Living With A Star Targeted Research and Technology
Abstracts of awarded proposals.
(NRA-03-OSS-01-LWS)

Below are the abstracts of proposals awarded funding for the Living With A Star Targeted Research and Technology Program. Principal Investigator (PI) name, institution, and proposal title are also included.

Charles Arge / University of Colorado at Boulder
Short-Term Time Evolution of Coronal Holes and Their Impact on the Solar Wind at 1AU

Project Summary: Coronal holes are the source of high-speed solar wind streams, and possibly of slow--speed streams, and thus play an important role in the nature and structure of the solar wind/heliosphere. Over the last decade, significant progress has been made in our ability to predict ambient solar wind conditions days in advance using a number of different models that vary widely in their sophistication (e.g., MHD and Potential Field Source Surface Models) but all of which are driven by photospheric field synoptic maps. These ambient solar models are not expected to and generally do not work well during periods of transient wind. However, a very recent comprehensive study by Arge et al. has shown that significant discrepancies often occur between model predictions and observations after transient wind has completed its passage past Earth and the observed solar wind has returned to ambient/background conditions (i.e., when the model is expected to resume performing well). Such discrepancies can persist for 2 to 3 days after the passage of the transient. To understand the origin of these differences, we will use coronal observations at time of CMEs to study variations in the pattern of coronal holes at the Sun. Our goal is to investigate if short-term changes in coronal holes (probably not visible in photospheric field synoptic maps) can be responsible for the changes seen at 1AU.

Sunanda Basu / Center for Space Physics, Boston University
Studies of Ionospheric Plasma Structuring at Low Latitudes from Space and Ground, their Modeling and Relationships to Scintillations

This research is a direct response to the near term emphasis in the announcement of opportunity for LWS TR & T on geophysical conditions favoring the development of low- and mid-latitude scintillations in the Earth's ionosphere. The exciting dataset from the GUVI sensor on the TIMED mission has opened up opportunities for global studies not hitherto possible. We utilize this dataset and couple it with models to isolate the drivers of equatorial electrodynamics. We will validate the results against electric field measurements by the Jicamarca radar (when available), a dense network of ground-based GPS receivers yielding total electron content and conjugate ionospheric imagers, all in the South American longitude sector. We have adopted a two-tiered modeling approach to drive the NRL bubble model with large-scale drivers derived from the SAMI3 model of the background ionosphere, constrained by the GUVI images at 135.6 nm. We will complete the loop by comparing the output of the bubble model against global scintillation measurements obtained from the AFRL scintillation network SCINDA. This will allow us to develop a metric for scintillation occurrence on a global scale at low latitudes. Our comprehensive approach will provide a better understanding of the characteristics of ionospheric plasma structures, and will lead to an improvement of the metric, thereby advancing our capability to predict the occurrence of scintillations. The societal benefit of such improved capability to predict ionospheric space weather will be considerable. This is because of the deleterious effects of large and small-scale plasma structures on satellite communication and GPS-based navigation systems. We will investigate how these effects are controlled by the solar influence on the background ionization density as well as, solar transients that lead to geomagnetic storms and penetration of high latitude electric fields into low latitudes. Such electric fields profoundly modify the ionospheric plasma processes in space and time. Thus the dual goals of this comprehensive research effort, better understanding of ionospheric plasma structuring and estimating impacts on technological systems, are what makes this project uniquely suited to NASA's LWS Program.

Robert Benson / Goddard Space Flight Center
Solar-Cycle and Short-Term Variations of Topside Ionospheric Electron-Density Profiles

The overall objective is to determine the dependence of the mid-latitude topside ionospheric electron-density (Ne) altitude distributions on long-term solar-cycle variations and short-term solar-wind and magnetic disturbances. The main focus will be on Ne profiles from the height of the ionospheric Ne maximum to ~ 3,000 km as deduced from ISIS (International Satellites for Ionospheric Studies) topside-sounder data. These data, obtained over an 18-year time interval, will be used to investigate secular changes in the topside Ne profiles, which reflect altitude changes in plasma temperature and ion composition, over more than a solar cycle. In addition to providing average distributions the data, which extend from the O+ dominated high-altitude F region to the H+ dominated plasmasphere, provide a unique framework for delineating the altitude dependence of mid-latitude ionospheric structures associated with the plasmapause, plasmaspheric tails and Storm Enhanced Densities. The approach will be to (1) extend the digital ionospheric topside-sounder data base at the National Space Science Data Center (NSSDC) back to the solar minimum of 1965, (2) process all digital topside-sounder ionograms recently made available at the NSSDC into topside Ne profiles (making them also available to the scientific community via the NSSDC) and (3) relate latitude/local-time changes in the average mid-latitude topside Ne profile characteristics, particularly scale-height variations, to changes in solar-activity indices, solar-wind parameters and geomagnetic indices. Our objective supports the Living With a Star (LWS) goal "to develop the scientific understanding … to effectively address those aspects of the connected Sun-Earth system that affect life and society" in that a knowledge of mid-latitude topside ionospheric structures and their dependence on solar conditions is needed to mitigate the ionospheric impacts on advanced technological systems, such as GPS positioning, where the ionospheric effects on trans-ionospheric radio propagation is often the limiting factor on overall system performance. It supports the LWS Targeted Research and Technology broad objective #1 by performing "…the analysis and interpretation of past and present data to identify and understand the basic physical processes underlying the Sun-Earth system …" and also one of the research topics listed of high current interest, namely, "The effects of varying solar EUV radiation on the Earth's ionosphere and atmosphere."

Joachim Birn / Los Alamos National Laboratory
Modeling Coronal Structures and Dynamics

Coronal mass ejections (CMEs) are a principal link in the chain of events that affect space weather and the Earth's plasma environment and hence play a central part in pursuing the objectives of NASA's Living With a Star (LWS) program. A crucial goal in the study of CMEs is understanding the evolution of the coronal magnetic field prior to an eruption. This goal requires the determination of the initial and boundary conditions that lead to an eruption and the identification of observable features associated with these conditions. Our proposed work consists of three major tasks. Task 1 is the derivation of suitable initial states. Since the pre-eruption state or states are not well known, a number of states need to be developed and tested. Here we propose to use an established analytical method, as well as a numerical method, to derive both force-free and non-force-free states and to determine their equilibrium properties. Some of these models will contain a twisted flux rope, connected to the photosphere and anchored in the corona by an overlying arcade, and others will include a helmet streamer configuration above the flux rope. These models will also be supplemented by several loop-type models previously suggested in the literature. Task 2 is the test of the stability and of the subsequent dynamic evolution of the various equilibrium configurations, using MHD simulations. Of particular interest are the potential development of current sheets, their breakup by magnetic reconnection, the development of flare loops and flare ribbons, and the identification of observable signatures that characterize the unstable configurations. Again, this requires the possible existence or formation of non-force-free configurations. The final task, 3, is to determine the energetic particles spectrum produced by reconnection as a function of space and time during the course of an eruption . In this work we will trace both ions and electrons as they propagate within the electric and magnetic field generated in the various MHD simulations. This test-particle approach will provide specific predictions for each model as to the type and distribution of energetic particles that it should produce. Such predictions can then be compared with energetic particle distributions that are inferred from the hard X-ray and g-ray emissions now being observed by the RHESSI spacecraft. Tasks 2 and 3 will also be supplemented by an investigation into kinetic aspects of magnetic reconnection, which might affect reconnection rates and particle acceleration.

Douglas Braun / NorthWest Research Associates, Inc.
Local Seismology of Solar Dynamics: From MDI to HMI

The Solar Dynamics Observatory (SDO) is the first major mission in NASA's Living With a Star Program, and is scheduled for launch in 2008. One of the major science investigations on board SDO is the Helioseismic and Magnetic Imager (HMI), designed to understand the structure and dynamics of the Sun's interior, especially the variation of magnetic activity, from helioseismic analyses. In this project, we are interested in addressing the following fundamental questions: 1) What is the nature of supergranulation?, 2) What is the subsurface nature of meridional circulation and how does it vary with time?, 3) What is the nature of other large-scale flows and how do they correlate with magnetic activity?, 4) what are the local acoustic properties of the tachocline and how do they vary with time? and 5) what are the local acoustic properties of the solar poles and how do they vary with time? To address these questions, we propose to apply a variety of diagnostic utilities in seismic holography to existing data from the Michelson Doppler Imager (MDI) with the goal of preparing for their routine use with data from HMI/SDO. The goals of this proposed project are designed to further our understanding and predictive capabilities of the solar magnetic variability that influence life and technological systems on Earth.

Joan Burkepile / National Center for Atmospheric Research
Data Environment: Creation of Online Access to the Complete Set of Solar Maximum Mission (SMM) Coronagraph/Polarimeter Observations

The Solar Maximum Mission (SMM) Coronagraph/Polarimeter (C/P) was in Earth orbit and observed the solar corona from February through September of 1980 and from June, 1984 through November, 1989. The observations were taken in broadband white light with a field-of-view from approximately 1.8 to 5.0 solar radii. During these years the SMM C/P instrument recorded over 1300 coronal mass ejections (CMEs) and observed coronal brightess changes that varied with the solar cycle. The SMM Mission was originally funded under NASA contract S-04167 which expired approximately one decade ago. A small sample of SMM images are currently available from HAO via the internet. This small set of images are scaled and provided for qualitative use only. We propose to provide the SMM observations in their entirety, to the scientific community and general public via the internet. This work will involve conversion of the binary data into fits format, widely used by the astrophysical community, which can be used for both qualitative and quantitative purposes. The data will be transferred from exabyte tapes to a newly acquired data storage jukebox accessible to the the internet by a new SMM web site. This new web site will include basic viewing and analysis tools to allow users to measure positions and brightnesses in the corona as well as generating trajectories, densities and masses of CMEs.

