Living with a Star Targeted Research and Technology
Abstracts of selected proposals.
(NNH07ZDA001N-LWSTRT)

Below are the abstracts of proposals selected for funding for the Living with a Star Targeted Research and Technology program. Principal Investigator (PI) name, institution, and proposal title are also included. 161 proposals were received in response to this opportunity, and 50 were selected for funding.

William Abbett/ University of California, Berkeley
Understanding the Dynamic Connections Between the Photosphere and Corona

Global models of the Sun's corona are a critically important component of current and future coupled models of the Sun-Earth system used to study and forecast ``space weather." The magnetic field in the corona determines its overall structure and is the source of energy for coronal heating, the solar wind, and other dynamic phenomena such as solar flares and coronal mass ejections. Thus, it is crucial that we understand how to properly integrate measurements of the solar magnetic field into numerical models of the corona.

The only routinely available magnetic field measurements, however, are made not in the corona, but in the photosphere below it, in the form of line-of-sight and vector magnetograms. While the distance separating the low corona and photosphere is a tiny fraction of the Sun's radius, physical conditions change so drastically in these layers that it is not clear how to best incorporate these measurements into numerical models. We will address this challenge by pursuing a two-pronged effort: we will model the emergence and evolution of active region magnetic fields using a numerical model capable of treating the photosphere-to-corona system within a single computational volume; and we will use this first-principles study to validate and improve techniques of incorporating photospheric vector magnetograms into models of the solar atmosphere and corona.

Graham Barnes/NorthWest Research Associates, Inc.
A Comparison of Flare Forecasting Methods

Recently, the number of published approaches to flare forecasting has proliferated, with widely varying claims about how well each works. Because of the different analysis techniques and data sets, it is essentially impossible to compare the results from the literature. We propose to host two workshops in which researchers will be invited to compute their own forecasting parameters for common data sets. The performance of the parameters will be judged in a consistent fashion, with a focus on all-clear forecasts. In the first workshop, we will use existing data bases of photospheric magnetic field observations, one from the MDI instrument on SOHO, and one from the Imaging Vector Magnetograph. These data sets are complimentary, and will allow us to settle on the best analysis techniques for producing forecasts. In the second workshop, the emphasis will shift to analysis of time series, using data from the HMI instrument on SDO, if sufficient data are available, or using MDI data to investigate the evolution of parameters, in preparation for HMI data. Where needed, we will develop analysis code to support the workshops, including more robust approaches to producing all-clear forecasts and ways to incorporate the evolution of the magnetic field into the forecasts. Standardized datasets and merit criteria will be supplied to the community for testing forecasting approaches developed in the future. The ultimate goal is to determine the best empirical flare forecasting method for use with the data anticipated from the HMI instrument on SDO.

John Bieber/University of Delaware
IMF Prediction with Cosmic Rays

Neutron monitors and muon detectors are ground-based instruments that record the byproducts of collisions between high-energy cosmic rays and molecules in Earth's atmosphere. At energies up to ~100 GeV, primary Galactic cosmic rays experience significant modulation in response to solar wind disturbances. Cosmic rays impacting Earth have passed through and interacted with magnetic fields in a large volume surrounding Earth, and they potentially contain signatures that could be used to predict the magnetic field in various directions. Specifically, the gyroradius of a typical neutron monitor primary cosmic ray is ~0.04 AU and that of a muon detector primary is ~0.2 AU. These correspond to solar wind transit times of ~4 and ~20 hours, which is significantly longer than the ~1 hour warning provided by a sentinel making direct measurements at L1.

This project proposes two research tasks aimed at developing and validating a tool to make IMF predictions based on realtime neutron monitor and muon detector data:
-- We will employ quasilinear theory to develop a physics-based method for interpreting cosmic ray fluctuations in terms of properties of the magnetic field integrated along the reverse path of the particle.
-- We will develop predictive digital filters based upon neutron monitor and muon detector data. Past data will be used to optimize the filters, and results will be benchmarked against an autoregressive filter based purely on magnetic field observations.

This project directly addresses the LWS Focused Science Topic (e): "Prediction of the Interplanetary Magnetic Field Vector Bz at L1." The project also directly addresses NASA's strategic goals, in particular Strategic Sub-goal 3B: "Understand the Sun and its effects on Earth and the solar system" and Science Outcome 3B.2: "Understand how human society, technological systems, and the habitability of planets are affected by solar variability and planetary magnetic fields."

John Bieber/University of Delaware
Extreme Solar Particle Event Modeling

Neutron monitors are ground-based instruments that record the by-products of collisions between cosmic rays and molecules in Earth's atmosphere. At a rate of roughly 15 events per solar cycle, the Sun emits cosmic rays with sufficient energy (GeV range) and intensity to increase radiation levels on Earth's surface, resulting in a "Ground Level Enhancement" (GLE). A coordinated array of neutron monitors remains our best tool for studying and specifying these most extreme of solar particle events.

There are several reasons why modeling of GeV cosmic rays is relevant to NASA LWS:
-- The GeV particles provide a particularly clear view of the particle injection profile at the Sun and of transport processes in interplanetary space, by virtue of their very high speed, comparatively large scattering mean free path, and the precise 3D directional information from the neutron monitor network, which is crucial for disentangling the injection profile from transport effects.
-- For radiation hazard to pilots and air crews, GeV particles are the only ones that matter, because less energetic particles do not raise radiation levels on Earth's surface or at aircraft altitudes.
-- While it is rightly asserted that particles in the tens of MeV energy range pose the most serious radiation hazard to unprepared astronauts, the astronauts would likely take shelter behind radiation shields during major solar events. However, it is unlikely the shields will be adequate to stop particles in the GeV range, and therefore an understanding of these particles is still of significance for mission planning.

We propose two tasks of relevance to the LWS Focused Science Topic "Extreme Space Weather Events in the Solar System."
-- We will capitalize on our detailed analysis of past GLEs (e.g., Bastille event, Easter event, January 20, 2005 event), an analysis that has already forced us to include interplanetary magnetic field geometry beyond the orbit of Earth. We are uniquely positioned to extend this modeling to the orbits of Mars and Jupiter.
-- We will use neutron monitor observations to model new events of Solar Cycle 24 as they occur, including expected effects at the orbits of Mars and Jupiter. (Based on historic averages, 3-4 GLE should occur during the term of this proposal, but if the Sun should not cooperate, we will instead extend our modeling to mid-size GLE of Cycle 23 that we have not previously considered.)

This project directly addresses NASA's strategic goals, in particular Strategic Sub-goal 3B: "Understand the Sun and its effects on Earth and the solar system" and Research Objective 3B.1: "Understand the fundamental physical processes of the space environment from the Sun to Earth, to other planets, and beyond to the interstellar medium."

Yue Chen/Los Alamos National Laboratory
An Investigation of the Electron Outer Radiation Belt's Boundaries

The population of relativistic electrons (E>0.511MeV) in the Earth's outer radiation belt creates a hazardous environment for space missions. As stated by the Focused science topics for Strategic Goal 3, a combined model of relativistic electrons requires "a global understanding of the influence of" critical physics processes controlling relativistic electron dynamics, and "this includes the transition region in the near Earth (6-12Re)".

Here we propose to investigate the electron loss by precipitation through the low-altitude boundary and the loss by magnetopause shadowing through the high-altitude boundary, aiming to determine the relative roles of these permanent loss mechanisms in controlling the dynamics of the outer radiation belt. We also propose to specify the conditions in the transition region and to establish their connection to the trapped relativistic electron population.

This research work involves comparison of simultaneous observations from multi-points. First, based on low-altitude observations (SAMPEX and POES), we will develop a statistical model of precipitation as functions of electron energy, longitude, latitude/L-shell, local time, seasons, storm phases and solar-cycle phases. This model, especially the local time distribution and energy dependence, will reveal dominant wave-particle interaction(s) causing precipitation into the atmosphere. In addition, by comparing the decay rate of trapped electrons observed near the magnetic equator (LANL GEO, GPS and Polar) to precipitation fluxes in the loss cone, we can quantitatively determine the role of precipitation on the loss of relativistic electrons for the radiation belt with L>4. Second, the loss of electrons by magnetopause shadowing/outward diffusion will be evaluated by comparing equatorial observations at different L-shells (GPS, LANL GEO and SCATHA). Finally, we will obtain the specification of the transition region by observations crossing this area (Polar and SCATHA), and then study the effects of this region on variations of trapped energetic electrons during disturbed times (GPS, LANL GEO, Polar and SCATHA).

This work addresses the following specific scientific questions:
1. At the low-altitude boundary: Is the precipitation distribution of relativistic electrons, especially the local time and energy dependences, consistent with observed wave distributions? What are the roles of pitch-angle scattering mechanisms, and how do they evolve with geomagnetic and magnetospheric conditions?
2. At the high-altitude boundary: Can and when does magnetopause shadowing/outward diffusion dominate over precipitation in the loss of relativistic electrons?
3. In the transition region: What is the electron radial profile across the boundary? Can we demonstrate the connection between the "seed" electron population in this region and the enhancement of trapped relativistic electrons?

Understanding and specifying loss through boundaries and the transition region in the radiation belts clearly fits NASA’s strategic goal 3B and research objectives that are to "understand the fundamental physical processes of the space environment..." and "develop the capability to predict the extreme and dynamic conditions in space..." due to the adverse effects of energetic electrons on satellites and humans in near-Earth space.

Geoffrey Crowley/ Atmospheric & Space Technology Research Associates
Hydrogen in The Thermosphere and Exosphere

Central Objectives: In this proposal we focus our attention on the neutral hydrogen in the thermosphere and exosphere, addressing the following scientific questions:

1) What is the hydrogen distribution in the exosphere, and how does it affect the thermosphere during magnetically quiet times?
2) What are the changes in the quiet-time hydrogen distribution in the exosphere and thermosphere as a function of season, and solar cycle?
3) How deep into the thermosphere do the effects of the exosphere penetrate?

