Living With a Star Program
Abstracts of Selected Proposals
(NNH13ZDA001N-LWS)

Below are the abstracts of proposals selected for funding for the Living With a Star program. Principal Investigator (PI) name, institution, and proposal title are also included. **187** proposals were received in response to this opportunity. On September 26, 2013, a total of **25** proposals were selected for funding.

Graham Barnes/NorthWest Research Associates, Inc.
Characterizing Coronal Magnetic Null Points and Their Relation to Eruptive Events

The topology of the coronal magnetic field is determined in part by the presence of magnetic null points, making them of fundamental importance in understanding the coronal magnetic field. In addition, the breakout model for the initiation of coronal mass ejections (CMEs) requires the existence of a null point. We propose to model the coronal magnetic field using a Potential Field Source Surface (PFSS) model computed from SDO/HMI vector magnetograms, locate null points in the PFSS model, characterize their evolution, and relate their presence to the occurrence of eruptive events. We will determine the typical lifetime of null points, and how they are formed and vanish in the context of whether they are associated with open field. The high cadence of HMI data will allow for following the evolution of the null points, and for a close temporal association with the start of CMEs, while the full disk magnetograms will allow the global structure of the field to be modeled, and potentially allow for an investigation of the distribution of null points at high latitudes.

The NASA/Heliophysics Living With a Star request 1.3.2, Science Analysis for the Solar Dynamics Observatory (SDO) Initiative "challenges proposers to use the data from the Solar Dynamics Observatory (SDO) to characterize the properties, evolution, and terrestrial consequences of the solar magnetic field". The proposed investigation will characterize the properties and evolution of one key topological feature the coronal magnetic field: null points. Relating their presence to CMEs also has indirect implications for the terrestrial consequences of the solar magnetic field.

Ashley Crouch/NorthWest Research Associates
Using SDO/HMI Observations to Probe Beneath the Sun's Magnetic Regions

The objective of the proposed research is to determine the internal and subsurface structure of solar magnetic flux concentrations, such as sunspots and plage. This will be achieved through a combination of local helioseismic data analysis and theoretical modeling of the interaction between solar oscillations and magnetic flux concentrations. We will develop models for the internal and subsurface structure of solar magnetic flux concentrations that are consistent with both local helioseismic measurements and measurements of the magnetic field at the solar photosphere. To make these measurements we will use the Helioseismic and Magnetic Imager (HMI) on the Solar Dynamics Observatory (SDO). To determine the internal and subsurface structure of solar magnetic flux concentrations we will take the following approach: (1) Construct a set of magnetohydrostatic models for a given magnetic flux concentration using the magnetic field observed at the photosphere as a constraint. (2) Use numerical simulations of wave interactions with the magnetohydrostatic models to generate synthetic helioseismic data. (3) Apply helioseismic measurement procedures to both the observational data and the synthetic data. (4) Select the models that provide the best agreement with observations. This approach will be validated using artificial data from realistic magnetoconvection simulations where the subsurface structure of the magnetic flux concentration is known.

Yue Deng/University of Texas Arlington
Vertical Winds: Possible Forcing and Influence on the Upper Atmosphere

An accurate description of vertical winds in the thermosphere is essential to understand how the upper atmosphere responds to the geomagnetic storms. Even small vertical winds have a significant effect on the atmospheric density, composition, dynamics, electrodynamics and ionosphere because of the large vertical gradients. However, vertical winds have not been observed systematically and the simulations of effects on the upper atmosphere are very limited. Recent observation deployments and modeling developments now permit substantial progress on this problem. Observations from satellites and expanding ground-based networks, such as Fabry-Perot interferometers (FPIs) in Alaska and Brazil, are providing unprecedented coverage for understanding the role of vertical wind dynamics. Developments in first-principles models, such as the non-hydrostatic model, enable significant improvement on vertical wind simulations. Therefore, it is timely to investigate vertical winds and influence on the upper atmosphere through complementary data analysis and model simulations. In this project, the data sets from FPI ground-based observations along with DMSP and CHAMP satellites and the simulations from non-hydrostatic General Circulation Model(GCM) will be used to investigate F-region vertical winds due to different forcings at both high and low latitudes and to characterize their influence on the ionosphere and thermosphere. Specifically, we will:

(1) analyze FPI vertical wind observations at F-region altitudes in the aurora zone. The correlation of vertical wind with geomagnetic energy inputs will be investigated. The observations will be compared with simulations from the non-hydrostatic Global Ionosphere-Thermosphere Model (GITM). It will greatly improve our capability to describe the neutral wind responses to the magnetospheric energy inputs.

(2) Simulate vertical winds in the cusp during storm periods with GITM in high resolution. The term analysis of the neutral continuity equation will be conducted to study the relative significance of vertical wind to the neutral density. It will significantly

advance our understanding of the neutral dynamics and its relationship to upper atmosphere storm time response.

(3) Process data of FPI observations at F-region heights from equatorial Brazil and conduct a climatological study of vertical wind at low latitudes for the first time. The climatology of vertical winds will be compared with the GITM simulations. It will give us a unprecedented view of the nighttime vertical wind at low latitudes, which is critical to specify the dynamics of the upper atmosphere.

(4) Investigate the influence of vertical wind caused by the perpendicular ion-drag force on the equatorial thermosphere anomaly (ETA) for the first time using the non-hydrostatic GITM. It will help us to unveil the ETA mystery and greatly advance the understanding of the momentum coupling between ionosphere and thermosphere.

The overall goal of this project is to substantially improve the description of the dynamics in the upper atmosphere associated with vertical winds and advance our understanding of the coupling between ionosphere and thermosphere. This investigation will make significant contributions to the scientific objectives of the NASA LWS Focus Science Topic: Thermospheric wind dynamics during geomagnetic storms and their influence on the coupled magnetosphere-ionosphere- thermosphere system. Specifically, it will improve modeling and characterization of thermospheric wind processes during disturbed periods and to improve understanding of the role of winds in ionospheric storm time dynamics. Furthermore, this investigation will make important contributions to three science questions from the Heliophysics Roadmap. We would intend to interact with space physicists in the team to work on problems of overlapping interest that may be identified.

Cooper Downs/Predictive Science Incorporated
Using EUV Waves to Probe the Solar Corona

SDO/AIA observations of large-scale coronal waves (EUV waves) triggered by CMEs provide a tantalizing amount of information about the dynamics of solar eruptions and the ambient plasma state of the solar corona. While much progress has been made during the lifetime of the SDO/AIA mission, many questions remain about the physical nature of EUV waves and the myriad of associated fine-scale structures that are now observed. Similarly, harnessing the potential of using EUV waves to make seismological estimates of magnetic field and/or plasma parameters remains difficult, due in part to the ad-hoc or simplifying assumptions often required for their interpretation.

