Heliophysics Infrastructure and Data Environment Enhancements
Abstracts of selected proposals
(NNH13_2ZDA001N-Roses 2013)

Below are the abstracts of proposals selected for funding for the HIDEE step 2program. Principal Investigator (PI) name, institution, and proposal title are also included. 42 proposals were received in response to this opportunity. On March 6, 2014, 12 proposals were selected for funding.

Richard Bogart/Stanford University
Data Services Continuation of the MDI Resident Archive and Stanford Helioseismology Archive

The Michelson Doppler Imager (MDI) data archive has been successfully migrated from its original architecture to the Data Record Management System (DRMS) used by the AIA/HMI Joint Science Operations Center for the Solar Dynamics Observatory (SDO), providing a stable environment for maintenance of the archive for the duration of the SDO mission. It also provides greatly enhanced capabilities in terms of data search, selection, retrieval, and delivery. In addition to the MDI archive, other datasets for which we have assumed archive responsibility within the Virtual Solar Observatory as part of the Stanford Helioseismology Archive are also being migrated to this system.

The MDI data are expected to be a vital data resource for the fields of solar and heliospheric physics for many years, as they provide a continuous and consistent baseline of information covering more than a solar cycle before the launch of SDO and much or all of the observing lives of other major solar space missions. Essential cross-platform calibration measurements among MDI, HMI, and GONG are already underway in order to provide a firm baseline for analysis of long-term variations in the dynamics and structure of the solar interior and the magnetic activity cycle. Although the recalibration activities themselves as well as general science analysis of the data in the archive are beyond the scope of this proposal, support by members of the MDI science team familiar with details of the instrument, observing programs, and data processing continues to be sought on a regular basis by those engaged in such work. It is also very important that the results of reanalysis of MDI data based on improved calibrations or on technical advances be incorporated in the archive.

We are proposing a basic archive maintenance program for the MDI data as well as other ground-based data sets of related historical interest that will assure continuing access of the scientific community to the data, along with expertise as needed and requested to help in proper interpretation of the data; support for any changes that may occur in the structure of the archive; periodic validation of the data and its supporting documentation as necessary; support for any recalibration or reprocessing activities that may be deemed useful; and support for the incorporation of newly processed analysis data sets in the resident archive. Maintenance of the archive in a ready and active state will be assured by

its incorporation and use within the SDO DRMS, of which we are the principal developers and maintainers.

William Coley/University of Texas at Dallas
Processing of Early DMSP Ionospheric Data: 1987-1994

This proposal describes a plan to upgrade the existing Defense Meteorological Satellite Program (DMSP) SSIES-1 dataset (F8, F9, and F10) to provide heretofore-unavailable coverage of in-situ ionosphere parameters including ion temperature, electron temperature, ion density, ion composition, and three-dimensional ion flow at approximately 830 km altitude during the 1989 1992 solar maximum. We intend to port the raw data from its current location on a legacy computer system and reprocess it to current standards, arriving at a high quality data product that will extend the available DMSP data base to over two and one-half solar cycles. This work will increase the quantity, improve the quality, and ensure the continued accessibility of the complete DMSP ionospheric data set, a data set that has proven to be a highly valuable compliment to numerous NASA programs.

James Eccles/Space Environment Corporation
Polar Cap's Topside Ionospheric Response to Storms: Data Services Upgrade to ISIS-2 Topside Sounder Data

Data sets that cover multiple solar cycles are rare and extremely valuable, in that they can provide crucial information about long-term changes and about infrequent events that may be difficult to capture in campaign-style observations. One such data set is the topside sounder data starting with Alouette I and continuing through ISIS-2. A small portion of the sounder data stored on magnetic tape has been archived with the Virtual Wave Observatory (VWO), but other data recorded on 35mm film remain offline and difficult for researchers to access; the preservation of these unique films is only guaranteed for a few more years. This proposal addresses the task of converting a specific set of the ISIS-2 35mm film into digital form compatible with the existing VWO.