Methodology: The methodology to be employed is to introduce new physics into an existing general circulation model - the Thermosphere Ionosphere Mesosphere Electrodynamics General Circulation Model (TIMEGCM) - to describe hydrogen transport in the exosphere. The TIMEGCM currently has its upper boundary in the 500 km region of the thermosphere. The proposed work will extend the specification of hydrogen out to about four earth radii. This will be accomplished by the development of both a ballistic transport algorithm for light atom non-local transport within TIME-GCM, and a suitable algorithm to explicitly describe the exospheric satellite component. In addition, simple light ion outflow and an empirical plasmasphere will be included as first steps in development of the new model. The effect of the new exospheric hydrogen module on the TIMEGCM-predicted thermospheric quiet-time hydrogen distribution will be validated for various solar-cycle and seasonal conditions using measurements from NASA's AE satellite, and the MSIS empirical model.

Perceived Significance for NASA: The proposed work is relevant to two of the LWS Strategic Goals specified in the AO: (1) the understanding and modeling required for effective forecasting/specification of magnetospheric radiation and plasma environments; (2) understanding and predictive models of upper atmospheric and ionospheric responses to changes in solar electromagnetic radiation and to coupling above and below. It will also have relevance to the NASA Mars program, because the exospheric model developed here can also be appled to models of the Mars atmosphere to predict the Martian thermosphere/ionosphere/exosphere, and used to interpret data from Mars. The resulting new Hydrogen module for the TIMEGCM will be available for later use as part of various coupled plasmasphere/thermosphere/ionosphere models.

Bart De Pontieu/Lockheed Martin Solar & Astrophysics Lab
Observations and Modeling of Alfven Waves in the low Atmosphere

Alfven waves have long been invoked as a possible mechanism for the heating of the solar corona and the acceleration of the solar wind. Using the unprecedented spatial (0.2arcsec) and temporal resolution (5s) of Hinode/SOT and 3D MHD simulations, we have recently found the first unambiguous evidence in the lower solar atmosphere of Alfven waves that carry an energy flux large enough to accelerate the solar wind. These waves have longer periods (100-500s) than the high-frequency kHz waves previously assumed in many models and observations of the solar wind. Our results directly support recent models based on low-frequency waves.

We propose to use an integrated approach of Hinode/SOT-EIS, SUMER and TRACE/AIA observations, Monte Carlo simulations and advanced radiative 3D MHD simulations to determine the source, propagation, and impact of these Alfven waves. We will directly constrain input parameters of solar wind models such as the Alfven wave amplitudes, periods, and energy flux (for quiet Sun, coronal hole and active regions) by using imaging and Dopplergram observations from photosphere through corona, as well as advanced radiative 3D MHD models that include a region from the convection zone to the corona.

Our results will lead to a much improved understanding of what drives the quiescent solar wind, an important step in improving predictions of CME propagation and impact on the Earth's space environment. Modellers will be able to use our results to pin down crucial details of wind acceleration and wave damping mechanisms. Our work will also help reveal what dominates the energy and momentum balances of the chromosphere, which are poorly understood. This will drastically improve our understanding of how the chromosphere impacts the magnetic field, which is crucial if we want to use SDO/HMI data to understand the coronal/heliospheric field.

Na Deng/California State University-Northridge
Exploring the Magnetic Connection and Associated Dynamics from the Photosphere through Chromosphere to the Corona

We have made great efforts and accumulated experience in exploring the magnetic structure and dynamics in the chromosphere in the past several years. By comparing the Stokes profiles between chromospheric and photospheric spectral lines and with Stokes asymmetry analysis, we have found significant differences between the two layers for various regions. These differences hint at dramatic changes of the field inclination, strength, and plasma flows from the photosphere to the chromosphere. We are collaborating with researchers in Max Planck Institute for Solar System Research (MPS, Germany), Big Bear Solar Observatory (BBSO), and University of California Riverside for chromospheric Stokes inversions, more chromospheric observations, and non-force free field extrapolations, respectively. These prepare us for exploiting the unprecedented imaging chromospheric Stokes data that can be provided by the newly launched Hinode (Solar-B) mission. We propose to make further efforts to study the accurate magnetic field and plasma flows in the chromosphere, as well as their connection with the photosphere and their role in the coronal models, with Hinode Spectro-Polarimeter (SP) and Narrowband Filter Imager (NFI) observations and our well established experience and techniques. We arrange our proposed project in the following three connected tactic steps:

(1) We will perform a detailed Stokes asymmetry analysis on the existing chromospheric spectropolarimetric data (Mg I b 517.27 nm line, the chromospheric line also used in NFI of Hinode) that we observed with ASP. We will use these Stokes profiles to test the inversion code for the chromosphere that has been developed at MPS and will be used on a routinely basis starting from 2008.

(2) We will make further chromospheric observations using Na D line with BBSO's Visible-light Imaging Magnetograph (VIM), a tunable narrowband filter-based magnetograph, which in principle is similar to NFI of Hinode. Na D line is also used in

Hinode NFI for detecting very weak fields in the chromosphere. We will apply the chromospheric Stokes inversion technique described in step (1) to BBSO's Na D data to test its feasibility to filter-based Stokes data.

(3) Finally, we will apply the matured spectral analysis tools and chromospheric Stokes inversion technique to Hinode SP and NFI data. We will use the accurately inverted magnetic and flow field both in the photosphere and chromosphere as boundary conditions to simulate the coronal field configuration with the non-force free field extrapolations, thereby to test the coronal models.

The proposed research clearly match the NASA's LWS TRT focused science topic for Strategic Goal 1 (Solar storms): Exploring the magnetic connection between the photosphere and low corona. Our observational results and developed techniques will significantly complement and optimize Hinode data. The expected products will promote real progress in the predictive qualities of the coronal and heliospheric models.

Marc DeRosa/Lockheed Martin ATC
Evolving Nonlinear Force-Free Magnetic Models of the Solar Corona

Despite considerable progress in observing the structure and evolution of the solar corona, the root causes of many phenomena remain elusive. The dynamics associated with coronal heating processes, particle acceleration mechanisms, and instabilities that lead to eruptive events such as flares and coronal mass ejections are all not well understood. Lack of progress in advancing our knowledge is a result of our inability to accurately map out the three-dimensional geometry of the coronal magnetic field and to observe its evolution in time. Because the three-dimensional coronal magnetic field does not easily lend itself to direct observation, much recent effort has been put toward modeling the coronal magnetic field using photospheric magnetograms.

We are proposing here to construct an evolving nonlinear force-free model of the three-dimensional coronal magnetic field driven by time series of photospheric magnetogram data. Evolving models represent a complementary approach to standard coronal field modeling, in which extrapolations are performed from a single magnetogram. Instead, our scheme will make use of high-cadence time series of vector magnetogram data derived from instruments such as the Solar Optical Telescope (SOT) on Hinode and the upcoming Helioseismic and Magnetic Imager (HMI) on the Solar Dynamics Observatory (SDO). Such evolving models of the coronal magnetic field enable the dynamics of the solar corona above active regions to be investigated in greater detail, allowing us to investigate questions involving the geometry and topology of the coronal magnetic field, the effects of photospheric flux emergence on this geometry, and the buildup and release of magnetic energy and helicity over time.

Mausumi Dikpati/University Corporation for Atmospheric Research
Development Of "Sequential" Data-assimilation In A Flux-transport Dynamo Model For Solar Cycle Prediction

Data-assimilation schemes have been developed in atmospheric weather and climate simulation models for 50 years; recently are they starting to be used in solar cycle models in their most simplified form (Dikpati, de Toma and Gilman 2006, GRL; Cameron and Schuessler, 2007, ApJ). Such models have shown skill in predicting solar cycle amplitude. Cycle onset has been simulated separately using time-varying meridional circulation. The obvious next step is to build data-assimilation models for predicting cycle amplitude and timing simultaneously. However two major difficulties are, (i) equatorward return meridional circulation is unknown, (ii) time-varying surface flow measurements have not been available for years prior to 1996. With recent progress of Mount Wilson Observatory's flow-data analysis by Ulrich and colleagues, we can now go back to 1985. We propose to first test the sensitivity of a flux-transport dynamo model to various meridional flow profiles, to determine which profiles are best at reproducing the solar cycle features. We will also estimate the model's memory of past magnetic fields for such flows, along with selected magnetic diffusivity profiles. We plan to build sequential and variational assimilation models by (i) solving mean and perturbation equations for the Sun's large-scale flux-transport dynamo by incorporating time-varying meridional flow since 1985; (ii)investigating transport of assimilated poloidal magnetic fields from surface to tachocline, where they are sheared by differential rotation to create spot-producing fields; (iii) updating model after a finite time-interval, by comparing model-output with observations; (iv) forecasting simultaneously cycle-amplitude, duration and shape; (v) forecasting cycles 24 and 25. Given SOHO and SDO, this is a particularly appropriate time to develop data-assimilation schemes to input solar velocities and magnetic fields into solar simulation models.

Thejappa Golla/University of Maryland
Remote Sensing of CMEs and Flare Electrons Using Multi-Spacecraft Observations and the Effects of of Refraction and Scattering

The goal of this proposal is (1) to investigate the effects of refraction and scattering on the radio emissions in the inner heliosphere, (2) to provide a method to incorporate these propagation related effects in the algorithms used to track the CMEs and electron beams by the STEREO, Ulysses and Wind spacecraft, and (3) to track some of the major type II and type III events. For example, a key goal of the STEREO mission is to remotely track the CME-driven shocks and flare accelerated electrons from their genesis in the low corona to their interaction with the terrestrial magnetosphere using the radio measurements. This scientific goal is based on two ideal expectations: (1) the 2 rays from the 2 spacecraft to the source intersect, which is necessary for successful triangulation, and (2) there is no anomalous delay in the burst arrival times at the two spacecraft. However, many studies have shown that due to refraction and scattering, the intersection of the rays from the 2 spacecraft to the source sometimes does not occur, and when it does occur, may be misleading. Furthermore, when the bursts are detected at the two spacecraft, the time delays may be abnormally large. The proposed study can provide the needed remedy to overcome these difficulties and make this science objective of the STEREO mission successful. This study will also provide constraints on the emission mechanisms, as well as on electron density models. This study fits into NASA Solar and Heliospheric Physics program elements "Theory and Modeling," as well as "Data Analysis."