Geoffrey Crowley / Southwest Research Institute
LWS: Effect of EUV and High Latitude Forcing on Thermospheric Densities

Changes in the density and composition of the neutral atmosphere create variable satellite drag, adversely affecting our ability to identify and track objects in space and to predict their re-entry into the atmosphere. We propose to use new density data from the GRACE, CHAMP and TIMED satellites, together with solar EUV drivers from TIMED, and various high latitude data to determine the effects of long and short-term variability of the Sun on the mass density of the atmosphere between 120 and 600 km altitude. Specifically, we will test our understanding and modeling of the effects of solar EUV, Joule and particle heating, and momentum forcing on thermospheric densities in the 120 - 600 km region. The proposed work will lead to improvements in our ability to understand and predict satellite drag variations during geomagnetic storms and during the solar activity cycle. Eventually, this work will lead to 1st principles models (probably with data assimilation) that describe these density (and associated composition) effects with accuracy better than 5%. In turn, the proposed work will lead to better predictions of satellite orbits. We propose to achieve our goals by answering the following three science questions: 1) What is the magnitude of thermospheric density changes in response to variability of the Sun on different temporal scales? 2) How does density in the upper thermosphere respond to Joule heating? 3) What are the key drivers of density perturbations in the upper thermosphere?

Giuliana de Toma / National Center for Atmospheric Research
Short-Term Time Evolution of Coronal Holes and Their Impact on the Solar Wind at 1AU

Coronal holes are the source of high-speed solar wind streams, and possibly of slow-speed streams, and thus play an important role in the nature and structure of the solar wind/heliosphere. Over the last decade, significant progress has been made in our ability to predict ambient solar wind conditions days in advance using a number of different models that vary widely in their sophistication (e.g., MHD and Potential Field Source Surface Models) but all of which are driven by photospheric magnetic field synoptic maps. These ambient solar models are not expected to and generally do not work well during periods of transient wind. However, a very recent comprehensive study by Arge et al. has shown that significant discrepancies often occur between model predictions and observations after transient wind has completed its passage past Earth and the observed solar wind has returned to ambient/background conditions (i.e., when the model is expected to resume performing well). Such discrepancies can persist for 2 to 3 days after the passage of the transient. To understand the origin of these differences, we will use coronal observations at time of CMEs to study variations in the pattern of coronal holes at the Sun. Our goal is to investigate if short-term changes in coronal holes (probably not visible in photospheric field synoptic maps) can be responsible for the changes seen at 1AU.

Matthew DeLand / Science Systems Applications, Inc.
Creation of a Composite Solar Ultraviolet Irradiance Data Set

A detailed knowledge of solar ultraviolet (UV) irradiance is critical to understanding the Sun-Earth system because of its impact in the terrestrial atmosphere. Satellite measurements of solar UV irradiance have been made since 1978, and numerous data sets are available (Nimbus-7 SBUV, SME, NOAA-9 and NOAA-11 SBUV/2, UARS SUSIM and UARS SOLSTICE). However, no single data set covers more than one 11-year solar cycle. Comparisons between overlapping data sets show both absolute offsets and time-dependent drifts. These differences need to be resolved in order to evaluate solar UV variations on longer time scales for climate studies. This proposal will merge the individual solar UV irradiance data sets from all available satellite instruments to create a unified composite UV irradiance data set. The wavelength range is 120-400 nm, which represents solar radiative input to the Earth's atmosphere from the surface to the mesosphere. The time period covered by the composite UV data set is November 1978 to the present, representing more than two complete solar cycles. Absolute offsets between data sets will be adjusted using comparisons to recently published reference spectra. Time-dependent differences between instruments during periods of data overlap will be evaluated using confidence limits assigned by the respective instrument scientists, as well as irradiance variations predicted by the Mg II proxy index. The composite irradiance product will then be created using a weighted combination of the observed irradiance data. This composite UV data set, in turn, will make it possible to examine relationships between irradiance and proxy data on multi-decade time scales. The composite UV irradiance data set will benefit additional areas of the Living With a Star program. We plan to merge our product with spectral irradiance data from the recently launched SORCE mission to provide a continuous irradiance data record for future climate studies. The solar extreme ultraviolet (EUV) spectral region below 120 nm provides energetic input for the ionosphere and thermosphere, but has not been measured with sufficient frequency or wavelength coverage to construct an equivalent irradiance data set. The composite UV irradiance data set will provide a comprehensive comparison product for all available EUV data sets, such as SOHO time series and TIMED SEE irradiances. This data set will also provide an improved basis for the development of empirical forecast models of solar activity.

Carsten Denker / New Jersey Institute of Technology

Data Environment: Data Mining and Visualization Server at Big Bear Solar Observatory

We are seeking short-term (1 year) support from the Living with a Star Program (NRA-03-OSS-01-LWS) to enhance the data environment at Big Bear Solar Observatory (BBSO). We propose to acquire a TByte storage system with the capability of storing about two years of BBSO data on-line. A WWW server with multiple CPUs and fast data I/O provides access to the data bank and tools for data mining and visualization. The BBSO on-line data sets include: 2k x 2k pixel, 14-bit H-alpha full disk images at a 1-minute cadence, daily 1k x 1k pixel, 12-bit Ca II K and white-light full disk images, 512 x 512 pixel, 14-bit H-alpha and Ca II K filtergrams from the 25 cm vacuum refractor with a field-of-view (FOV) of 300 arcsec x 300 arcsec at a 1-minute cadence, 512 x 512 pixel digital vector magnetograms from the 25 cm vacuum refractor with a FOV of 300 arcsec x 300 arcsec at a 1-minute cadence for the longitudinal magnetic field component and 4-minute cadence for the full Stokes vector, and high-spatial resolution 1k x 1k pixel, 12-bit filtergrams with a 75 arcsec x 75 arcsec at a 1-minute cadence from the 65 cm vacuum reflector obtained with the real-time image reconstruction system. All data have an extended SoHO-style filename and header information, which reflect the BBSO instrument specific characteristics, e.g., high cadence data, calibration level, spectral scans, etc. Flat-field corrected data is stored in JPEG format for quick look analysis and the corresponding FITS data (raw data and higher level data products) can be retrieved through WWW interfaces or simple scripts. All data analysis software is readily available. Only data storage limitations prohibited us so far from making all data available, which will no longer be the case with the proposed system. In the future, we intend to make higher level data products available such as MPEG movies of user selected regions of interest in the H-alpha full disk images, daily differential rotation maps in H-alpha and residual flow maps, and high-spatial resolution MPEG movies and corresponding horizontal flow maps. BBSO data has been used in many multi-wavelength studies of solar activity in coordination with NASA's space-based observatory platforms. One illustrative example are the H-alpha full disk images used to provide context data and operational information to the Reuven Ramatay High Energy Solar Spectroscopic Imager (RHESSI). We expect that the new TerraByte storage system and the fast WWW server for data mining and visualization will enhance the scientific output of NASA space missions and provide a valuable resource for the solar and space physics communities in the context of the Living with a Star program.

George Fisher / University of California Berkeley
A Global MHD Model of the Solar Interior for Coupled Sun-Earth System Studies

The primary objective of this proposed project is to understand how the observed evolution of magnetic fields on the Sun on long (solar cycle) time scales is related to dynamic processes occuring in the solar interior, where the Sun's magnetic fields are generated. This will improve our understanding of the connection between coronal and photospheric magnetic field topologies, as well as the connections between these fields and those in the solar interior. The successful achievement of this objective will allow the development of better predictive models for the transport and evolution of magnetic fields on the Sun, and a better understanding of the correct physics to include in solar cycle evolution models. To accomplish these goals, we will use two 3-D anelastic MHD models, an existing Cartesian model known as "ANMHD", and a new model in spherical coordinates that is now being developed, known as "SANMHD", as well as existing coronal models in use in our group at UCB/SSL. Both anelastic MHD models will be released to NASA/GSFC's Community Coordinated Modeling Center (CCMC), for general use by the "Living With a Star" (LWS) and Solar Physics communities. This project directly supports one of the 2003 LWS research topics of high current interest, "The magnetic field topology connecting the photosphere to the corona", as well as the general LWS goal of understanding basic physical processes governing the Sun-Earth system. Part of our effort will be to study the connection between the very different physical environments of the corona and the solar interior, crossing discipline boundaries.

Peter Foukal / Heliophysics, Inc.
Facular Studies to Improve Reconstruction and Prediction of Solar Irradiance

Our proposed study has three aims: 1.The recent balloon flight of the Solar Bolometric Imager (SBI) provides the first wide band images of the photosphere, creating an important opportunity to improve models of total irradiance variation.We propose to use SBI measurements of facular and spot contrast, together with ground-based and MDI magnetograms and photometry, to determine whether photospheric magnetic structures can account for rotational and 11-yr irradiance variation, or whether other mechanisms such as convective stirring might contribute. 2.Our recent reconstruction from archival CaK images indicates that solar total and UV irradiances differ significantly between 1915-1999 - a finding of key interest to climate modellers and aeronomers.We propose here to extend this reconstruction by using the white light facular area record compiled at Royal Greenwich Observatory between 1874-1976.Our aim is to compare the relative correlations with climate of the reconstructed UV and total irradiances, throughout the period of global warming,in order to assess their relative importance in driving recent climate. 3.The ratio of spot and facular areas early in a spot cycle has been shown to provide a good predictor of sunspot cycle amplitude in the 1874-1976 RGO data. It is also a key factor determining 11-yr irradiance variation.Our aim is to measure this ratio on WL images obtained at the onsets of cycles 22-23, to determine the more recent "skill" of this predictor, use it predict activity and irradiance levels in the forthcoming cycle 24, and study its implications for future non-axisymmetric,solar dynamo modelling.