In this context, we propose to improve upon current methods used for analyzing and understanding EUV waves. We will tackle this problem using a coupled observational analysis and modeling approach. This involves using a state-of-the-art MHD model to systematically couple the physical mechanisms of large-scale transients generated by eruptions directly to observables available from SDO/AIA. Our study will capitalize on the rich, high cadence multi-filter datasets provided by SDO/AIA, as well as recent MHD modeling developments that allow us to simulate solar eruptions for observed configurations in a global coronal model. In practice, this effort will involve two major arcs:

A) A series of eruption experiments which allow us to isolate and study specific aspects of EUV waves. A major component of this effort will be the express development and refinement of methods that can be used for the inverse problem, i.e. converting perturbations of the observables into meaningful insight on the changing magnetic and plasma state of the corona. We expect the output of these experiments to be broadly applicable to a large-number of events observed by SDO/AIA.

B) Case studies of selected solar eruptions observed by SDO/AIA. Here we will explicitly model the thermal-magnetic state of the entire corona before and during the eruption, bridging the gap between what was observed and the underlying physical evolution. These studies will also aid in characterizing the methods developed in the first effort.

The crux of this investigation is the synthesis of model results in terms of AIA observables and their direct comparison to available observational data. We believe that this coupled approach is a unique and complimentary way to harness the scientific potential of the SDO/AIA instrument, and is therefore relevant to the goals of the NASA LWS program.

Alex Glocer/NASA Goddard Space Flight Center
Competing Pathways of Radiation Belt Response to Solar Interplanetary Structures

Goals and Objectives: The response of the outer radiation belt to solar interplanetary structures is notoriously unpredictable. Such unpredictability is likely due to the numerous competing pathways through which Coronal Mass Ejections (CMEs), Corotating Interaction Regions (CIRs), and other structures can influence radiation belt sources and losses. It is the overarching goal of this proposal to understand what are the factors associated with interplanetary structures that affect the radiation belts, and to understand the pathways by which those factors exert their influences. Specifically, we will focus on the following objectives:

1) Identify the features of solar interplanetary structures associated with radiation belt sources and losses, and characterize how specific solar wind structures affect the radiation belt fluxes

2) Characterize and explain the pathways through which solar interplanetary structures regulate the wave environment, by:

a. Exploring the response of the plasmasphere, which is vitally important in understanding the propagation of waves, to these structures

b. Quantifying the response of the ring current electrons and ions, which provide the free energy for many of the important waves in the inner magnetosphere.

c. Characterizing how the magnetospheric composition changes in response to solar interplanetary structures. Knowledge of composition is vital to understanding wave generation and propogation.

d. Understanding the resulting generation and propagation of ULF, EMIC, Chorus and other waves in the magnetosphere

3) Identify how magnetospheric boundaries change in response to interplanetary structures and the consequences for sources and losses of radiation belt fluxes.

4) Translate the impact of solar interplanetary structures on the wave-environment and magnetospheric boundaries and plasma parameters to radiation belt fluxes.

5) Explain why and when pathways of influence dominate over competing ones.

Methodology: To achieve our objectives we propose a tightly integrated and well-coordinated Targeted Science Team (TST) to carry out a four-year study. Our TST will include observational studies correlating and characterizing the detailed space-time structures of interplanetary features impinging on the Earths magnetosphere with observations of the response of the radiation belts, global simulations (fully coupled magnetosphere, ring current, radiation belt, plasmasphere) of the magnetospheric response to these structures, and studies of wave generation and damping and the impact on radiation belt electrons. The core numerical models to be used include resistive, anisotropic and multi-fluid versions of the BATS-R-US magnetosphere code, the Comprehensive Ring Current Model (CRCM), the Radiation Belt Environment (RBE) model, and the SAMI3 model for the plasmaphere. Data for the observational aspects of the study will be drawn from various satellites including ACE, WIND, CLUSTER, THEMIS, SAMPEX, GOES, and the recently launched Van Allen Probes.

This work is directly related to LWS strategic goal number 3 which seeks to "...deliver the understanding and modeling required for effective forecasting/specification of magnetospheric radiation and plasma environments" to mitigate the effects of space weather on valuable space based assets.

Natchimuthuk Gopalswamy/NASA Goddard Space Flight Center
A Study on Flaring and Coronal Mass Ejection Activities at High Solar Latitudes using SDO Data

We propose to examine the flare and coronal mass ejection (CME) signatures of the polar crown prominence eruptions to test the hypothesis that the high latitude CMEs are similar to the low-latitude ones. In particular, we look for CME acceleration similar to the flare acceleration. The filter ratio method will be applied to the SDO/AIA images at 94 and

171 A to obtain the temperature evolution of post-eruption arcades. SDO and STEREO images will be combined to obtain CME kinematics.

The proposed work is important for a unified understanding of CMEs: they are all magnetically propelled from destabilized closed field regions. The proposed work also will clarify that the polar CMEs are not simple magnetic loop expansions, but are true eruptions like the low-latitude counterparts.

This proposal is submitted under "A Special Initiative: Science Analysis for the Solar Dynamics Observatory (SDO)"

Lon Hood/University of Arizona
Observed Atmospheric Responses to Short-Term Solar UV Variations

OBJECTIVES: The primary objective is to more completely determine the observed solar-induced change in stratospheric and upper tropospheric temperature, ozone, and circulation on active region and solar rotational time scales as a function of altitude, latitude, season, and QBO phase. The overall goal of the research is to follow how the initial solar-induced response in the upper stratosphere propagates downward to the Earth's surface, as needed to understand solar-induced climate change on longer time scales.

METHODS/TECHNIQUES: We propose a series of new correlative, linear regression, and cross-spectral analyses to better determine and characterize the response of the stratosphere and upper troposphere to short-term (< 40 days) variations of solar ultraviolet flux. Task 1 will consist of a determination of the dependence on altitude, season, and QBO phase of the stratospheric and upper tropospheric temperature and ozone responses, beginning with analyses of meteorological records and Version 8.6 SBUV column ozone data for 17 selected years since 1979 when short-term solar UV variations were especially large, and continuing with analyses of Aura MLS ozone mixing ratio and temperature data in the lower stratosphere for 45 selected months beginning in 2004. Task 2 will consist of a test of the hypothesis that short-term solar UV forcing is able to excite the Northern and Southern Annular Modes (NAM and SAM) in the stratosphere, which can then potentially penetrate downward to perturb tropospheric climate. Specifically, we will test whether the sensitivity of the tropical upwelling branch of the mean meridional circulation to short-term changes in extratropical wave forcing, which correlates with excitation of the NAM and SAM, varies with the solar UV flux on both solar rotational and solar cycle time scales.

SIGNIFICANCE/RELEVANCE: Short-term solar ultraviolet variations are a consequence of the production of magnetically active regions on the solar disk. A major forcing frequency corresponds to the 27-day solar rotation period, due to a tendency for the largest active regions to be on one side of the Sun. They penetrate into the upper stratosphere at low latitudes, modifying the concentration of stratospheric ozone, changing the latitudinal gradient of radiative heating, and perturbing the zonal wind at subtropical latitudes.On longer time scales, this solar forcing component is the main initiator of the proposed ``top-down'' mechanism for solar-induced climate change. The results of the work will help to identify primary dynamical mechanisms by which the solar-induced signal propagates into the lower stratosphere and troposphere; they will also help to validate general circulation and chemistry climate models, which can then be more confidently applied on longer time scales. The work directly addresses the observational part of Focused Science Topic (a) Short term solar/atmospheric variability and climate, as described in Appendix B.6 (Heliophysics Living With a Star Science) in the ROSES 2013 NRA.