Natchimuthuk Gopalswamy/NASA Goddard Space Flight Center
Coronal Mass Ejection Data Products for LWS Science

The primary objectives of this proposal are: (1) To develop, maintain and distribute value-added data products on coronal mass ejections (CMEs) for the use of the LWS science community, and (2) To use these data products to study the variability of CME rate to characterize their consequences in terms particle radiation hazard and plasma impact hazard, collectively known as geoeffectiveness. This effort has an important element of enabling science activity in the Living with a Star community to help achieve the objectives of the LWS program. The scientific objectives of the proposal will be achieved through analysis of the existing and future data from NASA missions and accumulating the data products into a CME catalog, which is currently the premier data base, serving thousands of heliophysicists worldwide. The catalog helps study every phase of solar eruptions from the Sun, ranging from the origin at the Sun, to the bumpy interplanetary propagation, to impacting planets (especially Earth where we live). A complete, authentic and standardized source of information on solar disturbances is essential for theoretical efforts, model development, and the analysis and interpretation of past and present data so that LWS science can be advanced as a community effort. The proposed work is directly relevant to the Living With a Star Targeted Research and technology program because the data products are essential for testing models that are being developed under this program. The proposed tasks will involve graduate students, who might eventually become part of the LWS science community.

Stephen Guetersloh/NASA Johnson Space Center
A Proposal to Host an All Clear Forecasting Workshop

Central to the objectives of the LWS program and NASA's Exploration Initiative are the hazards that explosive events on the sun pose to the safety of humans and technology both on the ground and in space. On the ground, critical electrical grid component damage, voltage control problems, protective system mis-operations and GPS outages can occur due to the impacts of geomagnetic disturbances. For NASA, space weather monitoring starts days before launch and continues throughout the mission. Prediction of a very low probability of significant solar activity, an 'all clear' forecast, will help mission planners determine periods of time when extra-vehicular activity (EVA) may be conducted with low risk of exposure to solar energetic particle events or energetic storm particles. 'All clear' forecasts become critical for protecting future expeditions into interplanetary space as crews will be at an increased risk of exposure compared to the current short duration low-earth orbit (LEO) missions where the Earth's magnetic field provides significant protection. The ability to predict intervals with a low likelihood of solar activity is of paramount importance to ensure that operations continue safely without disruption. Current scientific efforts are underway to explain the processes of the sun and some of the models being developed have the potential to benefit both government and civilian operations. We therefore propose to host a workshop focused on transitioning focused research models into operational tools for all clear forecasting.

Shadia Habbal/ University of Hawaii at Manoa
Eclipse observations of heavy ions, neutrals and dust grains in the solar corona

Coronal observations, spanning a field of view of approximately 4 degrees, are proposed for the total solar eclipses of 1 August 2008, 22 July 2009, and 11 July 2010. These eclipses coincide with three almost equally spaced periods of time in the rising phase of the new solar activity cycle. The goals are: (1) to map the ion abundance, electron temperature, and direction of the coronal magnetic field, (2) to explore the presence and distribution of neutral hydrogen and helium in the corona, and (3) to investigate the properties of dust grains in the near Sun environment, with complementary laboratory experiments. Polarimetric imaging in Fe X 637.4, Fe XI 789.2, Fe XIII 1074.7 and Fe XIV 530.3 nm, in S IX 1252.4 and Si X 1430.5 nm, in H alpha 656.3 nm, in He I 587.6 and He I 1083 nm, will be combined with spectroscopy in the visible and near infrared with polarization to target the properties of different ionization states of Fe, one from Si and S, and neutral hydrogen and helium. They will yield for the first time the locations in the corona where the transition from a collisional to a collisionless plasma occurs, and where the coupling between the different species decreases rapidly. This physics-based Independent Investigation for NASA's LWS TR&T program will explore the interconnected properties of coronal magnetic fields, heavy ions, neutrals, and dust grains in the corona. It will thus fill some of the deficiencies in the current understanding of the drivers of the solar wind. The complement of proposed instruments and observations will also serve as a test for an instrument suite for future space-based observations to explore this critical region of the solar wind flow that continuously shapes and controls Earth's magnetic environment.

Bradley Hindman/University of Colorado
Helioseismic Tools that Incorporate Corrections Arising from Magnetic Active Regions

One of the primary goals of the Helioseismic and Magnetic Imager (HMI) onboard the Solar Dynamics Observatory (SDO) is the study of magnetic active regions using local helioseismic techniques. We know from the pioneering work of Braun (1995) and Braun, Duvall & LaBonte (1988) that active regions and sunspots are insatiable absorbers of acoustic waves, absorbing as much as 50% of the incoming wave energy. Subsequent work has concentrated on understanding the physical mechanism responsible for this absorption (Bogdan & Cally 1995; Crouch & Cally 2005). Conversely, inadequate attention has been paid to the effects that such absorption has on other helioseismic measurements, such as the determination of flows in the immediate vicinity of active regions. Such effects are likely to be rather important since the absorption is strong and is an increasing function of wave frequency. Therefore, even outside of the region of strong field, the acoustic shadow cast by the active region will alter the acoustic line profile for waves that have passed through the activity. This anisotropic absorption could be interpreted as a flow by most local helioseismic techniques.

Here we propose (1) to directly measure the changes induced in p-mode line profiles by active regions and sunspots, and (2) to develop procedures that incorporate such magnetic modifications in flow and sound-speed determinations using the local helioseismic techniques of ring analysis and time-distance tomography. These new helioseismic tools will be implemented into the HMI data-analysis pipelines, allowing robust measurement of flows and circulations that form around active regions. With such reliable procedures we will be able to assess the importance that flows may have in the evolution and stability of active regions as they age.

Charles Jackman/NASA Goddard Space Flight Center
Long-term Atmospheric Effects of Solar Proton Events and their Contribution to the Polar Solar Cycle Variations

This investigation will quantify the long-term (months to years) atmospheric impact of solar proton events (SPEs) using the Whole Atmosphere Community Climate Model (WACCM). The model domain extends from the ground to 140 km and includes the chemistry and physics of the troposphere, stratosphere, mesosphere, and lower thermosphere. In our past work we created a publicly available daily average ion pair production rates (http://strat-www.met.fu-berlin.de/~matthes/sparc/inputdata.html), computed from IMP and GOES proton flux data, which we used in some studies with SPEs in WACCM. This previous work with WACCM focused on the short- and medium-term (days to weeks) SPE influences and has shown reasonable agreement between WACCM predictions and satellite instrument measurements of polar middle atmospheric NOx (NO+NO2) increases and ozone decreases due to the four largest SPEs in the past 45 years. This satisfactory agreement provides the motivation for studying the longer-term SPE influences.

The long-term downward transport of the SPE perturbation to the lower stratosphere is an important component of our research and we will use WACCM in its full general circulation model mode to study ozone and dynamical changes. We will also compare the polar atmospheric effects of SPEs to other solar cycle-dependent particle precipitation phenomena including auroral electrons; medium and higher energy electrons; and galactic cosmic rays. We will also study stratospheric NOy (N, NO, NO2, NO3, N2O5, HNO3, HO2NO2, ClONO2, BrONO2) changes using WACCM's "specified dynamics" mode, which is currently being tested. This mode uses reanalysis winds in the troposphere and stratosphere from the European Center for Medium-range Weather Forecasting (ECMWF) or the Goddard Earth Observing System (GEOS-5). By reducing the ambiguity associated with interannual dynamical variability, simulations carried out with specified dynamics allow detailed comparisons against observations of the atmospheric effects of SPEs and other charged particle precipitation in specific years.

The proposed research is relevant to the NASA Strategic Sub-goal 3B: "Understand the Sun and its effects on Earth and the solar system" discussed in Table 1 of the ROSES-

2007 NRA. In particular, we will address the NASA Science Question: "How do planetary systems respond?" and the NASA Research Objective: "3B.1 Understand the fundamental physical processes of the space environment from the Sun to Earth, to other planets, and beyond to the interstellar medium." We will be focusing on the long-term impact of solar proton events on the Earth's atmosphere and we will quantify the importance of SPEs relative to other solar cycle-dependent particle precipitation phenomena. We will also test our understanding of the impact of SPEs and other charged particle precipitation processes on atmospheric composition by comparing WACCM simulations against available satellite observations.

Jorg-Micha Jahn/Southwest Research Institute
Stepping Stones Toward CME Prediction: Characterizing the IMF at L1.

The heliospheric community is about to benefit from a significant increase in both the types and the amounts of solar observations. As a result, NASA in the 2007 LWS TR&T AO challenges the research community to work towards the long-term (12--24 hours) prediction of the IMF inside CME events prior to their passing of the L1 point. Particular focus is given to the prediction of IMF B_z, as B_z is (usually) a main driver for storm strength and allows to predict storm duration reasonably well.

In order to make progress towards predicting the IMF B-field vector, we propose a project focused on the characterization of the solar wind IMF at the L1 point. We propose to pursue the following objectives:
(1) Develop Self-Organizing Maps that can characterize the solar wind IMF at L1. A Self-Organizing Map (SOM) is a neural network algorithm that excels in pattern recognition as well as classification and clustering of complex, high-dimensional input data. SOMs are also used in time series prediction.
(2) Discover patterns in the temporal development of the solar wind IMF at relevant time scales. Temporal developments at the Sun will have to be related to temporal developments at L1 for reliable long-term forecasts. We propose to use a modification of SOM to uncover patterns in the time developments of the IMF inside CMEs.
(3) Relate L1 observations to and expand them with modeling results and solar remote observations in the focus topic working group. We plan to collaborate with other teams to interconnect our IMF investigation with remote solar observations and modeling efforts within the focus team working group, leading the way to uncover pattern correlations between developments at the source (during CME creation) and in the upstream solar wind at L1 once the CME passes.

Michael Keskinen/Naval Research Laboratory
Towards a Predictive Model for the Day-To-Day Variability of Equatorial Ionospheric Spread-F Bubbles

An outstanding problem in ionospheric-thermospheric physics, which has a major impact on human technology, is the day-to-day variability of equatorial ionospheric spread-F bubbles. The objective of the proposed research is the development of a predictive model for the day-to-day variability of equatorial spread-F bubble structures. The approach will be to use our recently developed 3D time-dependent first-principles nonlinear plasma fluid simulation model in combination with different seeding mechanisms. The effects of different seeding mechanisms, both separately and in combination, will be studied and assessed. The proposed research is significant in that it will lead to a much improved understanding of the mechanism(s) for the triggering and subsequent growth of equatorial ionospheric spread-F bubbles and a predictive model for the day-to-day variability of these bubble structures.