Reiner Friedel / Los Alamos National Laboratory
Quantifying Energetic Electron Precipitation from the Radiation Belts and their Relation to Storm-Time Dynamics

One of the major obstacles to understanding dynamic inner magnetospheric dynamics of energetic electrons is our limited understanding of their dynamic loss processes. The recent LWS Geospace Mission Definition Team Report states: ``To be able to specify and predict changes in the radiation belt populations requires measurement and a quantitative understanding of the dominant loss processes". Losses are the most dominant feature during the onset-phase of geomagnetic storms, and lead to increased fluxes at LEO orbit which is occupied by a large amount of space hardware, including the International Space Station. Energetic electron precipitation increases during active times, but it is not known whether this increase is due to increased loss rates or simply an overall increase in the radiation belt population. Several of the wave particle interaction processes that may be responsible for both losses and acceleration of relativistic electrons are thought to exhibit strong local time preferences - dawn for whistler chorus, afternoon to dusk for EMIC waves, and are active during different phases of a geomagnetic storm. We plan to test these and other hypotheses directly. We expect to answer the following specific scientific questions, which are directly in line with the ``questions critical for the quantitative understanding of the role of electron loss" as stated in the LWS Geospace Mission Definition Team Report: 1.Can we quantify and document a relative increase of particle losses during active times? 2. Is there a local time and/or radial dependence to enhanced particle losses? Do these dependencies agree with theoretical predictions? 3. What is the relation of these losses with regard to the onset, main phase and recovery phase of geomagnetic storms? We intend here to use low altitude data from four recent NOAA POES spacecraft together with (near-)equatorial data from several satellite missions - from POLAR (one spacecraft, L=3--8), from HEO (2 spacecraft, L=2--4), LANL GPS (4 spacecraft, L=4--5.5) and LANL GEO (6 spacecraft, L=6.2--7.2) to investigate the location and strength of energetic electron loss processes during geomagnetically active times. POLAR, the DOE/DOD geosynchronous and GPS missions, HEO and NOAA spacecraft are all currently operational. They form an inner magnetospheric constellation and are an ideal testbed for future constellation-type missions such as envisioned by the Living with a Star Program. The resources of this existing constellation can be used by the Living with a Star Program at no operational cost.

David Fritts / NorthWest Research Associates, Inc.
Experimental and Modeling Studies of Potential Gravity Wave Seeding of Plasma Dynamics at Equatorial Latitudes

Atmospheric gravity waves (GWs) have been suggested for many years to play a role in seeding Rayleigh-Taylor instability, equatorial spread-F (ESF), and plasma bubbles penetrating to high altitudes. But despite numerous modeling studies and measurements suggesting such a role, no definitive experiments have occurred. Our goal is to combine comprehensive ground-based optical and radar instrumentation, in situ and nadir imaging satellite observations, and modeling of GWs arising from tropical convection and their propagation to high altitudes to document such seeding, if it occurs, and to assess the geophysical conditions favoring seeding and controlling GW influences on ESF and bubble statistics and morphology. Our research team represents a collaboration between three research groups and two satellite PIs who will jointly perform two measurement programs in Brazil coordinated with TIMED and ROCSAT-1 or C/NOFS. Our method will be to observe GWs arising from deep convection in central and eastern Brazil as they propagate through the mesopause and into the thermosphere, to measure the responses in the bottomside F layer, and to correlate these responses with satellite and radar observations of ESF and bubble structures at greater altitudes. Modeling efforts will assess and confirm the links between GW sources and ionospheric effects.

Peter Gallagher / GSFC
Fields, Fractals, and Flares: Understanding Magnetic Complexity in Solar Active Regions

Solar active regions are the source of many energetic and geo-effective events such as solar flares and coronal mass ejections (CMEs). Understanding how these complex source regions evolve and produce these events is of fundamental importance, not only to solar physics, but also to the demands of space weather forecasting. We propose to investigate the physical properties of active region magnetic fields using fractal-, gradient-, neutral line-, emerging flux-, and wavelet-based techniques, and to correlate them with solar activity. This will form the basis of a real-time online database of spaceweather-relavent data products. This timely study represents a non-phenomenological approach to describing and understanding active region evolution and the conditions that result in energy release. The results of this study will provide an important knowledge base for future missions within the Living With a Star (LWS) program, such as the Solar Dynamics Observatory (SDO), and the development of online environments such as the Virtual Solar Observatory (VSO).

Trevor Garner / Applied Research Laboratories, University of Texas at Austin
An Investigation of Magnetosphere-Ionosphere-Coupling Through the Subauroral Electric Field with the Development of a Parameterized Subauroral Electric Field Model

LWS seeks to better understand the coupling of the magnetosphere, ionosphere and thermosphere (MIT). Ideally, studies of the storm-time coupling would involve completely coupled models of these two systems. However, this coupling is often computationally prohibitive, and theoretical studies of one region typically employ a proxy model for the other region. The proposed work will investigate the role of the subauroral electric field in MIT coupling. In particular, this work will examine the how changes in the MIT system caused by the subauroral electric field feed back into the electric field. The Rice Convention Model (RCM) and the Thermosphere-Ionosphere-Mesosphere-Electrodynamics General Circulation Model (TIME-GCM) will be pseudo-coupled in order to investigate these feedback mechanisms. Pseudo-coupling is the process of using outputs from one model as inputs to the other model while running each model as a separate code. The RCM has successfully modeled subauroral polarization streams (SAPS), strong shielding electric fields, penetration electric fields, and overshielding. These electric fields will drive ionospheric motion and heat the thermosphere, which will significantly alter the ionospheric conductance. This is the main feedback mechanism to be studied in this proposal, but not the only one. The coupled inputs to be examined here are the global ionospheric conductance, the location of the auroral boundaries, the neutral wind-generated electric field, and the Region-2 generated electric field. By incrementally adding coupled inputs, the effect of each input will be determined independently. A series of test runs will be conducted to investigate the general behavior of the coupling. In addition, a parameterized subauroral electric field (PaSEF) model will be developed from the results of the pseudo-coupled runs. It is hoped that this PaSEF will replace the Volland-Stern model in general community usage.

Philip Goode / New Jersey Institute of Technology
Earthshine: Measurements and Simulations of the Earth's Reflectance

It is important to know the Sun's role in the apparent on-going global change in the Earth's climate. In this effort, one needs precise, globally integrated measures of relevant quantities extending over many years. To that end, we propose to continue observations, both photometrically and spectrally, and interpretation of the earthshine, which is sunlight reflected from the Earth and then retro-reflected from the Moon back to the earth. Proposed Scientific Objectives in the Earthshine Project: 1) We propose to continue our photometric observations of the earthshine from Big Bear Solar Observatory (BBSO), while expanding these observations to a global network. These data are critical in our efforts to determine the relationship between a varying terrestrial albedo and a variable Sun. For this, we need a precise determination of the reflection of the Earth in all directions, the Bond albedo. From a single site, we can reliably determine the Bond albedo as an annual average. The global network is essential here because our modeling has convinced us that we can determine precise monthly averages with it. Monthly averages enable us to make more precise comparisons with climate parameters and various measures of solar activity from sunspot number to galactic cosmic ray flux at the Earth. 2) We propose to improve our simulations to include more sophisticated models of the terrestrial scenes, while including more parameters for the cloud cover by using data from the International Satellite Cloud Climatology Project (ISCCP). An improved treatment of the clouds is required to improve our simulations. 3) We propose to sharpen and exploit the connection of the earthshine observations to cloud cover data from ISCCP, which will significantly improve our understanding of cloud cover data and aid our efforts to determine the connection between the solar output and the net sunlight reaching us on Earth (solar irradiance plus any indirect effects of irradiance and/or solar magnetism on the Earth's reflectance) . The ultimate goal is to learn the origin of the terrestrial signature of the solar cycle, and the usefulness of the sunspot number as a proxy for the net sunlight reaching Earth. 4) Finally, we propose to perform and interpret spectral observations of the earthshine in the visible and near infrared to study the variation of the atmosphere's greenhouse gas (water, carbon dioxide, methane, ?) content to understand the physical origin of the Earth's radiation budget variability. Here we also will probe the wavelength dependence of the Earth's albedo. In the near infrared where some greenhouse gasses have a strong signature, we propose to compare our observations with modelled spectra to reveal essential information about the abundance of greenhouse species in the atmosphere, providing temperatures, optical path lengths and column densities for each of them. These parameters are otherwise difficult to determine as a global average, in particular for water vapor, which is not a well-mixed gas. Further, we propose to monitor changes in the abundances of those species and the radiative properties of the atmosphere. These Earth-as-a-star observations can also provide complementary information to future NASA missions searching for extra-solar planets. In "Astrophysics in 2001" by Trimble and Aschwanden (2002), the authors remarked about our earthshine observations saying that this "type of lunar-geo-solar observations is one of the rare interdisciplinary examples that naturally fulfills all requirements for NASA funding, for originality of astronomical research to direct benefits for humankind".

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

Data products based on coronal mass ejection measurements are currently made available on line (cdaw.gsfc.nasa.gov). In order to facilitate and enhance the data analysis and modeling activities geared towards achieving the goals of the Living with a Star program, the data base needs to be continually updated and maintained. We propose to enhance the CDAW data center with new value-added products such as mass of the CMEs and online computing facilities for easy accessibility and utility for modelers. The data base will also support the development of automatic CME detection schemes, which will become inevitable when LWS missions start collecting data The data base will also be used the develop the understanding of CME-rate variability over the current solar cycle (23).

Janet Green / LASP, University of Colorado
Relativistic Electrons in the Outer Radiation Belt: Understanding How Losses Contribute to Flux Variability During Storms

Recent studies show that storms can cause the outer radiation belt electron flux levels to increase or decrease suggesting that both acceleration and loss are enhanced and either process may dominate. The purpose of the proposed research is to understand how losses contribute to the variation of the outer radiation belt electron flux during storms. Several loss mechanisms have been proposed but not confirmed partly because of difficulties even identifying true loss that is often obscured by flux changes due to adiabatic electron motion. We propose to first identify times, locations, and amounts of true electron loss during storms by examining electron phase space density expressed as a function of the adiabatic invariants which highlights true irreversible electron loss. Secondly, we will examine whether precipitation to the atmosphere contributes to electron loss during storms by comparing the time, location, and amount of true loss to measured precipitation. Lastly, we will determine whether magnetopause encounters contribute to electron loss during storms by comparing the time and location of observed loss to modeled magnetopause encounters and by comparing electron and proton phase space density that should both be similarly affected by magnetopause encounters.

