into the inner magnetosphere for different solar wind, geomagnetic, and solar cycle conditions." [ROSES 2005 - A.21]. We will disseminate all of our research results at AGU sponsored meetings and journals as they become available. Moreover, we will attend Focused Science Topics team meetings where the PI and the Co-Is will present our results and participate in the discussions.