Heejeong Kim/University of California Los Angeles
Effect of Alfvén Fluctuations in Solar Wind on Dynamic Variability of Outer Delt Relativistic Electrons

Although IMF Bz primarily controls the amount of solar wind energy input, it has been observed that Alfvén fluctuations in solar wind structure can be an important contributor to the large-scale transfer of solar wind energy. Our recent analysis of incoherent scatter radars and THEMIS satellites data showed evidence that enhanced Alfvén waves in solar wind can substantially affect the global convection and contribute to plasma sheet structure and dynamics, and to the occurrence of disturbances such as substorms, even under northward IMF. In particular, our recent observations suggest that there may be a close connection between solar wind fluctuations, localized flow structures within the polar cap, and geomagnetic disturbances, which provides important clues on how solar wind energy can be coupled and transmitted to the magnetosphere-ionosphere system associated with enhanced Alfven fluctuations in solar wind.

It is known that large-amplitude north-south Alfvén fluctuations in IMF within the high-speed streams are associated with large enhancements in relativistic electron flux in the outer radiation belt, so-called relativistic electron events. In our early studies, we found that these waves can last for multiple days and cause intermittent occurrences of significantly enhanced magnetospheric convection. The enhanced convection periods are followed by repetitive substorm onsets. Repetitive injections of 10s to 100s keV electrons to the inner magnetosphere during substorm dipolarizations can provide the seed populations that are subsequently energized to MeV electrons. Prolonged periods of large-amplitude Alfvén waves embedded in high-speed solar wind streams can also lead to enhancement of both dawn-side chorus wave and magnetospheric ULF turbulence that are postulated to cause the relativistic electron energization. Although relativistic electron events occur during geomagnetic storms that are mostly associated with high-speed solar wind streams, some geomagnetic storms do not accompany relativistic electron events. This suggests that multiple factors in the solar wind or/and in the magnetosphere are required to work together to produce a relativistic electron event.

The primary goal of this proposal is to determine essential magnetospheric conditions for occurrence of relativistic electron events and what solar wind and interplanetary structure can drive those conditions. We will particularly focus on the role of Alfvén waves in the solar wind density and IMF; how their Alfvén wave power are correlated with outer belt MeV electron intensities after removal of all other solar wind and IMF effects, whether there exist certain cutoff values of wave power, time lag, and duration of Alfvén fluctuations for a relativistic electron event to take place, how Alfvén waves affect the plasmasheet conditions for providing the seed population and magnetospheric wave activity, and whether the enhanced and structured polar-cap convection driven by the interplanetary Alfvén fluctuations can be an important part of the process leading to the relativistic electron events. To do this, we will statistically analyze OMNI data for solar wind structures and Alfvén wave power, GEOTAIL and THEMIS data for the plasmasheet and the inner magnetosphere, AE index for substorm occurrence, ground magnetometer data for wave activities, radar observations for polar cap flows, and GOES and Akebono data for radiation belt electron fluxes.

The proposed work will evaluate effect of Alfvén fluctuations in solar wind on outer belt relativistic electron intensities by examining magnetospheric conditions from the polar cap, to the plasmasheet, and to the radiation belts associated with Alfvén waves in solar wind. Therefore this study will directly address the goal of LWS focused science topic Connection between Solar Interplanetary Structures and the response of Earths radiation belts".

Mark Linton/Naval Research Laboratory
Investigating the Origin and Evolution of Magnetic Flux Ropes in the Heliosphere

We propose a Targeted Science Team to attack the Living with a Star Focused Science Topic "Flux Ropes from the Sun to the Heliosphere." Our interdisciplinary team will address the fundamental aspects of flux rope formation and evolution, including the emergence of magnetic flux from the solar interior, the formation of flux ropes in the solar atmosphere, their eventual eruption and subsequent evolution as coronal mass ejections (CMEs), and their propagation as interplanetary coronal mass ejections (ICMEs).

We will closely couple observations, models, and simulations to develop a deep understanding of the properties of CME flux ropes from their birth in the solar atmosphere to their arrival at Earth and beyond. The expertise of our team members covers all the disciplines needed to track a CME flux rope during its life cycle.

Objectives and Methods:

Our investigation focuses on answering three key questions:

1) How do magnetic flux ropes form in emerging active regions? We propose to combine active region observations, including photospheric vector magnetic field and velocity measurements, with state-of-the-art magnetohydrodynamic (MHD) simulations of flux emergence and flux rope formation, to significantly improve the ability to characterize the properties of coronal flux ropes.

2) How does flux emergence lead to the eruption of CME flux ropes?
Our demonstrated ability to study CME events with unprecedented realism, together with our recent advances in coupling MHD simulations of flux emergence with the evolution of flux ropes in the corona,will lead to a richer understanding of the conditions that determine when flux ropes erupt. These theoretical investigations will be guided by the analysis of multi-wavelength observations of CME eruptionsassociated with flux emergence.

3) How are ICME flux ropes distorted by their interaction with the interplanetary medium? We propose to combine MHD simulations, white-light observations and modeling, flux rope reconstruction, and in-situ charge state measurements to understand the coronal origin of the features we measure at 1 AU. We will investigate how to combine CME morphology and flux rope reconstruction techniques to estimate the fields embedded in ICMEs prior to their arrival at Earth.

Significance to solicitation and NASA interests:
Understanding the life cycle of CME flux ropes is a critical challenge, not only from a purely scientific perspective, but because of the crucial role these structures play in space weather. Our proposed research combines detailed observational studies, state-of-the-art simulations, and practical empirical models to answer fundamental questions about the origin and evolution of CME flux ropes. The successful completion of our project will pave the way for a capability to predict geoeffective magnetic fields hours to days in advance of the arrival of Earth-targeted ICMEs

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Gang Lu/University Corporation for Atmospheric Research
A LWS Targeted Investigation on Thermospheric Dynamics During Geomagnetic Storms

We propose to undertake an integrated data analysis and numerical modeling of thermospheric dynamics in response to solar and magnetospheric energy inputs during geomagnetic storms. More specifically, we will address three science questions: (1) What are the temporal and spatial scales of thermospheric variations for various solar wind and magnetospheric energy inputs? (2) What is the influence of storm-time winds on the ionosphere? (3) What is the influence of storm-time winds on the plasmasphere?