Donald Gurnett / The University of Iowa
Data Environment Proposal for Archiving Cluster Wideband Plasma Wave Data for the International Living With a Star Program

The key objective of this data environment proposal is to archive high resolution spectrograms of all Cluster Wideband plasma wave data obtained to date. We propose to provide these data, along with useful documentation, to the Cluster Active Archive. The Cluster Active Archive is the repository for the high resolution data obtained from all of the Cluster instruments for the life of the mission. This repository is being constructed by the European Space Agency and will be part of that agency's contribution to the International Living With a Star programme. The Wideband data will be delivered to the Cluster Active Archive via either electronic link or on DVDs. A part of the proposed effort also involves the preparation of formal interface documents between the Cluster Active Archive and the WBD instrument Principal Investigator as to delivery products and schedules. The WBD data, in conjunction with the data from all of the other Cluster instruments, can then be obtained through the Cluster Active Archive to perform scientific research relevant to the Living With a Star program. We briefly describe some of the studies that can be carried out using these data, including (but not limited to) studies of the motion of the bow shock, reconnection at the magnetopause, the role of auroral kilometric radiation in substorms, and the significance of the intense storm-time chorus waves.

John Harvey / National Solar Observatory

Characterizing the Solar Vector Magnetic Field with Application to Space Weather Forecasting

We propose to acquire and use unique, new magnetic observations to characterize the physical properties and evolution of solar vector magnetic fields and to use this new understanding to help develop tools to forecast storms in the Sun-Earth system. A powerful new instrument called SOLIS provides the first regular, full-disk measurements of the solar vector magnetic field. It also measures the line-of-sight component of the photospheric and chromospheric magnetic fields with an unprecedented combination of sensitivity, freedom from instrumental polarization, high accuracy, and good temporal and spatial resolution. Although many aspects of the vector magnetic field will be examined, particular attention will be directed to spatial scales larger than a typical active region and to high latitude properties of the vector field. It is likely that these regions contain important information about the formation and evolution of open fields connected to the heliosphere and the magnetic structures that spawn coronal mass ejections. We will provide vector boundary conditions for models of the corona and heliosphere that have heretofore been forced to depend on only one component of the magnetic field. This will enable more accurate MHD coronal modeling. Vector observations of active regions will be used to calculate the fluxes of magnetic free energy and magnetic helicity. Variations of these fluxes will be evaluated as flare forecasting tools. We will study the structure and time variations of fields associated with filaments and large bipolar coronal streamers in order to test physical models of these phenomena and also to seek properties of use in building coronal mass ejection forecasting tools. We propose to operate SOLIS for daily periods up to two times longer than will otherwise be possible, to better support operating and forthcoming NASA missions such as SOHO, TRACE, RHESSI, STEREO, Solar-B and SDO.

John Harvey / National Solar Observatory

Translation and Correction of NSO Kitt Peak Vacuum Telescope Solar Synoptic Data

A 30-year record of daily full-disk observations of the solar magnetic field and helium chromosphere from the National Solar Observatory ended on September 21, 2003. These data have been widely used in support of NASA missions and in ~1000 scientific research papers and theses. The data suffer from various calibration problems and artifacts that can be corrected. The data and derived products are scattered across various media and are not readily accessible by users. We propose to correct known calibration problems, remove artifacts and store the data in a homogeneous environment that is easily accessible by users with widely available tools. We also propose to recalculate many secondary data products, including synoptic maps of several types. This restored data set will allow ongoing and forthcoming NASA solar missions to be placed in a longer context of varying solar magnetic conditions. The data will also be available for continuing research studies of the long-term behavior of the solar magnetic field and for studies of particular past periods of special interest.

Umran Inan / Stanford University
A Global Model of the Effects of ELF/VLF Chorus Emissions on Energetic Radiation Belt Electrons

We propose to construct a global model of the distribution of ELF/VLF chorus emissions in space and time during and following periods of magnetic disturbance. This model will be used to determine if the energization of radiation belt electrons to MeV energies is a result of interactions between the chorus and the electrons. We will use a non-linear test particle resonant interaction model calculation to determine the change in energy and pitch angle of resonant energetic electrons due to typical ELF/VLF chorus elements, including nonlinear effects due to the high intensity of the wave, the coherent nature of the waves, their frequency-time variation, and wave normal changes due to propagation effects. The chorus element will be characterized at the generation region using already analyzed POLAR and CLUSTER data. The characteristics of the waves after they leave the source region will be determined using raytracing. Using these results in conjunction with new findings concerning chorus occurrence and distribution in space and time, the global chorus-driven energization rates and pitch angle scattering rates will be calculated and compared with measurements to determine whether chorus is the dominant mechanism in the rapid, storm-time energization of electrons in the Earth's outer radiation belt.

Philip Isenberg / University of New Hampshire

A Kinetic Model for Preferential Acceleration and Heating of Solar Wind Heavy Ions

In the previous funding period, we developed our "kinetic shell" model of the maximal resonant cyclotron interaction for the energization of coronal hole protons by parallel-propagating ion cyclotron waves. Preliminary dispersionless results were encouraging, and we expected to obtain the evolution of both the fast wind proton distribution function and the wave spectra as functions of heliocentric radius in a coronal hole. However, we found that the addition of wave dispersion drastically limited the amount of wave energy which could be absorbed by the protons, and the perpendicular heating required to drive the fast wind could not be produced by this interaction. We concluded that some other energization process must be responsible for the bulk heating and acceleration of the protons. The situation is very different for heavy ions since, in contrast to protons, they can resonate with both sunward- and antisunward-propagating waves simultaneously. This capability results in second-order Fermi acceleration of the heavy ions, heating them primarily perpendicular to the magnetic field, in a manner not accessible to protons. We propose to model the radial evolution of a heavy ion distributions under the action of this Fermi acceleration along with the ion response to the standard gravitational and electromagnetic forces in the coronal hole. We will start with trace populations, like O^{5+} and Mg^{9+}, seeking to match the UVCS observations of these species. We will determine the required intensities of counter-propagating resonant waves and compare these results to recent theories of Alfven wave reflection and turbulent processes in coronal holes. We will then consider the case of alpha particles, whose bulk properties will affect the dispersion relation of the waves, leading to a more complicated interaction. Our goal will be to obtain a detailed kinetic description of the coronal hole heavy ion distributions, explaining the source of the preferential acceleration and heating of these ions which is consistently observed in the fast solar wind. This proposal seeks to address the Living With a Star RFA's under Goal II, SEC Theme, 1(a) and 2(a), which additionally support Goal I, SEC Theme 1(a).

Shrikanth Kanekal / Catholic University of America
Comprehensive Survey of Magnetospheric Relativistic Electron Dynamics over Complete Solar Cycle

Many geomagnetic storms result in the energization of electrons in the inner magnetosphere to relativistic energies with electron fluxes increasing by several orders of magnitude. It is well known that high solar wind velocity and southward component of the interplanetary magnetic field are the fundamental causative agents. Physical models of energization are many and invoke processes ranging from purely-adiabatic radial diffusion to in-situ acceleration by both stochastic and resonant wave-particle interactions. It is unclear under what circumstances a particular process or processes may be the dominant mechanism. This remains a major open scientific question in magnetospheric physics. It is also important from a space weather perspective since relativistic electrons are implicated in spacecraft anomalies and failures. The research proposed here will be to systematically survey electron energization over a complete solar cycle. The research undertaken will explore the internal magnetospheric dynamics and the dependence of electron energization upon external causative agents. We will measure characteristics of electron acceleration such as the spatial extent, temporal evolution of energy spectra, and acceleration, decay and isotropization times. We will compare relativistic electron events that occurr during different phases of a solar cycle. It is well known that during the declining and ascending phases of a solar cycle the magnetosphere is driven by recurrent high speed solar wind streams (HSS) and Coronal mass ejections (CME) respectively. The proposed work will also study of the relationship between the characteristics of relativistic electron enhancements and geomagnetic storm parameters. We will investigate the correlations between geomagnetic storm strength and duration, and the magnitude and extent of the relativistic electron fluxes. The uniqueness of our study comes from our use of data collected by the same suite of instruments over an entire solar cycle. These instruments provide a complete coverage of the entire outer zone over a wide range of energies. This research will be based upon data collected from PET, LICA and HILT sensors onboard SAMPEX and the HIST sensor onboard Polar. Both spacecraft provide energetic electron data over a wide energy and L-shell range. SAMPEX sensors cover the time periods starting from Aug 1992 to present and Polar from March 1996 to present. The use of high quality data collected from the same sensors over a long period of time reduces uncertainties in comparing different events. Interplanetary data will be obtained from sensors onboard ACE, Wind and other spacecraft. This study will provide valuable observational constraints on the various physical models of electron acceleration in the inner magnetosphere. Our results will also be a catalog of the properties of electron enhancement events over a complete solar cycle which will be highly useful in space weather studies.