Hyosub Kil/Johns Hopkins University Applied Physics Laboratory
A tool forecasting equatorial plasma bubbles

The equatorial plasma bubbles (EPBs) cause the most severe radio scintillation in the equatorial region at night. Its forecast is urgently needed to the users of satellite communication and navigation systems. Despite the significant progress in modeling and observational techniques in the last 30 years, the variability of the EPB activity is not yet fully understood. Not knowing the precursor of the EPB, EPB forecasting is still a challenging goal to achieve in the near future. The purpose of the proposed study is to support the on-going EPB and scintillation forecasting efforts by providing the database for the EPB properties and developing a forecasting tool. The nighttime FUV observations of the F-region from the TIMED/GUVI provide the global EPB images that show large variability in their depletion depth, longitudinal width, north-south elongation, tilt, and occurrence pattern. Retrieval of the EPB images from the GUVI data will provide a unique data source for the EPB properties that can be used for the study of the EPB distribution, seed perturbation, growth condition, and its forecast. A few techniques have been developed to retrieve the EPB images from the GUVI data but the EPB database has not been created. We propose to apply an image processing technique to retrieve the EPB images and produce the EPB database by processing the GUVI data during 2002-2004. We will also process the ROCSAT-1 data during 1999-2004 to retrieve the EPB characteristics. An EPB forecasting tool will be developed using the EPB database from the GUVI and ROCSAT-1. The EPBs often occur superimposed on large-scale structure that ranges a few to several tens of degrees in longitudes. This phenomenon occurs repeatedly and in all longitude regions. There may be coherence in the occurrence of EPBs. Our forecasting tool will exploit the possible coherent occurrence of EPBs.

Jozsef Kota/University of Arizona
Physical Models of Cosmic Ray Response to Solar Inputs and their Effects on Cosmogenic Nuclei

Cosmogenic nuclei, such as C-14 and B-10, archived in the environment, offer unique information on solar activity in the past when direct observations of the Sun were not recorded. Deciphering the data record requires a fundamental understanding of the various physical processes involved in producing the record and how these processes are related to the state of the Sun and hence to Earth's climate. The amount of cosmogenic isotopes deposited in ice cores or tree rings is determined by a number of complex

processes: their creation depends on the cosmic rays flux at Earth, and on the geomagnetic field, while their deposition depends on atmospheric conditions.
We focus on a subset of this complex problem. First, we investigate how interstellar cosmic ray flux is attenuated in the heliosphere in response of solar activity. We propose comprehensive theoretical studies and numerical simulation work to improve our understanding of the physical relation between cosmic ray modulation and processes on the Sun. We aim to identify the major agents of solar input that drive cosmic ray modulation. We have a number of state-of-the-art 2-D and 3-D numerical codes of cosmic ray transport in the heliosphere. We shall improve our existing codes and develop new ones. The effects of the large scale organized magnetic field, the open magnetic flux, the strength of the magnetic field, as well as the effects of transient Global Merged Interaction Regions will be investigated and be related to processes on the Sun.
Second, we also propose to utilize new updated nuclear cross-section data for calculating the production rate of cosmogenic nuclei and test our results on available observational record in the past 70 years.
The proposed research would improve our ability to decipher cosmogenic records and understand their implication on the behavior of the Sun in the past.

Mukul Kundu/University of Maryland
A Study of Space Environment and CMEs Using Radio Burst Imaging and IPS Measurements

The main objective of our `solar-interplanetary' studies is to make a detailed study of solar events on the surface of the Sun, to understand their evolution in the inner heliosphere, and, to investigate their effects at the near-Earth environment. The most dramatic events on the Sun, in so far as intense magnetic storms at the Earth are concerned, are solar flares and coronal mass ejections (CMEs). A flare-CME event may cause a variety of radio burst activities and radio measurements of a CME in the near-Sun region can provide a valuable probe to infer the magnetic field configuration of the CME-generating solar region. In the space between the solar surface and the Earth, the interplanetary scintillation (IPS)technique can provide important information on the size, speed, and density turbulence associated with propagating disturbances caused by CMEs. In this proposal, we plan to study specific cases of CME formation and initiation and their propagation in the interplanetary space. We shall address the following issues:

1)The magnetic configuration of the source region of CMEs;
2)The characteristic properties,if any,of these regions to forecast the occurrence of CMEs or release of energy;
3)The finger print of the CME origin carried to the Earth, including its effect at the Earth; and
4) The relation between the initial energy of a CME and its propagation toward the Earth or elsewhere through the ambient solar wind.

We address these questions with event studies that use radio,EUV,X-ray imaging,LASCO and IPS data,WIND/WAVES spectra.

The intellectual merit of this study is in understanding the initiation of CMEs. The broader impact of this study is that the information on the evolution of size and speed of CME generated disturbances will also be useful in understanding the prediction of CMEs' arrival at the near-Earth space.

Marc Lessard/University of New Hampshire
Thermal upwelling of neutral particles at high latitudes

Recent results from the CHAMP satellite show the persistence of neutral gas density enhancements at 400+ km in the cusp region. These observations were made using the ultra-sensitive accelerometer on CHAMP and, by comparison with CHAMP magnetic field data, were determined to be associated with strong field-aligned currents in the northern hemisphere cusp region. Unlike the situation at lower latitudes, attempts to understand density enhancements in this region in terms of Joule heating alone have not been successful; competing theories have since been put forth that attribute the upwelling to electrodynamic processes in the cusp, such as those related to ion outflow, etc. The goal of this project is to determine the extent these competing processes contribute. This will be accomplished with an effort that combines data analysis, numerical results of large-scale Joule heating and numerical results of electrodynamic processes. The approach will be to examine data from the FAST satellite during several of its conjunctions with CHAMP, which have already been identified. These data will both support the analytical aspect of this project, as well as provide input for the numerical studies.

Michael Liemohn/University of Michigan
Integrated Assessment of Radiation Belt Drivers

We propose to assess the physical processes responsible for the formation and dynamics of the outer zone radiation belt with an array of physics-based models. In particular, the magnetospheric topology, plasma sheet, ring current, and the plasmasphere are primary factors influencing the radiation belts. The dynamics of the radiation belts are highly dependent on each of these drivers: the magnetospheric topology and dynamics for drift shell deformation and ULF wave intensity; the magnitude and morphology of the ring current through magnetic field perturbations and wave excitation; the plasma sheet as a source/seed population; and the location and evolution of the plasmasphere, particularly of the plasmapause and the different plasma wave regimes inside and outside of this boundary.

The Space Weather Modeling Framework (SWMF) will be employed to quantitatively and systematically assess each driver's influence on radiation belt dynamics. The SWMF includes modules for the global magnetosphere, ring current, plasmasphere, and radiation belts. Because the SMWF allows for easy exchange of subroutines for a given science module (once implemented within the framework), several models each will be used for the plasmasphere, the ring current, the global magnetosphere, and the radiation belts, resulting in model combinations of varying degrees of sophistication. A new physics model will be incorporated into the SWMF as part of this proposed effort (namely, the inner magnetospheric particle transport model developed by Dr. Ganushkina).

The research implementation will include both idealized input studies as well as specific storm event studies. Input parameters will cover a range of driver dynamics and radiation belt responses. Several more events, intervals, or cases will also be simulated in the second half of the project, as defined by the Focused Science Topic (FST) Team. All model results will be made available to the other funded researchers for use in their observational, theoretical, or numerical studies of the radiation belts.

The idealized input case studies will reveal how the radiation belts respond to various driver conditions, while the real event studies will allow for the assessment of how these individual drivers combine to form the observed radiation belt for a particular interval. For the real event studies, extensive data-model comparisons will be conducted of the radiation belt fluxes/phase space densities as well as the lower-energy plasma populations and near-Earth electric and magnetic fields. In particular, the balance between simultaneous sources and losses of the radiation belt will be examined, with special emphasis on the connection to the lower-energy plasma populations and global field configurations.

Noé Lugaz/University of Hawaii
Studying Complex Ejecta at L1 Using Realistic Models of CME Evolution and Interplanetary Magnetic Field.

During solar cycle 23, a significant fraction of the largest Bz periods observed at the L1 point was the result of the interaction of a Coronal Mass Ejection (CME) with either a preceding event, or with a stream of fast solar wind. We propose to investigate the evolution of a CME into a complex interplanetary magnetic field (IMF), and the interaction of multiple CMEs from the Sun to L1. The science questions addressed in this proposal are:
How does the IMF vector at L1 evolve during space weather events?;
How does a preceding CME precondition the heliospace?;
How does the IMF connecting L1 with the Sun evolve with time?; and
What is the three-dimensional structure of shock waves and sheath regions of iCMEs en-route to L1?
To answer these questions, we will conduct self-consistent 3-D MHD simulations of selected events using existing, improved, and newly developed models of CME evolution, the IMF, and coronal emissions. These models will enable the LWS community to tackle problems related to some of the largest and longest-lived disruptions of the IMF's Bz component. We will work with the other members of the Focused Science Team from the topic T1-e of the LWS TR&T solicitation and make use of the STEREO Heliospheric Imagers. We will use data from ACE, SoHO and Wind to validate our models. Furthermore, we will investigate the scientific significance of having in-situ measurements closer to the Sun, as will be provided by the LWS Sentinels mission, to improve our understanding and forecasting of complex ejecta. By studying and modeling realistically the IMF from the Sun to L1, we will also provide some

physical insight the production and transport of SEPs, which may prove useful to the LWS community.

Dirk Lummerzheim/Geophysical Institute, UAF
Thermospheric Variability in Aurora

Observations from the ground, sounding rockets, and satellites demonstrate that the thermospheric composition and the neutral wind are influenced by auroral activity on local and regional scales. For example, the intensity ratios of auroral emissions are interpreted as relative depletion of atomic oxygen at F-region heights. Satellite measurements indicate an irregular density distribution in auroral regions. Simulation studies and rocket experiments provide additional evidence that processes other than thermal expansion play a considerable role in the vertical dynamics and composition of the thermosphere.
The proposed research will examine neutral density and composition changes in response to the inputs of Joule heating and auroral precipitation for typical day and night time conditions. The study will use a local three-dimensional fluid model in combination with an auroral transport model. The physics includes all relevant transport terms, i.e., ionization and recombination, friction between the various plasma and neutral constituents, and collisional energy exchange. To address composition changes the single neutral species will be replaced by separate neutral constituents in the simulation. The auroral electron transport model provides transport coefficients and self-consistent auroral emissions. The study will clarify the role of ion-neutral drag versus neutral expansion due to heating in combination with diurnal changes of photo-dissociation rates for the neutral density and composition.
Specific output will be the height distribution of atomic oxygen and the brightness ratios expected from the modeled profiles. Results will be compared to ground and satellite observations. The study will provide a clarification of the physical mechanisms for neutral density and composition changes, and it will identify optical diagnostic tools (emission line ratios) that are suitable to measure thermospheric composition.