We will use the neutral wind and density measurements from the CHAMP and GRACE satellites, global TEC data from COSMIC and the ground-based GPS network, together with electric field and plasma measurements from the C/NOFS satellite, to determine the spatial and temporal scales of thermospheric and ionospheric disturbances in response to various solar and magnetospheric energy inputs. Measurements of NO inferred radiation from the TIMED/SABER and the O/N2 column density ratio from TIMED/GUVI will also aid the data-model intercomparison. The assimilative mapping of ionospheric electrodynamics (AMIE) procedure will be used to specify magnetospheric energy dissipation into the high-latitude ionosphere and thermosphere by synthesizing various ground- and space-based observations. Numerical simulations based on the NCAR Thermosphere-Ionosphere-Mesosphere-Electrodynamics General Circulation Model (TIMEGCM) will be used to characterize the neutral winds and their role in producing thermospheric and ionospheric disturbances. Furthermore, the coupled TIMEGCM-SAMI3 model will be used to investigate the plasmaspheric effects by neutral winds. Knowledge gained from such a systematic data-model investigation is critical to a better understanding of the underlying physical/chemical/dynamical processes that control the overall storm-time thermospheric dynamics.

The proposed study directly addresses the Focus Science Topic (FST) 1.3.1(d) on Thermospheric wind dynamics during geomagnetic storms and their influence on the coupled magnetosphere-ionosphere-thermosphere system. The proposal is highly relevant to NASAs Strategic Goals to Open the Frontier to space Environment prediction and to Understand the nature of our home in space(see Science Plan for NASAs Science Mission Directorate 2007-2013). More specifically, it deals with some specific research focus areas of the Heliophysics Division: Determine changes in the Earths magnetosphere and ionosphere; Understand and characterize space weather effects on and within planetary environments. The National Research Councils 2013-2022 Decadal Survey report has called out Determine the dynamics and coupling of Earths magnetosphere, ionosphere, and atmosphere and their response to solar and terrestrial inputsas one of the top science goals for the next decade, and our proposed investigation is fully in line with this high-priority science objective.

Nagi Mansour/NASA Ames Research Center
LWS Workshops: Coupling the Multiphysics of the Heliosphere from the Deep Interior to the Corona: Simulation, Modeling and Data Assimilation

We propose a series of 5 annual workshops during the 2014-18 period with the purpose of enabling interactions between interdisciplinary research groups under the NASA-NSF Space Weather Modeling Collaborations, with other Living With a Star (LWS) space weather focused efforts, and with the broader heliophysics community. The NASA Heliophysics roadmap emphasizes the importance of coupling the wide range of multiphysics elements that interact to constitute Space Weather. In particular, the workshops will focus on the LWS science queue Heliospheric Magnetics (HMag) : Understand the flow and dynamics of transient magnetic structures from the solar interior to Earth. The massive amount of data from the LWS mission, SDO, is providing breakthroughs in our understanding of the variability of the Sun. We anticipate similar achievements from the IRIS mission. We also anticipate that the emergence of global evolutionary models of the solar interior, magnetic field, and corona will use this new generation of data, combined with improvements in ground observations, to validate models and assimilate observational data, thus providing improved understanding of the dynamics and improved accuracy in the forecasting of space weather. The proposed series of annual workshops will stimulate innovations in our ability to link the dynamics of transient magnetic structures from the solar interior to Earth. They will focus on the development of realistic quantitative models that take advantage of the NASA advanced supercomputing resources available for these studies. The focus on global supercomputer modeling will be a new and unique feature of the proposed workshops that distinguish them from other LWS workshops. The workshops will provide key support to the NASA-NSF Space Weather Modeling Collaborations projects. They will be organized using conference facilities provided by NASA Ames Research Center. The funds are requested for organizational and logistics support, as well as for travel support of students and young researchers to attend the workshops and get them involved in the development of innovative cross-disciplinary topics in support of the LWS program.

Petrus Martens/Montana State University
Formation, Evolution, and Eruption of Solar Filaments for a Full Cycle: Simulations Verified by Observations

We propose to simulate the formation, and evolution up to eruption of solar filaments for the entire solar cycle 23 and the beginning of cycle 24, drive our simulations by magnetogram observations, and compare the results with recently obtained filament metadata.

The novel aspect of this proposal is that we compare our results with systematic filament observations over the same period carried out by the filament detection module AAFDCC further developed by Pietro Bernasconi as part of the SDO Feature Finding Team, headed by PI Martens. This code not only detects, locates and tracks filaments, but also measures their chirality decisively for about half the cases. The filament module has produced filament metadata for the entire cycle 23 and cycle 24 up to now, and we have the most recent version of these metadata available. We will analyze and verify these data in detail.

We will then try to reproduce these results with the flux transport and non-potential coronal magnetic field simulation code developed by Co-I's Mackay and Yeates. This code has been well tested and already reproduces key aspects of filament evolution varying with the solar cycle. In particular it has already yielded a surprising weakening of the hemispheric chirality rule in the descending phase of the cycle, which seems to be borne out by the filament metadata as well.

The scientific relevance of this project is three-fold. First, with the simulations successfully reproducing the formation, chirality, evolution, and eruption of filaments over a cycle we will have made a decisive step towards physical understanding of the filament formation mechanism. Second, the correct moment and location of eruptions together with the magnetic structure are the necessary initial conditions for simulations of the evolution of interplanetary flux ropes, including Earth-directed CME's, and third, successful reproduction of an entire cycle of filament life-cycles from magnetogram data provides a solid basis for future predictive simulations based upon real-time magnetograms, e.g. from HMI.

David McKenzie/Montana State University
Physical Processes in High-Beta Current Slabs

In the evolution of a coronal mass ejection (CME) and the associated solar flare, a current sheet connecting the CME to the post-eruption flare arcade is important as the location of magnetic reconnection and energy release for the flare. Numerous observations in white light, UV, EUV, and X-rays indicate the presence of heated plasmas surrounding/within the current sheets, while numerical models are beginning to reproduce the temperatures and general appearances in EUV and X-rays. Conditions in this region are key for controlling the reconnection (e.g., length scales, onset, time-varying rate of flux transfer). However, only recently have high-resolution observations become possible with the capability to scrutinize the conditions within the sheet area. The most recent data from space-based telescopes reveal an environment far more complex than the simple laminar current sheet envisioned in two-dimensional and 2.5-D models of reconnection. It is a regime of complicated flows, eddies, and oscillatory bulk motions, likely pervaded by MHD shocks. While some observed oscillations have been treated as magnetosonic waves the presence of vortical flows and eddies is a relatively new discovery and is much harder to understand in the framework of a low-beta magnetized plasma. Indeed, analysis demonstrates that the plasma beta is of order unity, so that gas pressure forces and magnetic tensions have significant, and important, interplay in this crucial region.

The primary objective of this investigation is an empirical characterization of conditions and processes in the observed plasma sheets, including temporally and spatially resolved variations in temperature, density, and velocity. The observational analysis builds upon our recently published initial findings, taking maximum advantage of the high-resolution data returned from SDO/AIA. These measurements are important for understanding heating, thermal conduction, velocity variations, and turbulence within the plasma sheet. The findings are relevant to understanding the conditions that initiate, accelerate, and prolong reconnection (e.g., growth and spatial variation of anomalous resistivity), and directly address Priority Objectives in NASA's Heliophysics Roadmap, such as scale sizes and geometries of reconnection, kinetic processes responsible for reconnection, and the relationship between microphysical processes and large-scale topologies.