Ramona Kessel / Goddard Space Flight Center
Multi-satellite Magnetopause Data Environment

The primary objective of this proposal is to bring online and make web-accessible a database of magnetopause crossings comprised of satellites spanning more than 3 decades and nearly 3 solar cycles. The current proposal is comprised of legacy data sets from the 1960's, 1970's, 1980's, and 1990's, but the design of the database will easily allow the addition of later data sets. Some of our lists of magnetopause crossings exist only as paper copies or on old magnetic tape and could be lost. Some lists are available through the internet but are not widely known or not generally available. We intend to join all of these lists into one interface that will be featured on the main NSSDC Space Physics web page. The final list will contain crossing times, locations and solar wind parameters when available. The new magnetopause database will be joined with a recent web-accessible bow shock database with data from 1974 to 2002, and will inherit all of the latter's capabilities. The multi-satellite magnetopause database proposed here will significantly enhance long term and global science studies. LWS is particularly interested in quantifying the behavior of the physics, dynamics, and behavior of the Sun-Earth system over the 11-year solar cycle and the magnetopause database will provide 3 solar cycles worth of data. Magnetopause global shape and position have been modeled extensively but never with such a complete database. The database can also aid in finding crossings of interest such as those under extreme solar wind conditions. Multi-satellite studies are essential to determine motion of the magnetopause or to resolve waves such as those associated with the Kelvin-Helmholtz instability. The database proposed here will enable these studies. This proposal also responds to two of the science objectives and research focus areas of the Sun-Earth Connection theme of OSS: Goal II SEC RFA 1(c) and Goal I SEC RFA 1(c). The multi-satellite magnetopause database will span more than 3 solar cycles and will facilitate studies within a particular solar cycle as well as across solar cycles. The magnetopause is the outer boundary of the Earth's internal magnetic field and is a critical transition region for transferring solar wind mass, momentum and energy into the magnetosphere and driving space climate.

Joseph King / QSS Group, Inc.
Creation of High Resolution OMNI and Other Merged ACE, Wind and IMP 8 Data Sets, and Solar Wind Cross-Correlations

This proposal is for a solar wind structure analysis via comprehensive cross-correlation analyses of solar wind field and plasma data from the ACE, Wind and IMP 8 spacecraft. Analyses will be performed over multi-year durations, and will assess correlation levels as functions of spacecraft separation vectors, solar wind flow types (low vs. high variances, low vs. high speed, CME's vs. "normal" flows, etc.) and time resolution of data. In anticipation of this analysis, the first year will be committed to creation of a hierarchy of data sets to be used in the analysis and to be made community-accessible initially via the NSSDC FTPBrowser family of interfaces. All but the last member of the hierarchy will be spacecraft-specific. The hierarchy will consist of (1) merged IMF-plasma-position data sets at plasma moments resolution; (2) a version of the first set resampled at a common 1-min resolution; (3) a version of the second set time-shifted via the minimum variance techniques of Weimer et al (2003) to the nose of the Earth's bow shock; (4) a single 1-min data set created by interspersing data from the spacecraft-specific time-shifted data sets. This last data set may be considered as a high-resolution OMNI data set, and should be very useful for solar wind-magnetosphere coupling studies. The availability of this hierarchy of data sets will facilitate pursuit by many researchers of studies of LWS-relevant solar wind structures and of solar wind-magnetosphere coupling. Researchers will have the option of starting at whatever level of the hierarchy they deem optimal for their analyses. Results of the second-year solar wind structure analyses will contribute to the growing understanding of such structures important for space weather predictability purposes.

John Laming / US Naval Research Laboratory
Electron Heating in the Solar Wind

The aim of this proposal is to model in as accurate a fashion as possible the evolution of elemental charge state fractions in the fast solar wind as it flow out of a coronal hole. Besides using the most up to date atomic physics data for this work, the important new feature will be a physics based model for the electron heating at heliocentric distance 1.5 R_sun or greater. The main goal will be to use the observed ionization fractions to constrain as tightly as possible the electron heating, which arises as gyrating ions in the presence of a density gradient excite lower hybrid waves, which then damp by heating the electrons. We expect this work to be of supreme relevance to current the NASA mission SOHO (especially the UVCS instrument), and also to future missions such as STEREO and Solar-B.

K. D. Leka / NorthWest Research Associates, Inc.
Resolving the 180 degree Azimuthal Ambiguity in Solar Vector Magnetic Field Measurements

Measurements of the vector magnetic field at the photosphere are crucial to determining the magnetic field topology connecting the photosphere to the corona, and to advancing the understanding of the origins of solar energetic events which propagate through the heliosphere. Inherent in those measurements, however, is a 180 degree ambiguity in the direction of the transverse field in the image plane, which can render the inferred measure of the vector field incorrect if not properly resolved. Numerous algorithms exist for resolving this ambiguity in photospheric vector field data, but all fall prey to: "the answer is straightforward when the active region is simple, but problematic when it's interesting." Shortcomings in the algorithms primarily stem from a lack of information on the variation of the field with height, and rely instead upon a priori assumptions concerning the magnetic field morphology to resolve the ambiguity. Such approaches typically search for the azimuthal solution which minimizes a measure of the complexity of the resulting field over the observed area. While minimizing these quantities results in a "lowest complexity" solution, it is not clear that the Sun itself is in the minimum state. We propose to improve upon this situation in two ways. The capability of the U. Hawai`i/ Mees Solar Observatory Imaging Vector Magnetograph (IVM) to obtain polarimetric data in the NaI D-2 spectral line will be exploited. The resulting magnetic field maps, obtained at a range of heights in the solar atmosphere from the photosphere through low chromosphere, will be used to impose div(B)=0 and obtain the correct solution to the azimuthal ambiguity. However, this approach is of limited utility by itself, since most vector magnetic field measurements are available at only a single height. Thus, the multiheight observations will be used in conjunction with model data derived from numerical solutions to Maxwell's equations, to test algorithms which require only single-height photospheric data. Using both multiple-height observations and simulated data, it will be possible to determine whether the Sun is indeed in a minimum state of magnetic complexity, and a quantity which measures that complexity. Then, an efficient and robust algorithm for optimizing that quantity can be determined. Although the algorithm will be developed using IVM vector field data, the code will be made available for use with other vector field data including that from upcoming NASA programs (e.g., Solar-B, SDO).

Janet Luhmann / University of California Berkeley
Inner Heliosphere Multispacecraft Data Analysis Tool

We propose to develop a web-based tool specifically for putting inner heliosphere multispacecraft data sets in the global context provided by solar wind models based on solar magnetic field measurements. The tool will be developed and tested using the twin spacecraft Helios data set in conjunction with contemporaneous near-Earth data from IMP-8 and ISEE-3. Three-dimensional global solar wind models will be constructed from the historical solar magnetogram data bases to provide displays and data manipulation options exploiting measurements at different spacecraft locations. The tool will provide new insight into the Helios mission multipoint observations using state of the art visualization capabilities and knowledge of coronal sources of the ambient solar wind, together with a new resource for interpreting future STEREO and MESSENGER mission data in combination with ACE measurements. It will similarly be ready for future LWS sentinels and any other serendipitous or planned heliospheric constellations that similarly seek global inner heliosphere context information for nowcasting, forecasting, or CME event backgrounds. The project will make heavy use of students in the user-interface design and testing of the tool.

Peter MacNeice / Drexel University
Modeling the Geoeffectiveness of Coronal Mass Ejections

We propose to develop a community tool that would enable users to quickly estimate the likely geo-effectiveness of Coronal Mass Ejections, initiated using an initiation process of their choosing . At present we have a 2.5D MHD model which has enabled us to study the `breakout' initiation process in the inner corona. While this model is ideally suited to study the initiation of the ejection, it is missing some critical components which are needed to enable it to follow the eruption to 1 AU.We propose to extend the model to achieve this. These components include, modifications to the energy balance description, and user interfaces to control set up of both the background magnetic field and the complex field topology required in the initiation region, and the solar wind state into which the eruption occurs. We will add a graphical user interface to allow users to modify the solar wind and initial magnetic field configurations, and the final tool will be made available to the community through the CCMC and through our web site. We will apply it to the `breakout' model, comparing results with those from our completed studies which used a simplistic description of the outer corona, to study the impact that a more realistic solar wind environment has on the evolution of the CME. Our modeling tool will report those properties of CMEs known to be key in determining geo-effectiveness. We will encourage and facilitate proponents of other initiatiation mechanisms in the use of the tool to perform similar studies for those models.

Petrus Martens / Montana State University-Bozeman
Stars as Suns: Unraveling Long-term Solar Variability by Stellar Dynamo Modeling

We propose dynamo simulations of stars that are very similar, but not identical to the Sun. The main goal is to better understand the nature and evolution of the solar dynamo by studying how its main characteristics (period, activity level), as simulated with the well tested mean field dynamo code, vary within the parameter space close to the observed or assumed input parameters and profiles that reproduce the solar dynamo, and by comparing these results with the periods, X-ray and Ca HK activity levels, that are known for various Sun-like stars. In particular we will carry out simulations for both the Babcock-Leighton (surface) and the mean field (convection zone) alpha-effect to determine which one reproduces better the dynamo periods and activity levels of Sun-like stars, and thereby is the more likely mechanism operating in stellar (and solar) dynamos. The relevance of this work is that a better understanding of the evolution of the dynamo mechanism will enable us to make more confident predictions for the Sun's variability spanning from solar cycle-like timescales to stellar evolutionary timescales. This will provide more reliable input for space weather and Earth's climate forecasters and is relevant for understanding the long term evolution of the Sun's magnetic field and its subsequent effect on the Sun-Earth connection. The proposal includes partial support for a postdoc and an undergraduate, and full support for a graduate student. It is our intention that this project will constitute the thesis research for the graduate student.

John McCormack / US Naval Research Laboratory
Investigating the Influence of the 11-Year Solar Cycle on Dynamics Using a High Vertical Resolution Zonally Averaged Photochemical-Dynamical Model of the Middle Atmosphere

This is a proposal to examine the influence of the 11-year cycle in solar ultraviolet irradiance on the dynamics of the middle atmosphere over the altitude region extending from the lower stratosphere to the mesopause. Recent results from a low-vertical resolution (~2.5km) version of the NRL CHEM2D model indicate the 11-year solar cycle can influence the quasi- biennial oscillation in stratospheric winds, but the effect is smaller than observations indicate. In addition, there are considerable uncertainties in the observed solar cycle effect on temperature near the mesopause. In both cases, current state-of-the-art interactive photochemical models may not have sufficient vertical resolution to adequately capture interactions between photochemical and dynamical processes that may help to explain the observed variations. The objective of this proposal is to perform detailed model simulations of the 11-year solar cycle with increased (0.5 km) vertical resolution to better represent the momentum deposition by breaking gravity waves that governs the dynamical variability of the middle atmosphere over seasonal and interannual time scales.