Yingjuan Ma/ University of California Los Angeles
Study of the Martian Ionospheric and Atmospheric Responses to Extreme Space Weather Events

As a weakly magnetized planet, Mars directly interacts with the solar wind. Under extreme solar wind conditions, the ion escape rate is estimated to be more than an order of magnitude larger than in normal situations. We propose to study the detailed responses and long-term consequences of the Martian ionosphere and atmosphere to extreme space weather events using two sophisticated 3D models. One is a global multi-species MHD model with a very high spatial resolution (~10 km inside the Martian ionosphere). This model calculates the densities of the solar wind protons and all the major ion species in the Martian ionosphere, as well as the plasma bulk velocities and energies. The Mars-solar wind interaction is self-consistently calculated in the model by including the effects of the crustal magnetic field, ion-neutral collisions, and major chemical reactions. Another numerical tool is a newly-created highly-parallelized test particle model, which is to address the kinetic effects of pick-up ions in the Martian plasma environment. The most novel feature of the test particle model is that more than one billion test particles are launched in the simulation domain. This substantial improvement enables an unprecedented examination of the pickup ion flux distribution in velocity space, which is not achievable in previous studies. In this proposal, the ionospheric and atmospheric particle escape from and precipitation into the Mars will be studied under the impact of extreme space weather events by comparing a variety of representative model runs. The study will also provide useful information for the understanding of the energetic charged particle environment on the surface of Mars, thus important for the evaluation of the survivability of life on or near the surface, including the health of future human explorers on Mars.

Petrus Martens/Montana State University
Evolving Solar Magnetic Activity on Time Scales Relevant for Space Climate

"One of the major challenges facing humanity is global climate change. In order to gauge the response of the terrestrial climate system to natural and anthropogenic forcings, NASA's Living With a Star program needs to deliver the understanding of how and to what degree variations in the solar radiative and particulate output contribute to changes in global and regional climate over a wide range of time scales." (Adapted from NASA LWS TR&T Steering Committee Report, 2006-2007).

We propose to use a new and innovative stellar dynamo simulation code, which we have developed under a NASA predecessor grant, to explore the origins of, and decipher the evolution of solar magnetic activity over multiple timescales ranging from centuries to stellar and planetary evolutionary timescales. The results from that dynamo code will be used as input for a surface magnetic flux transport code developed by our collaborators at the University of St. Andrews in Scotland to produce accurate predictions for the Sun's surface magnetic fields and open magnetic flux. The former regulates the variations in the total solar irradiance and the latter the amount of Cosmic Rays that penetrate the atmosphere of the Earth, both of which are key physical agents of the solar influence on the Earth's climate.

In keeping with MSU's tradition of involving students with NASA sponsored forefront astrophysical research, a graduate student will be involved with our project for his thesis research, and undergraduates will carry out appropriate portions of the work for research credit.

Dennis Martinez-Galarce/Lockheed Martin Advanced Technology Center
Understanding solar EUV Irradiance (EUVI) observed over the 11-year solar cycle

The principal focus of the proposed 3-year investigation is to empirically determine the solar EUV spectral irradiance (EUVI) measured by the SoHO-EIT instrument over its lifespan of operation covering a full solar cycle. Using this dataset, the thrust of the investigation will be threefold: 1) to determine the full-disk EUVI in each of the four EIT wavebands (171, 195, 284 and 304 Å); 2) to quantify the percent coverage of active versus quiescent region emission (over the full disk) in each waveband; and 3) to study the diffusely unresolved component of EUV emission emanating from quiet regions recorded in EIT, CDS and TRACE spectroheliograms.

Solar EUVI is known to be the primary source of energy that drives the photochemistry, ionization and heating of the Earth's upper atmosphere above ~ 100 km, contributing to Earth's delicate heating balance and therefore its climate. Changes in atmospheric density caused by EUVI (e.g. a thickening of the ionosphere) affect space-based satellites by "dragging" them to lower orbits and lowering their expected operational lifetimes. A priori knowledge of EUVI variation in conjunction with satellite tracking models will assist satellite operators in countering such affects. Accurate determination of EUVI is also useful for climate and geospace modelers wishing to improve their prediction of solar EUVI effects on the Earth's thermosphere, ionosphere and atmospheric composition and how it affects and modulates Earth climate (e.g. EUV models NRLEUV2, HFG, EUVAC and SOLAR2000).

The source of EUVI is known to be the solar atmosphere. To understand long term variability, we will test state-of-the-art models of coronal funnels. These structures are open magnetic field regions rooted in the supergranular network, expanding outward into the corona and solar wind and produce a sizeable component of the EUV and soft X-rays from quiet regions. Funnels are also believed to be the source of the fast solar wind coming from coronal holes. Using CDS and TRACE observations in conjunction with simultaneously recorded EIT data we will measure areal expansion of funnels at different temperatures, and over a select number of observations throughout the solar cycle to understand the morphological transformation the EUV Sun traverses over this period.

The knowledge gained will be especially important to Earth climate modelers wanting to understand how EUVI affects Earth's climate (vis-à-vis global warming) as well as give solar physicists a better understanding of the heating mechanisms that produce solar EUV radiation and those that generate the solar wind. The results will also be important to geospace modelers to help predict EUVI effects on space weather and its impact to human-engineered systems.

The tools developed in this study will also be useful for analysis of STEREO, Solar-B and SDO-AIA observations.

John McCormack/Naval Research Laboratory
Investigating the impact of solar variability on weather and climate with the high-altitude NOGAPS-ALPHA global spectral forecast model

We propose to perform a detailed series of atmospheric model simulations to study the link between variations in solar ultraviolet (UV) irradiance and variations in the Earth's weather and climate. These simulations will test new theories on wave-induced stratospheric ozone heating feedbacks and their role in communicating solar-induced heating anomalies near 50 km altitude downward to the troposphere and upward to the mesosphere. This study will employ the NOGAPS-ALPHA global spectral forecast model extending from 0-100 km altitude with an interactive treatment of solar UV heating and ozone photochemistry. We will perform a large number of simulations over seasonal and interannual time scales to isolate interactions between solar-induced heating anomalies and planetary wave propagation. We will also carry out detailed comparisons between modeled and observed solar cycle variations in stratospheric ozone, temperature, and zonal winds. Differences in the atmospheric response from one solar cycle to the next will be explored using state-of-the-art reconstructions of solar UV irradiance variations over the past 150 years. This investigation will provide new information on how changes in the sun's UV output can affect global weather and climate, and provide important new information on the dynamical response of the mesosphere to solar UV variability to improve lower boundary conditions for space weather prediction models.

Scott McIntosh/Southwest Research Institute
Coronal Morphology - The Interplay of Structure and Energetics

Alfvén waves have been invoked as the driving force behind solar coronal heating and solar wind acceleration since their theoretical inception even though they had not been directly observed in the inner heliosphere (closer than the ~0.3AU of HELIOS), solar corona or below. That was the case until recently when they were directly observed in the corona by NCAR's CoMP instrument and then in the Chromosphere by Hinode/SOT.

The discovery of ubiquitous Alfvén waves that carry an energy flux large enough to power the quiet Sun corona and the solar wind has significant implications for the solar atmosphere and inner heliosphere. Our goal is to use the unique spectropolarimetric-imaging observations of CoMP as a foundation to understand coronal magnetic morpholgy and its impact on the energy flow through the solar atmosphere and inner heliosphere in a reasonable, self-consistent fashion. Such a goal is possible through a tightly constrained fusion of data analysis (timeseries analysis from CoMP, line-of-sight density estimation from white light coronagraphs, EUV imaging data of the corona) and forward-modeling (based on magnetic field extrapolations).

The proposed project is relevant to the LWS Targeted Research & Technology portion of the ROSES 2007 solicitation and, in particular, focused science topic one (for Strategic Goal 1) "Exploring the magnetic connection between the photosphere and low corona". This work has direct relevance to NASA's Strategic Sub-goal 3B: "Understand the Sun and its effects on Earth and the solar system" and, in particular, Research Objective 3B.1 "Understand the fundamental physical processes of the space environment from the Sun to Earth, to other planets, and beyond to the interstellar medium". Understanding and monitoring the energy input mechanism to the corona and solar wind will eventually lead to a better understanding of the solar atmosphere, nascent solar wind and their structure.

Dibyendu Nandi/Montana State University
Workshop Support: Solar Variability, Earth's Climate and the Space Environment

We are organizing a cross-disciplinary International Workshop on "Solar Variability, Earth's Climate and the Space Environment", to be hosted by the Montana State

University, in Bozeman, Montana from June 1-6, 2008. The Sun's influence on the Earth and the heliosphere involves numerous physical processes (solar dynamo output, magnetic reconnection, flares, CMEs, TSI and open flux variations), occurs over multiple spatial (solar convection to heliospheric) and temporal scales (space weather to space climate). Therefore, a unified understanding of Sun-Earth-System science requires crossing traditional boundaries and assimilating and building upon ideas and experiences of researchers across multiple disciplines. This is precisely the aim of this workshop -- linking together solar and space physicists to climatologists. The workshop will cover research topics ranging from the solar interior and internal processes, the Earth's atmosphere and climate, to the influence of the Sun on Earth's space environment and climate. Focused working groups on space weather modeling, long-term solar evolution and space climate, will bring together scientists with diverse expertise to review our current state of understanding and discuss future prospects. The presentations of the meeting will be made available online, the reviews by experts in the field will be put together in a book already approved by the Cambridge University Press and the focused working group outcomes will be published as research papers. Therefore, this workshop will have a lasting value that is expected to have a wide reach in the Sun-Earth-System community. This workshop addresses the LWS program's objective of "Understanding the changing Sun and its effects on the Solar System, life, and society", and NASA's strategic sub-goal 3-B - "Understand the Sun and its effects on Earth and the solar system".