The investigation will be augmented by MHD modeling of perturbations moving through magnetized plasma. In our preliminary examination, recently submitted for publication, our model indicates shocks propagating in the un-reconnected field adjacent to current sheets, and density rarefactions suggestive of the plasma voids observed in supra-arcade downflows. The modeling component of the investigation supports and is supported by the observations, through exploration of the relative importance of density and magnetic field gradients, variations in plasma beta, and the effects of sub/supersonic flows.

In addition to the named PI and Co-Is, two graduate students will be supported (names not available at this time).

Viacheslav Merkin/Johns Hopkins University Applied Physics Laboratory
Relative Roles of Different Solar Wind Drivers of ULF Waves in Radial Transport of Relativistic Electrons in the Outer Radiation Belt

Relativistic electron intensities across the outer radiation belt vary on the timescales from minutes to days. A major mechanism responsible for this variability is radial transport of electrons across their drift shells. Radial transport is driven by interactions of the gradient-curvature longitudinal drift motion of trapped particles around Earth with the ULF waves in the Pc4-5 frequency range (2-22 mHz). The waves with small azimuthal wave number (m) can resonantly interact with the electron drift motion leading to effective scattering of particles across the drift shells. The dominant low-m ULF modes draw their energy from different sources of solar wind origin. First, ULF waves can be generated by the Kelvin-Helmholtz instability (KHI) at the magnetopause flanks. Another major source of ULF wave activity is fluctuations in the solar wind dynamic pressure. Magnetosonic waves induced at the magnetopause couple with standing Alfven waves termed field line resonances. Magnetosonic waves can also get trapped inside and reflected from the plasmapause resulting in global cavity modes. While previous studies established that low-m ULF waves can resonantly interact with the electron drift motion, the relative importance of the waves of different solar wind origin in sculpting radial profiles of radiation belt intensities still remains a mystery. The proposed study is intended to close this understanding gap via addressing fundamental science questions of ULF wave interaction with relativistic electrons in the outer radiation belt:

1) What are the properties and rates of radial transport driven by the two main types of the solar-wind driven ULF waves: velocity shear induced KHI and dynamic pressure variations?

2) What is the difference in transport due to a single isolated ULF mechanism compared to realistic conditions when both ULF wave mechanisms operate simultaneously?

3) What is the relative contribution of radial transport due to externally driven ULF waves in the build up and decay of radiation belt intensities during events observed by the Van Allen Probes?

We will use a global MHD model of magnetospheric dynamics (LFM), and a 3D guiding center radiation belt model. The global model possesses both very high resolution and the ability to simulate the cold plasmasphere, which are necessary to reproduce the KHI and properly describe mode coupling. The fully 3D test-particle model is necessary to 1) describe possible deviations of the transport from radial diffusion, requiring kinetic rather than phase-averaged (Fokker-Planck) approximation; 2) take into account 3D aspects of particle motion, e.g., drift orbit splitting and orbit bifurcations. Our science investigation will be based on a series of numerical experiments: First, with idealized solar wind and IMF conditions allowing separation of KHI and dynamic pressure driven modes; Second, with realistic solar wind inputs allowing direct assessment of electron radial transport with observations by Van Allen Probes. Relative contributions of the different ULF generation mechanisms will be assessed by computing transport rates from the 3D test-particle simulations in the resultant MHD fields.

Proposed Contribution to the Focus Team Effort: The proposed research is directly relevant to Focused Science Topic (c), the Connection between Solar Interplanetary Structures and the response of Earths radiation belts. The research will contribute to the focus team efforts both by providing global models to aid in analysis of observational studies and characterizing the physical processes responsible for radial transport of electrons in the outer belt. The project metrics will assess progress in (1) completion of simulations of idealized cases and event studies and (2) in understanding the relative roles of different ULF generation mechanisms in radial transport of relativistic electrons.

Ryan Milligan/NASA Goddard Space Flight Center
SDO/EVE Irradiance Observations as a Diagnostic of Energy Transport During Solar Flares

The extreme ultraviolet (EUV) component of radiation emitted during solar flares is known to be a major driver of ionospheric fluctuations in the terrestrial atmosphere. The bulk of this emission originates in the chromosphere, and is believed to be driven by a beam of high-energy electrons accelerated from an energy release site in the corona, although the details of how this energy is transferred are still poorly understood. The numerical simulations of Allred et al. (2005; RADYN) suggest that chromospheric emission is energetically dominated by various recombination continua, in particular, the Lyman, Balmer, and Paschen continua of hydrogen, and the He I and He II continua, as opposed to line emission. Assuming thick-target interactions, we aim to use HXR imaging and spectroscopy from RHESSI observations to obtain the location, flux, and distribution of nonthermal electrons deeded to be responsible for driving chromospheric enhancements. These parameters can be used to generate a heating function in the RADYN code with which to heat an ambient model solar atmosphere. The resulting synthesised line and continuum emission will then be directly compared to observations taken with the EVE instrument onboard SDO, which is now routinely observing time-resolved measurements of the recombination continua of H and He during flares as well as prominent emission lines such as He II 304A and Lyman-alpha (Milligan et al. 2012a).

Lightcurves of isothermal emission from EVE can be generated using the methods described in Chamberlin, Milligan & Woods (2012). From these it has been seen that plasma at a several megakelvin can peak both during the impulsive phase and during the main phase of a flare. By examination of the corresponding AIA images, the the chromospheric component of this high-temperature emission can be determined. This will establish the temperature to which the chromosphere was heated during the impulsive phase, allowing a comparison to be made with the model predictions of RADYN. It has also been shown that EVE data can be used to determine plasma densities at high (>10MK) temperatures using emission line ratio techniques (Milligan et al. 2012b). By applying these techniques to lines formed over a range of lower temperatures a more comprehensive picture will be made of the density structure of flaring plasma.

Comparisons can then also be made with the density of the simulated atmosphere as predicted in the RADYN models.

Understanding how different continua contribute to the overall energy of flares, as well as the temperature and density of the heated plasma, are therefore crucial for corroborating current solar flare models. This allows the mechanism(s) by which the associated emission is generated to be determined, as well as the depth of the atmosphere at which it is emitted. Although the EVE instrument onboard SDO was primarily designed to monitor the Suns EUV irradiance over multiple timescales, we have been pioneering the use of its data to understand the physics behind some of the most fundamental processes during solar flares. The overarching goal of this proposal is therefore to improve our understanding of the processes responsible for EUV irradiance variations and determine the energy balance in dynamic phenomenain accordance with the Science Analysis for SDO Initiative.