Jan Merka / NRC, NASA/GSFC
Solar Wind Input into the Magnetosphere: Assimilation of Multi-Spacecraft Data

The primary objective of this proposal is the reconstruction of the solar wind and IMF shear and gradients perpendicular to the Sun-Earth line by assimilating data from multiple solar wind monitors. This will allow the consideration of asymmetrical or non-uniform solar wind input into the magnetosphere based on multi-spacecraft data that is magnetohydrodynamically self-consistent. NOAA has been using L1 solar wind observations from ACE, and previously from WIND and ISEE-3, with considerable success to forecast geo-effective events with an approximately 45-minute warning time. However, there is still a significant rate of false alarms and some potentially dangerous events are missed all together. This proposal aims to enable better understanding of the solar wind input into the magnetosphere as a result of modern data assimilation techniques to reconstruct the variable solar wind profile across the magnetospheric cross-section in a more realistic manner using already available data from ACE, WIND, IMP 8, Geotail and Interball-1. The first portion of this study will implement data assimilation techniques (statistical interpolation) widely used in the meteorological community on the various data sets and the 3-D MHD numerical model ENLIL of the solar wind. The reconstructed transverse profile of the solar wind will be compared with observations near/inside the Earth's magnetosphere in order to estimate the gains in prediction accuracy of magnetospheric events. As a further refinement of the assimilation process, the shapes and orientations of the interplanetary shocks/discontinuities will be taken into account. The detailed knowledge of the transverse solar wind profile across the magnetospheric cross-section, which will be provided by the technique developed in this study, will allow the development of better understanding of the Sun-Earth interactions and will result in more accurate space weather predictions. In summary, this work will employ modern data assimilation techniques to reconstruct the solar wind profile, compare the results, based upon as many as five spacecraft, with single spacecraft observations and thus provide scientific guidance for future L1 multi-spacecraft concepts, as well as mission concepts for monitoring space weather conditions, one of the main goals of the NASA LWS program. This proposal aims to develop new techniques that will increase the utility of multiple spacecraft observing the solar wind as a single observatory.

Tom Narock / NASA/GSFC/L3 Comm
Extending the LWS Data Environment: Distributed Data Processing and Analysis

Current studies demand the combination of data from multiple instruments aboard different spacecraft. The curvature of shock fronts and the correlation scales of turbulent processes serve as prime examples. The need for quick and reliable access to this data is an ever-increasing one. In the current space science paradigm various data sets are available from different data providers, often in different countries. The currently developed SEC virtual observatories (e.g. the Virtual Solar Observatory (VSO) and Virtual Heliospheric Observatory (VHO)) primarily address the need of the scientific community to discover and access the most appropriate space science data sets via a user-friendly common interface that allows queries. Thus the VxOs will locate and deliver data from a large number of missions but, at least in their early form, will leave post-processing of the data to the user. Mere access to distributed data is not sufficient to create a comprehensive data environment. Specifically, there is clear need in the scientific community for some common post-processing of the data such as re-averaging, merging of multiple data sets to the same time grid, coordinate transformations and basic filtering and formatting. Therefore, we propose to develop a mechanism to provide distributed data services that can serve as an additional building block of the VxOs. Moreover, a prototype would be deployed - providing processing support for WIND and IMP 8 magnetometer data - to test the architecture and would be useful to the community even before integration into the VxOs. Since our concept is fully extensible, once the architecture is developed, tested, and integrated into the VHO with full public documentation, other members of the heliospheric community could add further data processing services with relative ease.

Merav Opher / JPL-Caltech
Numerical Modeling of the Evolution of CME Shocks in a Realistic Lower Corona and their Radio and Energetic Particles Signatures

This proposal will address two important questions for Living with a Star motivated by recent CME-related solar energetic particle (SEP) and radio observations: (1) Can strong CME-driven shocks form in the lower corona (~3 solar radii) and accelerate particles to the GeV/nucleon energies observed in some ground level CME-related events? and (2)

Can some CMEs drive multiple coronal shocks, as suggested by radio observations, because of the strong variations in the magnetosonic speed in the lower corona? While it is general accepted that the largest energetic particle events are created by CME-driven shocks in interplanetary space, the relative importance of CME-driven shocks versus flare-related processes in creating energetic particles low in the corona is not understood and is an area of active research. To answer these questions, we will use the state-of-the-art 3D MHD BATS-R-US code to model CME-driven shocks in the lower corona. This code is the most suitable for this task because its adaptive grid capability will allow sufficient resolution near the Sun to follow the CME and shock evolution. The CME will be modeled as a buoyant flux rope lying under a closed field region. The MHD code will first be used to create realistic background corona using observed photospheric fields for boundary conditions so that results from the model can be compared to SEP and radio observations from specific CME events. We will validate the background corona by computing the magnetic field topology and solar wind from the Sun to 1 AU and comparing results from the model with in situ solar wind observations from ACE. This will be the first 3D MHD study focused on understanding the formation and evolution of CME-driven shocks in the lower corona and their role in SEP creation. In keeping with the goals of the LWS TR&T program, this research will increase our scientific understanding of the basic physical processes underlying the Sun-Earth connection. The team assembled, consisting of scientists from JPL, the University of Michigan, GSFC and the University of Florence, has the necessary numerical, analytic and observational experience needed for the proposed work.

J. Michael Picone / US Naval Research Laboratory

Predicting EUV Irradiance and Induced Upper Atmospheric Density Changes from EIT Solar Imagery

Since solar EUV radiation controls the temperature and composition of the upper atmosphere and ionosphere, the ability to predict the EUV irradiance is crucial for predicting the impact of space weather, as evidenced by upper atmosphere mass density effects on spacecraft drag, and ionospheric electron density effects on communications and navigation. The overall goal of the proposed work is the capability to forecast solar EUV irradiance and induced upper atmospheric density changes on time scales of days to weeks. The approach is to analyze the east limb portion of full-disk EIT images to extract information about active region EUV sources on the verge of becoming visible at the Earth. This approach is possible because sources of bright EUV emission are loop structures that extend up to a few solar radii above the visible surface of the disk. Bright EUV sources near the limb, but on the far side of the Sun, can thus be present in the field of view of the EIT EUV images. Since a bright active region has its maximum impact on EUV irradiance roughly 7 days after it appears on the limb, when it reaches the central meridian, we will be able to predict EUV irradiances on times scales of days to weeks from analysis of the EIT images. We will test the predicted EUV irradiances, determined from the EIT images, by direct comparison with the actual irradiances to quantify the probability that the predicted irradiances will fall within specified ranges. We will also compare the EIT-based predictive tool with the forward propagation of the primary power identified through statistical analysis of the irradiance time series. We will then use the newly developed predictive tool to forecast solar EUV-induced upper atmospheric density changes, and evaluate the space weather utility of the work. This will be accomplished by inputting the predicted irradiances to the NRLMSIS upper atmosphere density specification model (converted to the solar activity proxy that the model uses). The predicted total mass densities will be compared with actual mass density variations which we have derived in past work from the orbits of three Starshine spacecraft during the period from 1999 to 2003, with geomagnetic effects removed. Thus we will quantify the uncertainties of the EUV irradiance predictions in terms of induced density changes, and hence, orbital drag.

Edward Rhodes / University of Southern California
Improvement in the Data Environment for Global and Local Helioseismic Studies of the Changing Solar Interior

This is a proposal to improve the data environment for studies of the changing solar interior which are currently being carried out within the Living With a Star Program under NASA Grant NAG5-13510. Recently, several hints of possible temporal changes that have occurred during Solar Cycle 23 have been obtained through the application of helioseismic techniques to observations made with the Michelson Doppler Imager (MDI) Experiment onboard the SOHO spacecraft. These hints have included the discovery of the so-called Solar Subsurface Weather (SSW), and the confirmation of the existence of the so-called torsional oscillations in the sub-photospheric layers. The discovery of the SSW has included a reversal in the meridional circulation beneath the solar surface in the northern hemisphere during the years 1998 through 2001. NASA LWS Grant NAG5-13510 provides partial support for verifying that these same features can be seen in co-temporaneous ground-based observations taken at the Mt. Wilson Observatory 60-Foot Solar Tower since the SOHO mission began in 1996 and for searching for changes in both the meridional flow and in the torsional oscillations during Solar Cycle 22 using earlier MWO observations obtained on an annual basis since 1987. With the partial support of this grant, we have recently transferred 176 consecutive days (out of a 17-year total of 3270 days) of MWO Dopplergrams taken during mid-1996 to Stanford where we have employed two consecutive 72-day subsets of these images to confirm the existence of the torsional oscillations below the photosphere at that time. This data environment proposal will leverage the support provided by the above LWS grant since its approval will allow us to double the level of support of the three data analysts who have been processing the past MWO data and transferring the processed data to Stanford for analysis and permanent archival. Doubling their support will enable us to conduct our studies using a much larger amount of the past MWO archive than the current grant support will allow. We also propose to improve the radial resolution of the measurements of the shallow sub-surface layers by incorporating measurements of the frequencysplitting coefficients of the high-degree p-mode oscillations now that we have been able to remove the contamination introduced into those measurements by solar differential rotation. As soon as our MWO data have been archived at Stanford, they will also be available for use by the entire helioseismic community.

Aaron Ridley / University of Michigan
A New Data Environment for Ionospheric Electrodynamics Based on AMIE Results

In this proposal we seek funds to make a large database of ionospheric electrodynamic quantities available over the web. This database will be for the Northern and Southern polar regions (extending from the poles down to +/- 46 degrees magnetic latitude), and will include 1 minute assimilative mapping of ionospheric electrodynamics (AMIE) results for all of 1997-2001, or 5.25 million patterns. The patterns will be of ionosphere electric potential, Hall and Pedersen conductance, average and total electron energy flux, horizontal and field-aligned currents, electric fields, and Joule heating. In addition, AMIE provides the Auroral Electrojet (AE, AU, and AL) index and Dst index, which will also be provided. If funded, we will make a user friendly front end interface to the AMIE database.