Vahe Peroomian/University of California Los Angeles
The impact of sudden storm commencement on magnetotail ions

The sudden storm commencements (SSCs) of geomagnetic storms represent the most dynamic and large-scale compressions of Earth's magnetosphere and have profound effects on magnetospheric electrons and ions, including the formation of radiation belts and the acceleration and injection of ions into the ring current.
Motivated by our previous work on the population of the magnetosphere during geomagnetic storms and by recent results indicating that ion velocity distributions in the near-Earth plasma sheet and nightside ring current are profoundly affected by SSCs, we propose to carry out a systematic investigation of the impact of SSCs on the acceleration and transport of ions in the near-Earth magnetotail. We do so by utilizing a simulation model incorporating electric and magnetic fields from global magnetohydrodynamic (MHD) simulations of Earth’s magnetosphere and large-scale particle tracing calculations.
The scientific objectives of the proposed work include the delineation of the characteristics and time scales of ion energization in the inner magnetosphere and their dependence on the type and severity of the storm, the previous state of the solar wind and interplanetary magnetic field, and preconditioning by substorms occurring prior to storm onset. We also propose to examine the similarities and differences in the acceleration and transport of H^+ and O^+ ions during SSC events, the characteristics of ion precipitation during storm onset, and the physics responsible for the density and temperature differences reported for CIR- and CME-driven storms.

This proposal addresses NASA's Living With a Star (LWS) program's Focused science topics for Strategic Goal 3 (Near Earth Radiation): Toward combined models of acceleration, loss and transport of energetic electrons and protons in the magnetosphere.

Donald Reames/Goddard Space Flight Center
Onset Times, Spectra, and Abundances of Historic Large Solar Energetic Particle Events

We propose to study large solar energetic particle (SEP) events, emphasizing the ground level events (GLEs) where GeV protons create radiation sufficient to penetrate the Earth's atmosphere all the way to ground level. These events present a radiation hazard to men and equipment in space and to the passengers and crew of aircraft on polar routes. Spacecraft observations of the onset timing, energy spectra, and element abundances have not previously been studied systematically for most of the 46 GLEs that occurred from 1972 to 2005. Onset times for particles of different velocity define the magnetic path length traversed and the initial particle acceleration time, which we can compare with the timing of Hα, Radio, and X-ray emissions to distinguish flare and shock acceleration. Previously unanalyzed timing data from Pioneer, IMP, ISEE, Helios, and Voyager spacecraft will be recovered from archived data to reconstruct properties of the events, and will be combined with observations of recent GLEs using data from Wind and ACE. A few of the early GLEs were viewed from multiple spacecraft, at as many as 5 different locations in the inner Heliosphere, allowing a study of spatial variations that has been difficult to duplicate for GLEs during the last 20 years. Acceleration onset times for spacecraft magnetically connected to different solar longitudes may vary as the expanding shock wave encounters them. We believe that multi-spacecraft onset timing can be a powerful new tool to investigate the physics of particle acceleration in GLEs and in SEP events generally. The behavior of an SEP events viewed at different longitudes and different radial distances (e.g from ~0.3 AU to the orbit of Mars) will be studied.

Alexander Ruzmaikin/Jet Propulsion Laboratory
Extreme Solar Energetic Particle Events: Origin and Impact on the Moon, Mars, and Interplanetary Space Environment

Objectives: This proposal addresses "the quest to understand extreme space weather events and their effects throughout the solar system" formulated in the Focus Topic "Extreme Space Weather Events in the Solar System." The proposed activity is based on interdisciplinary knowledge of solar-heliospheric physics and space environment of the solar system. The scientific question for the proposed work is "What is the frequency of occurrence and the origin of the extreme solar energetic particle (SEP) events and their expected impact on the space environment at Moon, Mars, and interplanetary space." To answer this question we apply the following methodology: We will

1. estimate the expected frequency of occurrence of extreme SEPs using spacecraft data and reconstruct fluxes and fluencies (time integrated fluxes) of these events

2. evaluate space environments produced by the extreme SEP events at Moon, Mars, and in the interplanetary space using an environmental model developed by our team

3. demonstrate an insight as to what the solar conditions that give rise to the fast coronal mass ejections that produce extreme SEPs.

Expected Significance: Our first-cut modeling efforts will contribute toward initiating more detailed research that will lead to a better understanding the space hazards affecting space exploration. The estimation of expected frequency of occurrence of extreme SEPs can be used in designing future manned and robotic space missions.

The normalized response matrix concept we generate will advance the capability of studying the planetary radiation environment in a more systematic way, regardless of energy spectrum and elemental composition of the impinging SEPs. Currently, due to the lack of actual measurements of radiation environment, the understanding of the radiation exposure at the Moon and at Mars is based on transport analyses using different choice of tools. There has been no coherent effort to understand uncertainties in these estimates, which originate from many sources: soil composition and atmospheric profile, nuclear data used in the codes, etc.

The perceived impact of our study on the state of knowledge of the interplanetary space environment is that for the first time we will have a statistical, predictive SEP model that includes the proper distribution function of the events.

The association of the fast coronal mass ejections that produce extreme SEPs with clustering of solar magnetic activity will stimulate the modeling of the clustering and underlying dynamo mechanisms causing the clustering of solar magnetic fields.

The proposed study will be used to better predict dynamic radiation environments for future NASA robotic and human missions to the Moon, Mars, outer planets, and interplanetary space. It will also provide a scientific basis for the space environment evaluations for the LWS missions such as the Solar Probe and the Heliophysical Explorers as well as for future planetary missions.

Relevance: The proposal is relevant to the Focus Topic 'f' of this AO. It directly addresses the LWS strategic goal 1: "Solar energetic particles and galactic cosmic rays pose major radiation hazards for space hardware and astronauts. Penetrating particle radiation adversely affects aircraft avionics and potentially the health of airline crews and passengers on polar flights. "In support of NASA's Vision for Space Exploration and the national communication, navigation, and transportation infrastructure, the TR&T needs to deliver the understanding and modeling required for useful prediction of the variable solar particulate and radiative environment at the Earth, Moon, Mars, and throughout the solar system."

Ludger Scherliess/Utah State University
Determination of the Causes of Day-to-Day Variability in the Middle and Low Latitude Ionosphere

Data assimilation models have been successfully used for several decades as a dominant tool for specifications and forecasts in meteorology and oceanography and recently also gained prominence in ionospheric studies. We have developed a data assimilation model that uses a physics-based ionosphere-plasmasphere model and an Ensemble Kalman filter as a basis for assimilating a divers set of measurements. The primary output of the model is the 3-dimensional electron density distribution in the ionosphere and the self-consistent global distributions of the ionospheric drivers.

We propose to use this new data assimilation to specify monthly-mean electron densities, electric fields, and neutral winds and composition in the low- and mid-latitude region. This innovative approach will combine the multitude of diverse data sets with a physics-based model for the ionosphere in a synergistic way to enhance the scientific return of both the observations and the model. The data that we will assimilate include: Radio occultation, UV radiance, and Tri-Band Beacon data from the six COSMIC satellites; UV from the GUVI inbstrument; Total electron content from hundreds of GPS sites and from the TOPEX and Jason-1 satellites; Ne profiles from ionosondes; and Ne observations from DMSP satellites.

Our research plan is specially tailored to serve the objectives of Focused Science Topic for Strategic Goal 4. Specifically, the accurate specifications of the ionosphere-thermosphere environment will be used to identify the causes of day-to-day variability in the 3-dimensional ionospheric plasma distribution. The important components of this proposal are specification of the ionospheric plasma morphology on a monthly basis including its drivers, an investigation of the ionospheric variability using our month-mean values as a baseline, an investigation of the variability of ionospheric drivers and its relationship to the plasma density variations, and the comparison of our data assimilation results with observations from incoherent scatter radars.

David Smith/University of California Santa Cruz
Duskside Relativistic Electron Precipitation (DREP) Events and Outer Belt Electron Losses

Understanding the Earth's radiation belts requires understanding of the ways energetic particles are lost as well as the ways they are accelerated to high energies in the first place. The most significant radiation belt particles in terms of their danger to astronauts and robotic probes are the highly relativistic electrons in the outer radiation belt. We propose an in-depth study of the loss of these electrons to the Earth's atmosphere, concentrating particularly on a seldom-studied phenomenon we call Duskside Relativistic Electron Precipitation (DREP). DREP has been reported in a few cases using spacecraft, but has not been considered a dominant loss mechanism from these results. Data from balloons, however, suggest that DREP actually is the dominant mechanism for the loss of high-energy electrons from the outer belt.

Using archival data from the SAMPEX satellite, we will search for DREP events, characterize the differences between them and other sorts of precipitation, and quantify the time-averaged loss rates due to the DREP mechanism. SAMPEX data are particularly good for this study, since the satellite carried large detectors in a favorable orbit for 12 years of operations. With this study we will reconcile the historical balloon and satellite data, explore plasma physics in the magnetosphere (DREP are thought to be caused by electromagnetic ion cyclotron waves, or EMIC) and better understand the balance between loss and acceleration in the outer belts and the cause of their extreme variability.

Stanley Solomon/University Corporation for Atmospheric Research
Ionosphere-Thermosphere Variability: The Interaction of Solar Irradiance Changes with Atmospheric Dynamics

Understanding the day-to-day variability of the ionosphere and thermosphere requires unraveling the relative strengths of forcing mechanisms of the I-T system, including solar ultraviolet, extreme-ultraviolet, and X-ray fluxes, magnetospheric processes resulting in geomagnetic activity and auroral effects, and propagation of dynamical variations driven by lower atmosphere weather and middle atmosphere tides. The goal of this investigation is to advance understanding of the observed day-to-day variability of the ionosphere-thermosphere using three-dimensional general circulation models, solar measurements, lower atmosphere analyzed temperatures and winds, and space-based measurements of thermosphere and ionosphere density and composition. As part of a focused science team, we will concentrate on solar forcing, including flare effects, and internal dynamics driven by lower atmosphere processes, in creating observed daily variability. We will complete the extended-altitude version of the Whole Atmosphere Community Climate Model that extends from the ground to the thermosphere/ionosphere, and use solar ultraviolet measurements and a measurement-based flare model as optional inputs. We will impose analyzed meteorological fields on the troposphere/stratosphere region of the model in order to study how atmospheric dynamics propagate into space. We will attempt to understand the seasonal behavior of the thermosphere/ionosphere as well, addressing the hypothesis that the lower atmosphere is responsible for variation on time scales ranging from diurnal to inter-annual.