Storm-time behavior of the topside ionosphere is of interest for model validation and development. The ISIS-2 topside data from the Resolute Bay region in the VWO archive have been examined, but additional observations are needed to understand the upper atmosphere response to geomagnetic storms. Additional observations have been located in the film archives of the Canadian Space Agency (CSA). No procedure exists, however, for converting these film archives into a useful online form. Space Environment Corporation (SEC) proposes to develop the procedure and the necessary software, and utilize it to produce a database suitable for the comparison of model polar wind-driven profiles to topside sounder data.

SEC has experience with the conversion and analysis of conventional bottomside ionograms archived on 35mm film. The topside ionograms present unique challenges with coordinate registration and feature detection but a successful effort will provide a practical framework to economically add ISIS-2 film topside sounder data and potentially topside sounder data from the other Alouette/ISIS satellites, to the existing online archive.

Our goal is to expand the available online Resolute Bay topside data set by converting 35-mm film ionograms into digital representations in the same format used by the current online archive. The proposed study has the following objectives:

1. Design an efficient method to convert ISIS-2 topside film ionograms into the same digital format used by the VWO online topside ionogram archive. This task requires digitization of the film ionogram and registration of the frequency and range coordinates for the digital record.

2. Modify existing SEC tools developed for bottomside ionograms to analyze topside ionograms for the generation of topside vertical electron density profiles.

3. Use both converted film and current online topside data to produce a useable digital database with documentation and metadata for the VWO.

Ivan Galkin/University of Massachusetts Lowell
Data Services Continuation for Resident Archive of IMAGE/RPI expert-derived data

The key objective of the proposed activity is to continue resident data services for the IMAGE radio plasma imager (RPI). While the primary RPI data (raw telemetry and processed legacy products in physical units and accessible data formats) can be found elsewhere at NASA SPDF, it is the derived and interpreted secondary data products that are unique to the RPI Resident Archive and are still being provided by the science team. We propose that the archive (1) continues the acquisition and preservation of the unique expert knowledge derived from the RPI raw data, (2) loads previously derived products for storage, search, and retrieval using RA services, (3) interoperates with the Heliophysics Data Environment via existing and new data services, and (4) enhances metadata, documentation, and user interfaces so as to facilitate visibility, understandability, and utility of the higher-order RPI science data, e.g., the inversion of echo traces into magnetic-field-aligned electron-density profiles, to enable new Heliophysics research projects.

Timothy Guild/The Aerospace Corporation
Data Services Upgrade: Process TWINS-ES/HiLET and release to VxOs

The stated intent of the Data Services Upgrade proposals is to improve the quality, utility, and accessibility of datasets relevant to Heliophysics research. We propose to improve the quality of existing Aerospace observations (HiLET proton telescope, 6-30 MeV/nucleon H and He) made on the TWINS-2 vehicle by inter-calibrating the dataset to other radiation belt sensors and verifying that the data yield science-quality proton fluxes to study the inner radiation belt and solar particle events. We will improve the utility of the dataset by merging it with Cartesian and magnetic ephemeris. Most significantly, this proposed effort will make the dataset accessible to NASA virtual observatories (VxOs) with a sufficient amount of meta-data for science community use; presently it is not accessible to the broader Heliophysics community. As the NASA Van Allen Probes mission continues returning measurements of the inner radiation belt protons, these TWINS-ES/HiLET radiation belt measurements will provide a continuous dataset connecting the Van Allen Probes era to historical radiation belt dynamics, include additional local time and L-dependent coverage, as well as provide an independent constraint on the 6-30 MeV proton population at the outer edge of the inner radiation belt. This region has been demonstrated to be the conduit through which solar particles become injected into the inner radiation belt [Selesnick et al., 2010], in what turns out to be a significant source of the entire inner belt population [Selesnick et al., 2007]. The proposed effort will provide the Heliophysics community an on-going, complementary resource to the Van Allen Probes for understanding inner radiation belt dynamics and climatology.