David Rind / Goddard Institute for Space Studies
The Sun's Role in Decadal Climate Change since 1980, and in the last Century

The goal of this research is the empirical and modeling quantification of spatial climate patterns associated with decadal solar forcing, as distinct from ENSO, volcanic and greenhouse gas influences. A multiple regression of surface and satellite-based temperature data with the observed forcings will be done for the last 20 years, the time period covered by space-based data. The spatial pattern of the trend component may offer clues about its origin, specifically the relative importance of anthropogenic and solar forcings. The forcings/events will also be input to a high resolution climate/middle atmosphere model with chemistry to assess its responses for comparison with the observational record. The model will allow for a detailed evaluation of the potential response mechanisms. The analysis will then be extended to the past 100 years, and the patterns compared to the more recent data, to understand the consistency in response and the validity of the proposed forcings over this time (in particular the solar forcing). The research should provide new characterizations of contemporary regional climate responses to solar irradiance variations.

D Aaron Roberts / Goddard Space Flight Center
Tools for Global Understanding of the Sun-Earth System

We will develop and provide the LWS community with a suite of related tools that will greatly aid the understanding of large quantities of data from disparate sources, which will be essential for attaining a global understanding of the Sun-Earth system. SPDataShop will allow a scientist to read data in many formats (e.g., HDF, CDF, NetCDF, FITS, ASCII) and produce a panel plot or image as well as file output in the desired format. SPGifWalk will unite a large number of browse-level sites offering everything from SOHO movies of the solar corona to gif images of overview time series plots from the Polar spacecraft. SPBrowse will use uniformly formatted survey data from many missions (including various indices) to allow a user to examine long and short data intervals, comparing the results from many spacecraft with ease. The survey data will also allow simple but effective types of data mining. Finally, additions to the existing ViSBARD 3-D visualization software will allow a scientist to see multispacecraft data in a variety of input formats in the context of Tsyganenko field lines and other models. All the above tools, along with software and documentation libraries, will be integrated with the Virtual Space Physics Observatory that is being designed under separate funding; this will combine easy data access with many analysis tools, making, for example, the basic analysis of a "Coordinated Data Analysis Workshop" a matter of a day's work by a single researcher using numerical data rather than a multi-day meeting of many people who share gif plots.

Robert Schunk / Utah State University
USU GAIM Data Assimilation Model: A Scientific Tool for the LWS Program

The Global Assimilation of Ionospheric Measurements (GAIM) model is a physics-based data assimilation model of the ionized medium surrounding the Earth. It provides specifications and forecasts on a spatial grid that can be global, regional, or local. GAIM uses a physics-based ionosphere-plasmasphere-polar wind model and a Kalman filter as a basis for assimilating a diverse set of real-time (or archived) measurements, and it is capable of assimilating in situ and remote sensing satellite data as well as ground-based data. The resulting specifications and forecasts are in the form of 3-dimensional electron density distributions from 90 km to 30,000 km. In addition, GAIM provides global distributions for the self-consistent ionospheric drivers (neutral winds, electric fields, and particle precipitation patterns), and in its specification mode, it provides quantitative estimates for the accuracy of the reconstructed plasma densities. We propose to install the GAIM model on the CCMC computers so that the GAIM results will be available to the LWS community for scientific studies. We also propose to assimilate additional data sources and initiate a validation program.

Neil Sheeley / Naval Research Laboratory
Observational Signatures of Time Variations in the Sun's Open Magnetic Flux

OBJECTIVES: Geomagnetic activity is closely correlated with the strength of the interplanetary magnetic field (IMF), which in turn varies in proportion to the Sun's total open flux. Active region emergence, photospheric transport processes, and coronal mass ejections (CMEs) can cause the total open flux to increase or decrease. In situ measurements indicate that the IMF strength can vary by a factor of 2 on timescales of months, consistent with source surface extrapolations of the photospheric field. However, direct observational evidence for the opening up and closing down of magnetic flux in the corona or at 1 AU has been hard to find and/or interpret, leading to suggestions that the open flux remains constant, simply undergoing footpoint exchanges with closed loops. Our objectives are (1) to identify, using photospheric, coronal, and interplanetary data, the observational signatures of the opening-up and closing-down of flux and of footpoint exchanges; and (2) to determine whether the locations, times, and occurrence rates of such events are consistent with the predictions of the photospheric flux transport and potential-field source-surface models. APPROACH: To search for signatures of the opening-up and closing-down of magnetic flux and of footpoint exchanges, we will make use of the large variety of data accumulated during solar cycle 23, including coronagraph, EUV, and photospheric field observations from SOHO, near-Earth magnetometer, plasma, and composition data from ACE and WIND, and ground-based magnetograms and He I 10830 spectroheliograms. We will determine if relationships exist between different types of events that might be associated with changes in the open flux, including (1) increases or decreases in the radial IMF strength, (2) photospheric flux emergence, (3) changes in coronal hole boundaries, (4) gradual outward expansions of helmet streamers, (5) CMEs, (6) streamer blobs, (7) coronal inflows, (8) electron heat flux dropouts and other plasma sheet variations at 1 AU. In addition, we will employ flux transport simulations and source surface extrapolations to predict changes in open field regions, and test these predictions against the observations. RELEVANCE: By identifying and elucidating the mechanisms that regulate the IMF strength at Earth, the proposed cross-disciplinary research addresses Objective 1 of the LWS TR&T program and at least one of the Specific Research Topics of High Current Interest ("The magnetic field topology connecting the photosphere to the corona"); also OSS Strategic Goal I, SEC Theme, RFA 1(a), Goal II, SEC Theme, RFA 1(a), 2(a).

Paul Straus / Aerospace Corporation
Contribution of Ionospheric Occultation Experiment (IOX) Observations to the

LWS Data Environment

The Ionospheric Occultation Experiment (IOX) is a GPS occultation sensor that is currently in orbit on a US Air Force Space Test Program (STP) satellite. IOX is the only currently operational GPS occultation sensor with an ionospheric mission focus and has been collecting a substantial database of GPS occultation data since late-2001. The IOX measurements of the GPS L1 and L2 signals can be used to derived precise line-of-sight total electron content (TEC) values, electron density profiles with good vertical resolution, and L-band scintillation. These types of measurements are key to fulfilling many LWS objectives. The IOX data is particularly useful for scintillation (including mid-latitude) studies and assimilative model evaluation and development. We propose to provide the science community with on-line access to IOX data together with a simple search/browse capability and ancillary information about IOX mission parameters useful for research.

James Thieman / Goddard Space Flight Center
A Space Physics Archive Search and Extract (SPASE) System for Data Access and Retrieval

This proposal concerns the Space Physics Archive Search and Extract (SPASE) system. The existing SPASE concortium intends to create a data search and retrieval system for the Space Physics science community. This will allow searching for data across multiple, diverse, international data archives through a single search mechanism. Underlying this effort is a common data dictionary/data model that serves as an "interlingua" to translate the user's query into the language understood by each individual archive and to put the metadata search results into a common language for intercomparison. SPASE allows the user to compare search results from the multiple archives through information sorting, visualizations, etc., and to extract data sets or parts of data sets based on these intercomparisons, such as parts of data sets spanning common time intervals. Some initial work has been done for SPASE but funding now is necessary to build a robust system on a reasonable timescale. In particular, it is necessary for a critical number of collaborating archives to be ready more or less simultaneously. Parts of SPASE require implementation at these individual data archives. We have assembled a team that is sufficient to demonstrate that SPASE can connect very heterogeneous archives of both satellite and ground-based data. The SPASE system that is created will be a very useful tool for space physics researchers even with only the archives participating in this proposal. It will be useful not only in locating and acquiring data, but also in connecting to services to help understand which data are useful. While connecting the diverse data centers together we will develop a variety of software tools which will ease the connection of other data centers to SPASE. We anticipate others joining in the effort using their own resources. In particular we will be working to connect with the Space Physics Virtual Observatories as they develop. This will facilitate the multi-discipline studies crucial to the understanding of Sun-Earth Connection science.

Richard Thorne / UCLA
Physical Processes Responsible for Relativistic Electron Variability in the Outer Radiation Zone over the Solar Cycle

Our basic understanding of the physical processes responsible for the variability of relativistic electrons in response to solar activity is currently incomplete. These extremely energetic electrons have important effects on life and society ranging from the disruption of satellites to the modification of the chemistry of the middle atmosphere and associated effects on climate and the quality of life. As an integral contribution to the LWS program we propose to investigate the basic non-adiabatic processes responsible for the injection, transport and loss of relativistic electrons in the outer radiation zone. Most of the important process that violate the adiabatic invariants involve interactions with various plasma waves. We propose to utilize existing satellite data to characterise the properties of relevant waves and their variability with solar activity, and then use this data base to evaluate diffusion coefficients to describe the non-adiabatic dynamics of relativistic electrons over the solar cycle. This will allow us to quantify the rates of electron acceleration and loss under different geomagnetic conditions, and thus understand why some disturbances lead to electron enhancement while others lead to net loss. This research is is central to NASA's interests in understanding the dynamic response of the near-space environment to solar activity and the coupling between the magnetosphere and the middle atmosphere.