Christopher Mouikis/University of New Hampshire
The Ring Current Response to Solar and Interplanetary Structures and the Corresponding Radiation Belt Variability

The goal of this proposed work is to characterize the ring current response to solar and interplanetary structures (CMEs, CIRs, high speed streams etc.) and the impact that this response has on the outer radiation belt variability. For this, a multitude of different data sets, that cover more than a full solar cycle (from 2001 to ~2016), will be put together. The Cluster observations of the inner magnetosphere will be the primary data set used to monitor the ring current variability. After 2012, this data set will be complemented by the data from the RBSP mission. The Radiation belt variability will be monitored using data from the SAMPEX and RBSP missions while data mainly from ACE and Wind,will be used to characterize the interplanetary disturbances. The outcome of this work will become a valuable input to inner magnetosphere models for comparison/reality checks of the model predictions with in-situ observations.

Thomas O'Brien/Aerospace Corporation
Drift Phase Sructure as a Diagnostic of Different Radial Transport Mechanisms in the Outer Radiation Belt

Goals and Objectives:

We hypothesize three main mechanisms of radial transport for relativistic electrons in the outer radiation belt: (1) incoherent scattering in the drift invariant, (2) impulsive events, and (3) monochromatic ULF oscillations. The relative importance of these mechanisms is unknown in general, and it is likely that the relative importance of each is quite different for different kinds of solar wind driving. For example, a coronal mass ejection (CME) might very well bring about more of (2), while a high speed stream (HSS) may stimulate more of (1) and (3). Drift phase structure is a critical diagnostic of these mechanisms.

Mechanism 1 should lead to little or no detectable drift phase structure and it is the only listed mechanism necessarily compatible with the widely-assumed quasilinear radial diffusion. Mechanism 2 should lead to coherent drift phase bunching across a large range of energies and pitch angles (i.e., particles with very different drift periods). Mechanism 3 should lead to drift phase bunching only over a narrow range of energies and pitch angles corresponding to drift frequencies near the frequency of ULF oscillation. A superposition of many interactions with a series of randomly-phased impulses (e.g., Falthammar, 1968) or monochromatic waves (e.g., Albert, 2010, JGR) will lead to outcomes sufficiently similar to quasilinear radial diffusion that the quasilinear formulation can be retained. However, it is not known what proportion of radial transport should be attributed to each mechanism in general or for specific kinds of interplanetary drivers. We will estimate how often we observe drift-phase bunching at and near geostationary orbit, and whether it is coherent across energies and pitch angles (mechanism 3), if it is confined to a narrow range of drift periods (mechanism 2), or if it is incoherent across energies and pitch angles (mechanism 1). We will categorize radiation belt events by their interplanetary driver to determine whether CMEs, HSS, or corotating interaction regions lead to systematically different kinds of radial transport in the outer zone.

Methodology:
We will survey recent GOES observations, which have energy and angle resolution with high rate time sampling (1 minute or better, and thus shorter than the drift period). We will complement this survey with SCATHA data, which cover a larger L range, and include on-board plasma and field measurements. We will supplement these analyses with data from Van Allen Probes, which provide greater radial extent, but lack the stationary sentrycapability of the GOES vehicles.

Relevance:
Our proposal addresses Focused Science Topic (c) Connection between Solar Interplanetary Structures and the response of Earths radiation belts. Our proposed research will delineate radial transport mechanisms for the radiation belt electrons in the outer zone, and identify which mechanism, if any, is systematically dominant for different kinds of solar wind driving.

Alexei Pevtsov/National Solar Observatory
Evolution of the Photospheric and Chromospheric Magnetic Fields and Dynamics of the Lower Solar Atmosphere during Flares

This proposal will target Science Analysis for the Solar Dynamics Observatory (SDO) special initiative in Heliophysics Living With a Star science.

Flares are often seen as a tumultuous breakup of a previously stable configuration leading to release of a significant amount of energy, material eruption, particle acceleration, and restructuring of magnetic configuration. This magnetic restructuring may be a key for understanding the physics of processes taking place throughout the solar atmosphere in response to flares: magnetic field supplies energy to flares, and serves as a trigger and as a conduit of energy transport. The main objective of this proposal is to investigate the magnetic restructuring associated with flares and its effects on thermodynamic processes in the low solar atmosphere. The changes in the magnetic field will be evaluated in respect to two alternative models: coronal implosion and twist removal model. Either of these scenarios may take place in flares, but the two models can be distinguished based on expected magnetic field changes. The proposed research is based on full vector magnetic field data from two NASA missions, SDO and Hinode, and supplemented with observations from two ground-based instruments, GONG (line-of-sight only) and SOLIS (vector data). These two auxiliary data sets will enhance the interpretation of SDO data, strengthen the statistics. The auxiliary data sets could be critical in finding the proper interpretation in cases when the magnetic field derivations may be affected by the poor spectral resolution of HMI, or hampered by the poor temporal cadence of SOT/SP. These data sets will also allow including flares prior to SDO launch for greater statistical sample, if needed. SOLIS Ca II 854.2 nm line-of-sight (LOS) magnetograms will expand the study to the chromosphere. Using SDO vector magnetograms we will investigate the changes in orientation and strength of the magnetic field and the associated changes in Lorentz force. For selected cases, we will also derive pseudo-vector fields using high-cadence SDO/HMI and GONG line-of-sight (LOS) magnetograms based on the approach of azimuthal averaging. Evolution of the derived pseudo-vector fields during flares will be investigated and validated with the result from SDO/HMI vector magnetograms.

To investigate changes in thermodynamic parameters associated with flares, we will use existing observations of flaring regions with the Stokes Polarimeter on Hinode. In addition, we will use existing flare observations with SOLIS for a few selected flares and conduct new observations if needed. As a proof-of-concept, several successful SOLIS observational flare campaigns were conducted in the past. The use of SOLIS data will enhance the interpretation of SDO/HMI spectral data as SOLIS/VSM has higher spectral sampling as compared with SDO/HMI data. Changes in thermodynamic parameters will show the effect of flares through the formation height range of the Fe I 630.1-630.2 nm photospheric and Ca I 854.2 nm chromospheric spectral lines. Finally, we will compare the location of footpoints of flare loops derived from RHESSI observations in an energy range of 50-300 keV with the locations that show significant topological changes in the magnetic field. We will examine the rate of flux loss in the reconnection events associated with flares.

We expect that the results of this study will bring a better understanding of physics of flare processes in active regions and constrain some existing flare models.

Cora Randall/University of Colorado Boulder
Response of the Atmosphere to Impulsive Solar Events (RAISE)

The Response of the Atmosphere to Impulsive Solar Events (RAISE) Targeted Science Team will comprehensively address the Focused Science Topic Short term solar/atmospheric variability and climate. Our goal is to answer the broad question of how the Earth's atmosphere responds to impulsive solar events (ISEs). The proposed work has four primary objectives:

(1) How well do coupled chemistry climate models simulate effects of recent ISEs?

(2) What are the primary factors that control the atmospheric response to ISEs?

(3) What is the range and sensitivity of the atmospheric response to ISEs?

(4) Are there long-term, cumulative effects of ISEs on the atmosphere and climate, and with what certainty can these effects be modeled?