Thomas Sotirelis/JHU/APL
Empirical Model of Electrons and Ions at the Inner Edge of the Plasma Sheet

Currently, simulations of radiation belt formation and ring current dynamics have no reliable estimate of the seed populations at their outer boundary. We propose to construct the first empirical model of both electron and ion properties at the inner edge of the plasma sheet. The temperature, density and pressure will be observed at low altitude, and empirically fit as a function of solar wind/interplanetary magnetic field parameters, and auroral boundary indices. The behavior near the time of substorm onset will receive separate treatment. Simultaneous high and low-altitude observations will assess the uncertainty involved in estimating high-altitude properties from low-altitude observations. The resulting model will provide a crucial input to first principle models of radiation belt formation and ring current dynamics, by providing estimates of the particle populations at their outer boundary.

Model formulation will be guided by the results of several correlation studies, between plasma sheet properties, and solar wind/interplanetary magnetic field parameters and various indices. The model will be calculated by fitting analytical expressions for the temperature, density and pressure to the assembled observations, separately for individual local time bins. THEMIS observations will be used to estimate the high-altitude location of the plasma sheet's inner edge and to verify the expected correspondence between high and low altitude observations.

The following science questions will be addressed:

1) How are the properties of the inner edge of the plasma sheet impacted by solar wind driving?

2) What is the relationship between the high and low altitude extensions of the near-Earth plasma sheet.

Alphonse Sterling/NASA/MSFC/NSSTC
Solar Spicules, Spicule-like Features, and their Magnetic Environment

Solar spicules, and similar features, are a major component of the magnetically-dominated solar atmosphere between the photosphere and the low corona. As such, they are a crucial factor in the lower boundary condition of the heliospheric space weather system. We propose a three-year program to study chromospheric and UV/EUV spicules, and their relationships with their magnetic environments. Our data will be from the Solar Optical Telescope (SOT) and the EUV Imaging Spectrometer (EIS) on the Hinode satellite, supplemented with UV/EUV images from TRACE, and images of X-ray jets from the Hinode X-Ray Telescope (XRT). Magnetic field data will be vector magnetograms from SOT, supplemented with line-of-sight magnetograms from SOT and from SOHO/MDI. We will study the morphology and the statistics of: (1) the magnetic characteristics at the bases of various spicules and jets, and (2) the relative appearance of the various spicules and jets at different wavelengths. This investigation will address questions such as: whether some types of spicules are produced by a magnetic, rather than a purely wave-based, mechanism; what magnetic configurations are necessary for the existence of spicules and jets; what percentage of chromospheric spicules evolve into UV/EUV spicules; and what chromospheric features correspond to X-ray jets. We will train and partially support a postdoctoral-level scientist during this program.

Richard Thorne/ University of California Los Angeles
The Excitation of Equatorial Magnetosonic Waves and Their Effect on Radiation Belt Particles

Intense magnetosonic waves are generated in the inner magnetosphere during geomagnetically active periods. These highly oblique whistler-mode waves are confined close to the geomagnetic equatorial plane and are thought to be excited by the injection of a ring distribution (with df/dv_perp >0) of ring current ions. The waves interact with both the ion ring current population and with energetic electrons, leading to rapid particle scattering and heating. The ion heating may enhance the generation of EMIC waves. A recent study indicates that magnetosonic waves could provide an important local acceleration process for relativistic electrons. When combined with the EMIC waves they may also enhance the rate of scattering towards the loss cone and hence precipitation. A thorough understanding of the origin of these waves and a quantitative modeling of the scattering of resonant ions and electrons is fundamentally important for understanding energetic particle dynamics during active conditions in preparation for the RBSP mission.

We propose to use a combination of data analysis and modeling to provide closure on the excitation of the equatorial magnetosonic waves and the role of these important waves in magnetospheric dynamics. Data from CRRES will be used to develop statistical models for the global distribution of magnetosonic waves, their response to geomagnetic activity and their relationship to the local ring current ion distribution. The MLT distribution of ion ring distributions, and their response to solar and geomagnetic activity will also be studied using LANL satellite data. The RAM code will be used to model the dynamic change in ring current ion flux during injection events, and identify preferred regions for magnetosonic and EMIC wave excitation. The scattering rates of resonant ions and electrons will be quantified using the statistical model developed for the global distribution of these waves, and used to follow the dynamical evolution of ions and electrons during storm conditions. Selected events will be identified for in-depth study and comparison with Cluster data.

The proposed study is directly relevant to NASA's Research Objective 3B: "Understanding the Sun and its effect on Earth and the solar system". The proposed investigation is specifically directed towards to the 2007 LWS Focused Science topic (c), and the prime science objectives of the RBSP mission: to understand the acceleration, global distribution and variability of energetic electrons and ions in the inner magnetosphere.

Bruce Tsurutani/Jet Propulsion Laboratory, California Institute of Technology
Research on the Properties of Electromagnetic Chorus in Dayside Minimum-B Pockets: Relevance to Energetic Electron Losses and Acceleration

The proposed effort is to study the intensities and properties (direction of propagation, relative frequencies (omega/omega_ce), Landau damping, etc.) of dayside minimum-B pocket chorus using the Cluster, Double Star and Polar plasma wave data. Such a survey has never been performed before, except for a cursory look using OGO-5 analog data done many years ago (1977). It will be argued that the strongest cyclotron resonant wave-particle interactions occur in these dayside regions and/or at large L and these waves may be important for the losses and acceleration of energetic electrons. The study will determine (construct statistical surveys of) chorus properties as a function of phases of the solar cycle. Chorus during ICME-induced magnetic storms and during high speed stream-related geomagnetic activity will be studied on a case basis. It has recently been shown that chorus 0.1 to 0.5 s duration "elements" are composed of even smaller "wave packets". The instantaneous intensity of a wave packet can be an order of magnitude more intense that the time-averaged intensity of the element itself. It was also shown that dayside chorus can also have many interelement gaps such that the chorus "fill factor" (chorus element versus interelement spacings) can be as low as 10%. Thus from the combined two effects, the instantaneous wave intensities determined in the past may have been underestimated by several orders of magnitude. The "typical" dayside wave packet intensities and fill factors will be examined and characterized in this study. The aim of the study is to provide all of the chorus information needed for modelers to explore the role of minimum B pocket/outer L dayside chorus losses and acceleration of relativistic electrons.

Sharon Vadas/NorthWest Research Associates
Collaborative Research: Midlatitude Spread F - Exploring Correlations with Geophysical Forcing and Gravity Wave Propagation Conditions

This proposal is one part of a collaborative research effort entitled "Collaborative Research: Midlatitude Spread F - Exploring Correlations with Geophysical Forcing and Gravity Wave Propagation Conditions " led by PI Dr. Greg Earle, University of Texas. A complete solar cycle (1996-2006) of digital ionograms from Wallops Island, Virginia have been archived and statistically analyzed at the University of Texas at Dallas. The ionograms were taken around the clock every day of the year with a 15 minute cadence; hence the statistical significance and temporal resolution of the dataset are very high. An autotmated software algorithm has been developed to analyze these digital ionograms using adaptive noise filtering and pattern recognition techniques. Using these tools we have characterized both the seasonal and solar cycle variability of midlatitude spread F at Wallops Island. As a result of this study we have been able to formulate anecdotal conclusions about the causes of midlatitude spread F (MSF). In this proposal we describe a two-phase plan to test these conclusions while significantly extending our understanding of the underlying sources of MSF. One aspect of this plan involves testing the hypotheses developed from the Wallops Island records against data taken at a separate site that has a very different declination angle. The second aspect involves comparison of the statistical results against the GW characteristics predicted by a state-of-the-art GW propagation model. This will be done using a combination of specific case studies and average behavioral characteristics. The results of this study should provide new insights into midlatitude spread F that will likely guide future theoretical understanding of the phenomenon.

Haimin Wang/New Jersey Institute of Technology
Evolution of Magnetic Fields and Flows
Associated with Flares and CMEs

Recent advances in observations revealed new results on the relationship between evolution of magnetic fields and onset of solar flares and Coronal Mass Ejections (CMEs). The most remarkable finding of our group is that of rapid penumbral decay in the outer part of delta sunspots, and the enhancement of transverse fields at the flaring neutral lines. It is timely that the problems can be studied further, as the unprecedented data are obtained from newly launched Hinode mission that is complementary to more than 8 years archive of vector magnetograph observations at the Big Bear Solar Observatory (BBSO), and the tools for coronal magnetic field extrapolation have been matured. We assemble a team consisting of researchers from BBSO, National Astronomical Observatory of Japan (Dr. Suematus, Hinode observations), and Max-Planck-Institute for Solar System Research (Dr. Wiegelmann, coronal field extrapolation). Our objective is to advance the study of evolution of surface magnetic structures and flows in the flare productive active regions and to understand the energy release process and magnetic reconfiguration associated with flares and CMEs. Our research will focus on the following two related topics:

(1) With the aid of high-cadence, high-resolution, and high-sensitivity vector magnetograms from Hinode, as well as the rich archive of data from vector magnetograph systems at BBSO, we propose a comprehensive study of rapid changes of photospheric magnetic fields associated with flares. More specifically, we will study the evolution of 3-D magnetic topology by analyzing new data and carrying out non-linear force-free extrapolation. Although our primary task is to explain the observed photospheric magnetic field evolution related to flares, analysis of the same data set will also advance our understanding of 3-D pre-flare magnetic condition.

(2) We will study photospheric flow fields, including shear and converging flows, of flare productive regions. With Adaptive Optics (AO) equipped ground-based observations, we have found solid evidence of strong shear flows along flaring neutral lines. From a limited number of events using Center-of-Mass techniques, we have detected sudden variation of mean converging and shear flows associated with flares. Continuous sub-arcsecond observations from Hinode will allow us to analyze the spatial distribution and temporal evolution of the flows, and their association with flares and CMEs.

We will also compare our observational findings with theoretical models of flares to find if the observational signatures match the predictions of specific models.