Jon Vandegriff / Johns Hopkins University Applied Physics Laboratory
Data Environment - Restoration of AMPTE/CHEM Data

The Charge-Energy-Mass spectrometer (CHEM) on NASA's Active Magnetospheric Particle Tracer Explorers Charge Composition Explorer (AMPTE/CCE) mission made detailed measurements at high time resolution of energetic particle populations in the inner magnetosphere. This data contains a wealth of information about the behavior of the magnetosphere and the ring current. In particular, the high time resolution data is useful for studying sub-storm ion injection, as well as details about the relationship between Solar wind changes and magnetospheric response. Yet the high time resolution data for CHEM has never been readily available to the community. We will transition high time resolution CHEM data from its aging VAX/VMS-based storage and put online two new ASCII versions of the entire four and a half year dataset, one version calibrated, one version raw counts. The data will be placed on servers at JHU/APL and will also be archived with documentation in the NSSDC at Goddard. Furthermore, we will make the data available in an existing web-based tool for analyzing energetic particle data (the

Mission Independent Data Layer or MIDL; see the web site at http://sd-www.jhuapl.edu/MIDL). Finally we will provide CHEM meta-data to emerging Virtual Observatory (VO) systems. Our comprehensive efforts will permanently restore to the LWS program a valuable dataset on the inner magnetosphere, a region which will soon be receiving increased attention with the launch of the LWS Geospace Storm Probes.

Harry Warren / U.S. Naval Research Laboratory
The Magnetic Topology of Coronal Mass Ejections

Understanding the magnetic configurations of solar active regions that give rise to coronal mass ejections is a major component of space weather. Coronal mass ejections can drive geomagnetic storms, which disrupt communication and knock out power systems. Solar energetic particles generated by the CME as it expands into the ambient heliosphere pose a significant risk to human exploration in space as well as to satellite systems. Mnay models of CME initiation, such as the tether cutting and flux rope models, emphasize the activity near the core fields. In these models shearing motions along the neutral line lead to a build up of magnetic energy that is violently released once a critical threshold is reached. Recent work, however, has questioned the possibility of releasing magnetic energy from simple magnetic field topologies. The breakout reconnection model asserts that the magnetic field associated with a coronal mass ejection must be quadrapolar and have a null. In this model the overlying fields constrain the fields near the neutral line and allow stress to build up. Reconnection near the null point removes the overlying fields and permits the stressed fields to erupt. We propose to test the breakout, tether cutting, and flux rope models by performing a systematic study of the magnetic topology of coronal mass ejections. We will combine SOHO MDI magnetograms with potential and linear force-free field extrapolations and TRACE image data to determine if complex magnetic fields are really necessary for coronal mass ejections. We will also investigate the timing and location of pre-flare reconnection.

Simon Wing / Johns Hopkins University, Applied Physics Laboratory
3D Empirical Tools for the Magnetotail

The roadmap of NASA SEC STP calls for launch of several multispacecraft missions, namely Magnetospheric Multiscale (MMS), Magnetospheric Constellation (MC), and Geospace Electrodynamic Connections (GEC). NASA SEC LWS program will also launch complementary multispacecraft missions, e.g., Ionospheric Mappers (IM). New technique will be required to assimilate and display these multi-point measurements in the ionosphere and magnetosphere into coherent and unified 3D global images of the magnetotail. We have previously developed a method for inferring plasma sheet ion density (n), temperature (T), and pressure (p) from ionospheric observations. This method relies heavily on the accuracy of the ionosphere-magnetosphere mapping, which shall be improved with a new technique. The new technique could be applied and tested on the existing NASA and non-NASA satellites. The resulting 2-D/3-D plasma sheet profiles not only help guide the upcoming multi-spacecraft missions, e.g. spacecraft orbits and spacing, but also contribute to the NASA LWS science objectives. Therefore, we propose to (1) radically improve the ionosphere-magnetosphere mapping using grad p= j x B relationship; (2) expand the method to incorporate mid-altitude and high-altitude measurements; (3) construct 2-D/3-D plasma sheet n, T, and p from DMSP observations for over one solar cycle binned by solar wind and IMF parameters as well as storm and substorm onset times; (4) link our model profiles to Fok ring current-radiation belt model [Fok et al., 2001]; and (5) develop a 3-D magnetotail viewer. Relevance to NASA LWS Program The proposed work can significantly aid the upcoming NASA SEC STP and LWS multi-spacecraft missions. In addition, it is relevant to the NASA LWS TR&T Objective 2, which calls for developing new empirical tools and numerical simulations that predict the occurrence and amplitudes of solar, interplanetary, and geospace disturbances, including software that identifies, retrieves, assimilates, and portrays data and model results from different sources for LWS forecasting and research objectives (http://research.hq.nasa.gov/code_s/nra/current/nra-03-oss-01/appendA3_7.html). The proposed work addresses 3 NASA OSS Science Objectives and Research Focus AREAS (RFAs): (1) Goal I, Sun-Earth Connection Theme, RFA 1(b); (2) Goal II, Sun-Earth Connection Theme, RFA 1(c); and Goal II, Sun-Earth Connection Theme, RFA 2(b).

Yuk Yung / California Institute of Technology

Solar Forcing of Climate through Stratospheric Ozone Changes

There is compelling evidence that solar variability is implicated in climate change, but no credible mechanism has been established to date. The main difficulty in establishing a mechanism is that changes in total solar radiation absorbed at the surface are too small to explain observed changes in climate. We propose to investigate a mechanism that amplifies the influence of the sun through UV-induced ozone changes in the stratosphere. We will test our hypothesis by investigating various historical periods that have anomalous temperature and solar activity levels such as the Maunder Minimum and the Medieval Maximum. We propose a four-pronged approach to study the solar forcing of climate through stratospheric ozone changes. We will first investigate the well-documented changes in the ozone layer and their associated climate changes for the last two solar cycles. We will model the response of ozone in the stratosphere to UV changes using a 2-D photochemical model that includes the effects of realistic quasi-biennial oscillation and catalytic chemistry. The radiative forcing due to ozone changes will be modeled using the MODTRAN code and compared to data from NCEP/DOE Reanalysis II. The changes in stratospheric ozone and radiative forcing will be used as input to an idealized GCM to drive changes in heating rates and the stratospheric zonal wind patterns. These changes will affect the strength of the stratospheric polar vortex by changing the propagation of upwelling planetary-scale waves, which in turn can effect tropospheric dynamics. Therefore, the ozone-induced changes in stratospheric winds can indirectly affect tropospheric climate. The experience gained from the idealized GCM will be used to carry out more realistic investigations using the Whole Atmosphere Community Climate Model of NCAR. We will analyze the state of the paleoclimate climate using the most recently obtained data and compare the model-predicted impacts with these data. We have shown that the tropospheric Northern Annular Mode is influenced by changes in the solar UV radiation, suggesting that a mechanism of solar influence on climate involves modulation of this mode. Our proposed mechanism couples the changes in solar UV emission to those of ozone and ultimately tropospheric dynamics. If we successfully demonstrate that this mechanism is at work in the best climate models, this study will open a door to future space-borne observations of the solar-climate relationship.

Eftyhia Zesta / University of California, Los Angeles
Space Weather Effects of Solar Wind Pressure Fronts: Atmospheric Energy Input and MeV Particle Energization

Recent studies have suggested that solar wind dynamic pressure enhancements can cause energetically very significant disturbances in our environment's Space Weather. Specifically, large amounts of energy are deposited on the Earth's upper atmosphere and energetic particles in the inner magnetospheric region are further energized. We propose to use dynamic pressure step changes and long-lasting pressure pulses in the solar wind unambiguously identified from 2-point measurements from SoHO and WIND from 1996 to present to determine the specific affect of such pressure fronts on the total energy input to the Earth's upper atmosphere and the energization of MeV particles in the inner magnetosphere. Complementary solar wind data from IMP 8, ACE, Geotail, and Interball 1 spacecraft will also be used when available in order to more accurately determine the timing of the pressure front impact on the magnetosphere. We will then use data from ground magnetometers (MACCS, CANOPUS, Greenland), the SuperDARN radars, all-sky imagers and median scanning photometers, Polar UVI, IMAGE FUV, low-altitude DMSP, and geosynchronous LANL and GOES spacecraft to determine the magnetospheric and ionospheric response and the temporal propagation of this response across the magnetosphere and ionosphere. We will focus our research on answering the following three scientific questions regarding the responses to solar wind pressure fronts: 1) the response of the auroral precipitating flux to solar wind pressure enhancements for different IMF conditions, 2) the response of the ionospheric and large-scale field-aligned currents as well as the ionospheric Joule heating under different IMF conditions, and 3) energization of MeV particles in the inner magnetosphere under different IMF conditions before and during the pressure front event. We will then investigate the physics driving the responses using the UCLA-GGCM global MHD model. This will be accomplished by comparing the observations with the results of the model, identifying what major features of the observations can be accounted for by the model and determining the causes of those features using properties in the model. We will also determine what features of the observations cannot be explained by the model physics, thus providing the modelers with clues on how to improve the model.

Jie Zhang / Center for Earth Observing and Space Research/George Mason U
A Systematic Study on Solar Sources of Major Geomagnetic Storms from 1996 to 2006

We propose to systematically investigate solar sources of major geomagnetic storms for an entire solar cycle from 1996 to 2006. This is based on our previous limited study for a period from 1996 to 2000. There are three major tasks: (1) unambiguously identify solar CMEs that are responsible for major geomagnetic storms and their surface source regions, (2) study the properties of geo-effective solar CMEs and their interplanetary counterparts (Interplanetary CMEs), and structural and magnetic linkage between solar CMEs and ICMEs (3) build an empirical model to predict onset time and intensity of major geomagnetic storms using solar inputs. The observational data used in this project include (1) ground-based observations of geomagnetic activity index Dst (2) in-situ solar wind plasma and magnetic observations in near-Earth space from ACE and WIND experiments, (3) solar CME observations from the LASCO instrument on SOHO, (4) coronal observations from the EIT instrument on SOHO, (5) solar magnetic observations from the MDI on SOHO, (6) other routine solar observations, e.g., flares and filaments. The data product of this project is a comprehensive set of geo-effective Sun-Earth connection events containing information on their source regions, and properties of the corresponding solar CMEs and ICMEs. The scientific goals are to answer what and why certain CMEs are particularly geo-effective, and what are the physical (structural and magnetic) connection between solar CMEs and ICMEs. The potential application of this project is to build an empirical-based model to predict major geomagnetic storms 30-100 hr in advance.