Solar energy input is a critical driver of the Earth's climate system, yet the climatic effects of ISEs are poorly understood. The key to improving our knowledge is unraveling the complex response of the atmosphere to ISEs, to clarify the mechanisms by which impulsive radiation and particle variations impact the atmosphere. RAISE is designed to address this challenge, and to explore implications for the climatological response of the Earth's atmosphere to ISEs. The focus of RAISE is variations in energetic particles and short-wavelength radiation that occur during ISEs. The bulk of this energy is initially absorbed in the upper atmosphere. Through dynamical and chemical processes the absorbed energy is redistributed, and its effects amplified through such mechanisms as catalytic cycles and nonlinear wave/mean-flow interactions. This coupling, and the extent to which it causes ISEs, either individually or cumulatively, to influence the atmosphere on time scales much longer than the ISE duration, are poorly understood.

RAISE will investigate these processes using measurements of high-energy solar particles and photons, comprehensive atmospheric models, observations of the atmosphere and ionosphere, and a team with the collective expertise to address the interdisciplinary aspects of this problem. The primary modeling tool is the Whole Atmosphere Community Climate Model (WACCM) under development at the National Center for Atmospheric Research (NCAR). This model will be driven with solar and magnetospheric inputs derived from space-based measurements, during quiet times and during ISEs, to investigate the physical mechanisms of ISE effects and their interaction with atmospheric dynamics. We will compare model simulation results with atmospheric observations from many space-based sources, and with ground-based observations of ionospheric changes. The measurement analyses will be performed for model validation and to explore the natural and event-driven components of variability. The interaction of atmospheric dynamics with chemical processes in the middle atmosphere will be investigated with ensemble model simulations and with runs constrained to observed meteorology. Ionospheric effects and changes in the global electrodynamo, driven by flare ionization as well as auroral processes, will be evaluated. Finally, we will ascertain through multiple ensemble simulations whether the model can produce any effects on stratospheric or even tropospheric climate, through episodic or cumulative forcing by ISEs.

Stanislav Sazykin/Rice University
Modeling of Storm-Time Magnetosphere-Ionosphere-Thermosphere Dynamics

Thermosphere is an integral part of the tightly coupled ionosphere-thermosphere-magnetosphere (ITM) system. Response of the global thermospheric winds to geomagnetic activity depends on the driving forces of magnetospheric origin, and it strongly influences ionospheric dynamics during storms. As thermospheric changes in circulation modify ionospheric electron density distribution at auroral and subauroral latitudes, these changes are expected to provide magnetospheric feedback. The two main objectives of this project are to develop a first-principles numerical model of the ITM system, and to use it to understand how storm-time changes in the thermospheric winds affect magnetosphere-ionosphere coupling, by addressing these science questions:

1. How do storm-time changes in the thermospheric winds at auroral latitudes modify ionospheric conductances and how do these neutral wind driven conductance changes affect ring-current dynamics?

2. What is the thermospheric and ionospheric response to Subauroral Polarization Stream (SAPS) events during geomagnetic storms?

3. What is the role of the neutral wind flywheel effect in modifying the ionospheric state?

4. What are the relative roles of the disturbance wind dynamo and magnetospheric prompt penetration electric fields on ionospheric electron density redistributions?

We will develop a first-principles numerical model of the ITM system that includes realistic magnetosphere-ionosphere coupling at auroral and subauroral latitudes, is able to describe storm-time changes in the ionospheric electron densities and thermospheric wind pattern, and has sufficiently high spatial resolution in the ionosphere on magnetic field lines that map out to the inner magnetosphere (ring current and plasmasphere). Our methodology will be:

(1) We will develop a new model of the ITM system by starting with the GITM (Global Ionosphere-thermosphere model), RCM (Rice Convection Model of the inner magnetosphere), and BATS-R-US (global MHD magnetosphere) physics-based models. Most of the required coupling is already in place as part of the Space Weather Modeling Framework (SWMF) (for example, within SWMF, RCM and BATS-R-US are already coupled, and GITM can also be driven by BATS-R-US). We will add necessary coupling between the three models, by providing auroral precipitation from the RCM to GITM, and using GITM-modeled conductances and neutral winds in the RCM. We will increase the spatial resolution of GITM at auroral and subauroral latitudes to match it to the RCM resolution. We will test the model with numerical experiments.

(2) We will conduct event simulations and will do extensive model-data comparisons. During this stage of work, we expect extensive collaborations within the focused science team (FST), by taking advantage of datasets and empirical models developed as part of

the collaborative FST work. We will contribute to the team by providing our simulations results to other interested members of the FST.

(3) We will conduct a series of idealized simulations by including or excluding various elements of the model, in an attempt to understand how various processes affect the response of the coupled system. In designing these idealized simulations, we will be guided by the science questions listed above.

Robert Schunk/Utah State University
Magnetosphere-Ionosphere Coupling in the Solar System: A Cross-Discipline Infrastructure Building Conference

Over the half century of exploration of the Earths space environment, it has become evident that the interaction between the ionosphere and the magnetosphere plays a dominant role in the evolution and dynamics of magnetospheric plasmas and fields. It is now being found that this same interaction is of fundamental importance at other planets and moons throughout the solar system. We propose to hold a cross-discipline AGU Chapman conference, which will examine the details of the coupling processes using results from both measurements and modeling. This conference addresses the Cross-Discipline Infrastructure Building Program portion of the Living With a Star (LWS) Program solicitation. Topics that will be discussed include the ionosphere as a source of magnetospheric plasma, the effects of the low energy ionospheric plasma on the stability of the more energetic plasmas, the role of currents and electric/magnetic fields in coupling the two regions, the unified global modeling of the ionosphere and magnetosphere, and the coupling of ionosphere and magnetosphere at other planets and moons in the solar system. Our goal is to enhance the understanding of this coupling by researchers in both the heliophysics and planetary science communities through the sharing of measurements and modeling techniques. This conference is planned to occur on the 40th anniversary of the initial magnetosphere-ionosphere coupling conference that took place at Yosemite National Park in 1974 giving a four decade perspective of the progress in understanding these fundamental processes. Short segments of the video of the original meeting in 1974 will be used to set the stage in the sessions and the total original video recording will be digitized for the use as an historical resource by the heliophysics and planetary sciences communities. The conference has been approved as an American Geophysical Union Chapman Conference and, in addition to the NASA support proposed herein, is expected to receive support from the National Science Foundation that will help with student travel.

Vikas Sonwalkar/University of Alaska Fairbanks
Thermospheric Wind and the Evolution of the Ionospheric and Magnetospheric Electron and Ion Densities at Altitudes below 4000 km During Geomagnetic Storms

We propose a four-year data analysis and numerical simulation program to study how thermospheric winds influence the evolution of the ionospheric and magnetospheric electron and ion (H+, He+, O+) densities during geomagnetic storms. We will use whistler mode radio sounding data and ray tracing simulations to obtain electron and ion densities and field aligned irregularities (FAI) at <4000 km altitude along the geomagnetic field line over a wide range of latitudes. Using SAMI2 numerical model, we will perform simulations to determine the thermospheric wind parameters needed to explain the evolution of electron and ion density as obtained from the radio sounding data. Measurements of electron density, ion composition, geomagnetic field, and thermospheric wind from various in situ (e.g. CHAMP, DMSP) and ground sources (e.g. Ionosonde) will be used to augment radio sounding results. We will interpret results of data analysis and simulations in terms of the physics of the coupling of thermosphere-ionosphere-magnetosphere system. An improved understanding of this system is essential for improving our ability to develop useful predictive models of satellite drag and ionospheric and magnetospheric electron density and ion composition variations during geomagnetic storms.