Stuart Huston/Atmospheric and Environmental Research, Inc.
Data Services Upgrade: Enabling heliophysics climatology research with improved POES/MetOp particle data

We propose to develop an improved version of the POES/MetOp space particle data for use in heliophysics climatology research. We will use spectral inversion techniques developed for the AE9/AP9 trapped particle models to derive unidirectional, differential particle fluxes from the integral channels of the POES/MetOp SEM-2 MEPED instrument. We will also apply data cleaning techniques to ensure that the resulting data are free from contamination and other artifacts of the detectors. The resulting data set will represent a significant improvement in the quality and usefulness of the POES/MetOp data. The data will be delivered in CDF format to NGDC. The data will enable new advances in our understanding of phenomena such as High Energy Particle Precipitation in the Atmosphere (HEPPA) and the dynamics of the Earth s trapped radiation belts.

Derek Lamb/Southwest Research Institute
Data Services Upgrade: A Catalog of Magnetic Flux Emergence Events for SOHO/MDI

We propose to produce a catalog of Magnetic Flux Emergence events from the entire SOHO/MDI 96-minute magnetogram archive. The MDI archive is NASA s longest duration, stable, high-quality photospheric magnetic field dataset, with line-of-sight magnetic field measurements occurring nearly every 96 minutes from 1996 2011. This time span covers the duration of Solar Cycle 23, the extended 23 24 minimum, and the rising phase of Cycle 24. Though MDI has been surpassed in resolution and cadence by SDO/HMI, the longevity and stability of the MDI dataset make it even now ideally suited for a wide range of scientific applications. These include: studies of ephemeral region emergence; association of flux emergence events with space weather events such as filament eruptions, solar flares, and coronal mass ejections; a detailed study of the magnetic flux budget of a solar cycle; comparison with other methods of active region emergence detection such as helioseismology.

Our team has already developed a module to automatically detect emerging flux regions in reducedresolution near-real-time SDO/HMI 12-minutemagnetograms. This code operates in the EventDetection System at Lockheed Martin in a pipeline mode, continually ingesting new magnetograms and emitting events that are stored in the Heliophysics Event Knowledgebase (HEK). The native 4k x 4k resolution of the HMI data being to large for efficient processing of the events of interest, we bin the HMI data down to a resolution comparable (or slightly worse than) theMDI resolution. Thus we expect adaptation of the code to be minimal and consist mainly of accounting for the greater motion of magnetic field features due to solar rotation in the 96-minute MDI data. We will obtain the entire 96-minute MDI full-disk magnetogram series from Stanford, and adapt the existing HMI code to run on the 96-minuteMDI data. After regulating the MDI magnetograms to account for spacecraft rolls, etc, we will test and refine the algorithm on a small sample of the data, and then run the code on the entire dataset. Our HMI pipeline code already possesses the ability to produce VOEvents, the data format expected by the HEK. Since MDI operations have terminated, we will run the code internally on our own servers and deliver a batch upload of MDI EF events to the HEK. These events will then be available for study using standard tools such as iSolSearch or IDL HEK queries.

Aki Takeda/Montana State University
Data Service Continuation: Resident Archive Services of the Yohkoh Legacy data Archive

Yohkoh was a very successful solar missions, providing X-ray images and high energy spectra of the sun for more than ten years until December 2001. The calibrated Yohkoh data and reduced products are maintained by the Yohkoh Legacy data Archive (YLA). Since 2009, YLA has served the Heliophysics community as one of the Resident

Archives (RAs) for NASA's Heliophysics Data Environment Enhancements program. Our Yohkoh RA receives 200 to 500 visitors per month since 2009, and have contributed to more than 40 scientific papers (Jan. 2009 through Dec. 2012) with sole or partial use of the YLA data.

This proposal will provide resources to continue the RA services of the YLA. The goal of our service is to keep Yohkoh data fully maintained, optimally accessible and used by a wide variety of users. Because of the complexity of Yohkoh Soft X-ray Telescope (SXT) modes and operations it has not been easy to define and prepare data products appropriate for a Final Archive -- at a time when NASA requirements are still in transition. Thus, we propose this RA Data Services Continuation for an additional 2 years, focusing on the following tasks.