The proposed research is clearly related to the NASA's strategic goal 3A: to understand the sun and its effects on Earth. This proposal has a strong education component. Continuation of this grant is crucial in supporting the very productive Ph.D. program in Solar-Terrestrial Physics at NJIT.

Yi-Ming Wang/Naval Research Laboratory
The Long-Term Evolution of the Sun's Open and Closed Magnetic Flux and Its Relation to Cosmogenic and Geomagnetic Activity Records

OBJECTIVES: Cosmogenic isotope abundances are widely used to infer long-term changes in solar activity and solar irradiance, and thus in Earth's past climate. However, the cosmic rays that produce cosmogenic isotopes are modulated by the Sun's open magnetic flux, whose variation is not the same as that of the closed flux which controls the total irradiance. We intend to exploit our recent finding that it is the nonaxisymmetric component of the open flux that correlates best with the cosmic ray modulation. Our objectives are (1) to derive the variation of the Sun's open and closed flux from the Maunder Minimum to the present, using a realistic source term based on historical sunspot records; (2) to predict the long-term variation of geomagnetic activity, cosmogenic isotope abundances, and solar irradiance; and (3) to compare these predictions with observations.

APPROACH: Building on our earlier modeling efforts, we will evolve the photospheric magnetic field using a transport code that includes the effects of emerging flux (in the form of active and ephemeral regions), differential rotation, supergranular diffusion, and meridional flow. The idealized source term that we have used previously will be replaced by one in which the strengths, pole separations, axial tilts, and locations of the bipolar magnetic regions are derived from sunspot data from 1610 to the present. The open flux will be calculated via a source surface extrapolation of the photospheric field. Long-term cosmic ray modulation will be inferred from the nonaxisymmetric component of the open flux, and total solar irradiance will be derived from the simulated photospheric field. The predictions will be compared with cosmogenic isotope and cosmic ray data, as well as with auroral and geomagnetic activity records.

RELEVANCE: The proposed cross-disciplinary research directly addresses the LWS TR&T program's Focused Science Topic for Strategic Goal 2 (Sun-Climate): "Solar modulation of galactic cosmic rays and the production of cosmogenic isotope archives of long-term solar activity, used to interpret past climate changes."

Wenbin Wang/University Corporation for Atmospheric Research
Investigations of the Sources and Changes of the Daily Variability of the Thermosphere and Ionosphere

We propose to undertake a comprehensive study of the driving mechanisms of the day-to-day variability of the ionosphere and the seasonal and hemispheric dependence of this variability. While there have been many correlation studies between ionospheric daily variations and solar radiation, solar wind/IMF and lower atmospheric planetary waves, the physical mechanisms driving this variability, the relative importance of these mechanisms, and the seasonal and hemispheric variations of the daily variability have not been fully characterized. We will use the NCAR-Thermosphere, Ionosphere, Mesosphere, Electrodynamics Global Circulation Model (TIMEGCM); Coupled Magnetosphere Ionosphere Thermosphere (CMIT) models, European Center Medium-range Weather Forecast (ECMWF) reanalysis fields, and observations to address these issues. Four scientific investigations will be undertaken:
1) The impact of planetary waves on ionospheric daily variability using the high-resolution TIMEGCM with its lower boundary being specified by ECMWF analysis fields. Diagnostic analysis will be performed to investigate which planetary waves can propagate into the thermosphere, and the mechanisms by which these waves drive ionosphere variability.
2) The impact of solar radiation, solar wind and magnetospheric conditions on ionosphere daily variability using CMIT models. Diagnostic analysis of model outputs will be

carried out to investigate the processes that cause ionosphere variability under these conditions.
3) The relative importance of each driving force to ionosphere daily variability. Comparisons between model simulations and observations will be made to examine the adequacy of the physics included in the model to simulate the observed ionosphere variability, and ways to improve the model.
4) The effect of seasonal and hemispheric conditions on ionosphere daily variability. This includes the studies: what are the causes of the seasonal variations of the ionosphere daily variability; what are the differences between the variability in the two hemispheres?

Stephen White/University of Maryland
Coronal Magnetic Fields from Radio Observations

This is a proposal to participate in the focussed science topic for strategic goal 1 by using radio measurements of coronal magnetic field strengths to test extrapolations of photospheric and chromospheric field measurements. New missions are acquiring extensive data on solar surface magnetic fields and extrapolation methods are being used to estimate coronal fields, but the tests of real data usually involve matching field line configurations available from EUV and soft X-ray images and are in no sense quantitative. Radio observations are capable of measuring coronal magnetic fields directly, and thus provide several complementary test diagnostics: they can be used to compare the magnitude of the magnetic field extrapolated into the corona, determine field-line connectivity, and address the height of the corona. We propose to acquire observations of active regions using the Expanded Very Large Array, which offers a major upgrade over the older VLA data, and to use them to test coronal magnetic field extrapolations in conjunction with other members of the team for strategic goal 1.
The intrinsic merit of the proposed research is a quantitative test of techniques important for future LWS studies. This proposal addresses NASA Strategic goal 3B.

Paul Withers/ Boston University
Simulations of the Effects of Extreme Solar Fares on Technological Systems at Mars

We propose to study the effects of extreme solar flares and other disturbances on the Mars ionosphere in support of the Joint Focus Topic on Extreme Space Weather Events. Such flares will increase plasma densities at relatively low altitudes on timescales of minutes to hours. Ionospheric total electron content will change, affecting the accuracy of GPS-like navigation systems. Radio wave attenuation due to D-region absorption will change, affecting communications systems. GPS range error and radio signal attenuation will be calculated from a suite of ionospheric simulations. Several different flares willl be simulated using time-dependent solar irradiances. Solar zenith angle and other model inputs will be varied to explore parameter space.

C Alex Young/ADNET Systems, Inc.
Solar Image Processing Workshop IV: Algorithms for LWS

We propose to organize the 4th in a series of workshops on Solar image processing and data analysis. This workshop will focus on testing and comparing tools and algorithms that extract, classify and quantify physical features and events from solar image data. The workshop will be held in the fall of 2008 in the city of Baltimore. We request funding to cover the cost of hiring a venue that will accommodate ~85 attendees. We also request travel and per diem support for ~15 students in the fields of solar physics and image analysis. Support for this workshop will also include the publishing of a single volume to publish work presented as well as any other appropriately related work. This workshop will address the LWS focus of testing and validating tools that support LWS as well as the LWS steering committee's need for support of a "heliophysics discovery infrastructure".

Vasyl Yurchyshyn/New Jersey Institute of Technology
Predictions the magnitude and orientation of magnetic fields in magnetic clouds from solar surface data

Solar coronal mass ejections (CMEs) are a principal link that connects the chain of events in the solar atmosphere and the Earth's magnetic environment. The occurrence of earth-directed CMEs is well associated with geomagnetic disturbances since they can impose large negative Bz interplanetary magnetic fields across the dayside magnetosphere at 1 AU. The goal of this LWS Focused Science Topic is "to quantify accurately the polarity and magnitude of the IMF Bz for the next 12 24 hours. The prime measure of success for this work would be a good agreement in the time series of predicted and observed Bz values at L1". This proposal is chiefly focused on the predictions of the Bz component associated with solar eruptions, specifically, with magnetic clouds. We propose to pursue the following scientific objectives.
1) Recent research from our group has demonstrated that the intensity of the Bz component (therefore the size of a geomagnetic storm, as measured by the geomagnetic index Dst) appears to be well associated with the expansion speed of the halo CME that triggered the storm. We will expand the study to a statistically significant number of data points. Also, we will explore the Vcme-Bz relationship by utilizing MC analysis data. We intend to correlate halo CME speeds (LASCO, STEREO) with various parameters of MC inferred from real data (ACE, WIND, STEREO) and MC fitting procedures (e.g., magnetic flux and peak values of the Bz).
2) During past several years we studied the relationship between magnetic fields of solar sources of CMEs and the associated magnetic clouds. We thus found that the orientation of majority of ejecta does not change significantly during their propagation from the Sun to the near earth environment and there is a possibility to predict MC orientation (polarity) from solar data and coronal field modeling. We will further investigate, via data analysis and with reference to relevant models, the correspondence between i) orientation and twist of the post-eruption arcades (EIT, STEREO, AIA, Halpha), ii) directions of the MC’s axial and azimuthal fields (ACE, STEREO), iii) orientation of the halo CME elongation (LASCO, STEREO) and the tilt of the coronal neutral line

(synoptic maps, CCMC models). This analysis, employed together with contemporary MHD models that are becoming incorporated into the CCMC, will permit a very rigorous investigation of the relationship between CME source region magnetic structures and the corresponding magnetic structures existent in the interplanetary CMEs at 1AU.
One NJIT graduate student will be involved in the project.

Ming Zhang/Florida Institute of Technology
An Investigation of Solar Energetic Particles from Poorly Connected CME or Flare Events

We will investigate the propagation of solar energetic particles (SEPs) in the 3-dimensional heliospheric magnetic fields. The theoretical and data analysis project will try to solve the mystery why SEPs can come from CME or flare events that are not magnetically connected and why SEPs often form a uniform reservoir in the entire inner heliosphere. Our specific goal is to assess the role of cross-field diffusion in particle transport.

To resolve the role of cross-field transport of solar energetic particles, we will develop and run code for SEP propagation in realistic 3-d heliospheric magnetic fields with perpendicular diffusion. We use stochastic simulation to solve the full particle transport equation. Features of SEP events with and without perpendicular diffusion will be compared. Models with various magnetic connections between the spacecraft and solar particle sources will run to test features expected from perpendicular diffusion. The models will also include nonstandard heliospheric magnetic fields. Comparisons with high-energy SEP observations by multiple spacecraft will be made to extract the physics of particle interplanetary propagation. Solar flare particle events may also be included in the analysis.

Since SEPs, particularly those high-energy ones from gradual events, are a great concern of near-Earth space environment, the knowledge we gain from this study will eventually become an important asset for future development of tools to forecast near-Earth space radiation environment resulting from solar events, thus having values in protecting human and investments both in space and on the ground. In addition, the knowledge of particle transport in the solar system will enhance our understanding of numerous high-energy phenomena (e.g. cosmic rays, supernova remnants, gamma-ray emission) in astrophysics, because astronomical objects share the same physics in similar environments. The project has education values because it will be used to train graduate students in modeling and data analysis.