Wenbin Wang/University Corporation for Atmospheric Research
Global Thermospheric Wind Response to Geomagnetic Storms

Proposal summary of NASA LWS-FST proposal 2013
Global thermospheric wind response to geomagnetic storms

During geomagnetic storms high-latitude electric fields and auroral precipitation are greatly enhanced resulting in large amounts of energy and momentum being deposited into the thermosphere-ionosphere (T-I) system. One consequence of this energy and momentum deposition is that there are significant changes to the global thermospheric wind circulation and thus also a fundamental impact on the composition and dynamics of both the neutral and the ionized components of the T-I system. The changes of the global neutral wind circulation, and the way that they affect ionospheric variations under geomagnetically disturbed conditions, are poorly understood. Most previous studies have focused primarily on the storm-time changes of neutral winds at high latitudes. A full understanding of the behavior of the neutral winds on a global scale during and after geomagnetic storms is still lacking. In particular, the processes by which storm-time changes at high latitudes affect low and middle latitude T-I system are not fully understood.

Thus, we propose to study the changes in the global structures of neutral winds and their associated ionospheric variations during and after geomagnetic storms and the physical mechanisms that cause these changes. To perform this study the proposed research will address the following specific questions:

1) How do global neutral winds and the ionosphere change during storms?

2) How does storm strength or duration affect changes of global neutral wind circulation during storms?

3) How long does it take for the global wind system and the ionosphere to recover to its pre-storm state? What are the main factors that determine this recovery?

4) What are the processes that produce vertical shears in the horizontal winds during storms?

We will carry out numerical studies using a state-of-art coupled magnetosphere ionosphere thermosphere (CMIT) model and the thermosphere ionosphere electrodynamics global circulation model (TIEGCM) and diagnostically analyze model outputs to address these questions. We will also use existing archived wind data from DE-2, UARS/WINDII and CHAMP measurements to ensure the fidelity of our modeled winds by comparing model results with these wind observations. Ionospheric peak electron densities from the global network of ionosonde observations, global ionospheric total electron content maps from GPS observations, and CHAMP in situ electron density measurements will also be employed to study the storm-time wind effect on the ionosphere.

The proposed effort will directly address NASA announcement NNH13ZDA001N-LWS focused science topic 1.3.1 (d) Thermospheric wind dynamics during geomagnetic storms and their influence on the coupled magnetosphere-ionosphere-thermosphere system by investigating storm-time changes of the neutral winds, the associated ionospheric variations and the mechanisms by which these changes occur. It will enhance our understanding of the global-scale behavior of the coupled thermosphere and ionosphere system during and after geomagnetic storms, which directly relates to the Science Goals for the Next Decade #2: determine the dynamics and coupling of Earths magnetosphere, ionosphere, and atmosphere and their response to solar and terrestrial inputsin the recently released National Research Councils Decadal Survey report.

Amy Winebarger/NASA Marshall Space Flight Center
Investigation of the Magnetic Causes of Coronal Heating in Solar Active Regions

Previous work has shown that the coronal X-ray luminosity of an active region increases roughly in direct proportion to the total photospheric flux of the active regions magnetic field. This observation is consistent with the present paradigm for coronal heating in active regions: the coronal heating is powered by convective mixing in and below the photosphere, with the building-up and burning-down of the free magnetic energy being in roughly steady-state balance on average over the active region.

It is also observed, however, that the coronal luminosity of active regions of nearly the same flux content can differ by an order of magnitude. This indicates that there are other conditions in active regions in addition to the flux content that together constitute a stronger determinant of the coronal heating. From preliminary work, we have found evidence suggesting that the main determinant of an active regions coronal heating in addition to the flux content may be the total free energy in the active regions coronal magnetic field. The free magnetic energy is the energy stored in the deformation of the field from its zero-free-energy potential-field configuration. The proposed study will empirically explore the strength of the free-magnetic-energy content as a determinant of the heating that sustains the coronal luminosity of active regions.

We will measure the magnetic flux content and a proxy of the free magnetic energy from whole-active-region vector magnetograms from SDO/HMI for a few hundred sunspot active regions. From SDO/AIA and Hinode XRT images of these active regions, we will obtain each active regions coronal differential emission measure, of which an integral over temperature is the active regions coronal luminosity. We will determine if the coronal luminosity of active regions of nearly the same flux content is strongly correlated with the free-energy proxy; this will imply that the free-energy content is a stronger determinant of active-region coronal heating than the flux content. This would challenge the present paradigm for active-region coronal heating by raising the possibility that in many active regions most of the free energy burned in coronal heating is stored in the field by convective deformation before and during the fields emergence into the corona. This outcome would suggest that at most times in the life of an active region the rate of burning-down of free magnetic energy by coronal heating is not nearly in balance with the rate of building-up of free energy in the active-regions coronal field.

Thomas Woods/University of Colorado Boulder
LWS 2014 Meeting Support: Space Weather Throughout the Heliosphere

The Heliophysics System Observatory has recently grown and will continue to develop, thus providing a more complete picture of the interactions of various environments that are subject to the Suns influence. The newest missions include the Van Allen Probes, the 2nd mission in the Living With a Star (LWS) program, and the soon to be launched Interface Region Imaging Spectrograph (IRIS). The other LWS mission is the Solar Dynamics Observatory (SDO) that launched in February 2010. Data from current and past missions, such as the STEREO, SOHO, ACE, THEMIS/ARTEMIS, TIMED, among many others, and future missions such as the Magnetospheric Multiscale Mission (MMS) and Solar Probe Plus (SPP) will be combined to pursue cross-disciplinary science goals that are broader and more complex than any single mission could address alone. These observations are supported by complementary theoretical and modeling studies that help maximize the science return from the LWS program.

The next Living With a Star meeting is tentatively planned for June 23-27, 2014, at the Skamania Lodge (http://www.skamania.com/) in Stevenson, Washington. The first-cut title for this meeting is Space Weather Throughout the Heliosphere, but may be refined soon. The focus will be connecting all the communities within the LWS program in order to look at the larger, and often common, science themes that are beyond the more focused science topics of the individual missions. All support for this meeting will come from registration fees, but through this LWS meeting proposal, the Science Organizing Committee (SOC) proposes travel support for students, post-docs, and early career scientists who would otherwise be unable to attend. This type of support, most recently for the LWS/SDO Meeting in Cambridge, Maryland, has shown outstanding results in boosting attendance of the next-generation heliophysicists at the LWS meetings.