(1) Keep the YLA products, access tools and analysis software safe, well maintained and improved in order to provide users with convenient access in a comfortable analysis environment.

(2) Provide personal assistance for data access, handling, interpretation and understanding/modification of analysis software (E-consultant service).

(3) "Load" SXT data products in physical units, including estimates of uncertainty, into the YLA.

(4) Provide YLA products to major existing data/information archives (i.e., Virtual Solar Observatory, Solar Data Analysis Center, Heliophysics Event Knowledgebase, Space Physics Data Facility, etc.) in order to assure the maximum utilization of this uniquely valuable archive.

(5) Continue to work with NASA officials to prepare the best possible and most useful final Yohkoh data products for NASA's Final Archive.

Allan Tylka/NASA Goddard Space Flight Center
Wind Data Services Upgrade: Energetic Particles at Interplanetary Shocks

Shocks are ubiquitous in astrophysical plasmas. Although the basic ideas of shock acceleration have been around for more than 50 years, details of the acceleration process are still only vaguely understood. Traveling interplanetary (IP) shocks are driven by fast coronal mass ejections, whose range of speeds and sizes generates shocks with a wide spread of parameters. In addition, over the course of the Solar Cycle, these shocks are launched into a variety of interplanetary plasma environments. Taken together, these factors make traveling IP shocks a key venue for deepening our detailed understanding of shock acceleration. Wind, with its unrivaled high time-resolution plasma and field measurements, offers a superb opportunity for studying IP shocks. However, as noted in the most recent Senior Review, availability of energetic-particle data from the EPACT

instrument package lags behind that of other Wind instruments, thereby hampering efforts of the Heliophysics research community to utilize Wind for IP shock studies. We will combine data from the STEP and LEMT instruments in EPACT to deliver 5-minute-averaged, spin-averaged He timelines and spectra for 285 shocks previously identified at Wind in 1995-2005 and catalogued at http://www.cfa.harvard.edu/shocks/wi_data. With this proposed effort, we will make a significant first step toward addressing the Senior Review concerns, by delivering a unique high-resolution dataset, from which the full capabilities of Wind, including EPACT, can be applied to energetic particle acceleration at IP shocks. However, this proposed effort does not fit within the very limited scope and funding of Wind MO&DA; accordingly, support from the HIDEE program is essential.

Yongli Wang/UMBC/GEST
Data Services Upgrade: Perfecting the ISIS-1 topside digital ionogram database

Over the years there has been a vast amount of fruitful research using topside ionogram observations from the International Satellites for Ionospheric Studies (ISIS) program and, more recently, from the digital ionogram format available for a subset of Alouette-2, ISIS-1, and ISIS-2 data. The digital format enabled more than 100,000 ISIS-2 topside vertical electron-density profiles to be automatically produced from the digital topside-ionogram files using software known as TOPIST. This large topside electron-density profile database enabled some large-scale studies. Topside electron-density profiles derived from the ISIS-2 ionograms, however, are limited to altitudes below 1,400 km, while many investigations need higher altitude observations. For example, significant discrepancies in high-latitude topside electron-density profiles are present between the International Reference Ionosphere (IRI) model predictions and the TOPIST ISIS-2 results and the discrepancies increase with increasing altitude. Thus there is a strong need to make ISIS-1 ionograms, which can provide topside electron-density profile information to much higher altitudes, ready for large-scale automatic processing into electron density profiles.

The current ISIS-1 ionograms have major data quality problems caused by difficulties in identifying the ionogram frame sync pulses and frequency markers during the analog-to-digital conversion process. As a result, the ionogram files can contain partial ionograms or multiple ionograms, rather than a single ionogram, and single ionogram files with incomplete, incorrect, or no frequency information. Also, to use the present ISIS-1 digital topside ionograms, each user has to include special treatments in their program to handle some special cases, including frequency treatment within certain ranges, which is a large burden and prone to errors. In this project, we will use mature software tools developed by this team to fix all the above-mentioned problems with the digital topside ionograms and significantly increase the total number of valid ionograms for TOPIST to successfully process. Here we propose to use this software to reprocess all available ISIS-1 digital topside ionograms from the Ottawa telemetry station from 1969 to 1983 which covers more than a solar cycle. We expect to process, and make ready for auto processing, some 50,000 high quality ISIS-1 digital ionograms from this station. The new

data product will be archived at the NASA Space Physics Data Facility (SPDF <http://spdf.gsfc.nasa.gov>) and made accessible and searchable through the Heliophysics Virtual Wave Observatory (VWO <http://vwo.nasa.gov>).

The proposed upgrade in this project represents a significant improvement in the quality and utility of the ISIS-1 digital topside-ionogram data, its format, and its accessibility. This digital topside-ionogram database will complement the 35-mm film topside-ionogram database because the original tapes included many that were never processed into film ionograms. We will fix all the problems in the existing ISIS-1 digital ionogram files and create a new product. The result will significantly improve the data utility and enable many ionosphere/magnetosphere investigations, e.g., those involving the plasmasphere boundary layer, i.e., the plasmapause vicinity, and those requiring a significantly improved IRI model for the mid-to-high latitude high-altitude topside ionosphere.

James Weygand/The Regents of the University of California
Data Services Upgrade: Restoration of OGO and Explorer Fluxgate Magnetometer Data

It has been shown that the Sun s Sunspot number has an 11 year cycle; however, the Sun s magnetic polarity has a 22 year cycle. This means that since the first interplanetary magnetic field (IMF) measurements in the early 1960 s the Sun s magnetic field has completed just over two cycles. For a number of years now it has been demonstrated that the IMF correlates with auroral electrojet activity, ring current indices like sym-H and asym-H, and cosmic ray modulation. In addition to solar cycle studies, data from the OGO-5, Explorer 33-35, 41, and 43 missions are critical for improving statistics of rare events such interplanetary field enhancements, which are attributed to clouds of fine-scale charged dust picked up by the solar wind after an interplanetary collision between objects in the diameter range of 10 1000 m [Lai et al., 2013]. Also, these data are pertinent for studying in detail potentially deadly coronal mass ejects events such as the one on August 4, 1972, which appears to be one of three such recorded events during the space age [Russell et al., 2013]. Despite the increasing advances in the speed of the internet and the online storage capabilities, access to older spacecraft measurements of the IMF from OGO-5 and Explorer 33-35, 41, and 43 has become more difficult because many of these data sets are not stored online and they are stored in older binary formats. The main goals of this study will be to make these data more readily available in a higher temporal resolution than the resolution OMNI has available for that time period and provide accompanying metadata in a simple easy read ASCII format through the Virtual Magnetosphereic Observatory (VMO).

Making the higher temporal resolution data available in a simple ASCII format is highly relevant to the goals of the Heliospheric Infrastructure and Data Environment Enhancements opportunity. Furthermore, the final products of this project can contribute to NASA s goals of understanding the influence of the Sun via the solar wind on the

magnetosphere through space weather studies. The products are relevant to the influence of coronal mass eject on the earth, specifically society s power grids and communications, and relevant to magnetic field turbulence effects on the scatter of cosmic rays. In addition, this project will be pertinent to NASA Heliospheric research program s goal of understanding the nature of long term solar activity.

The final products of this study will be the OGO-5 and Explorer 33-35, 41 and 43 magnetic field and spacecraft ephemeris data sets, which will be made available through the VMO. These enhanced magnetic field data will help fill a high temporal resolution gap in the over 44 years of observations of the IMF, which will be of interest to both the space weather community and studies on the solar cycle variations of our Sun.

James Weygand/The Regents of the University of California
Data Services Upgrade: Spherical Elementary Current System Archive for Magnetosphere-Ionosphere Coupling over North America

Ground magnetometer data from a number of groups are available through individual magnetometers arrays and from large consortiums like Tromsø Geophysical Observatory, SuperMAG, and others. Except for the IMAGE array covering only a fraction of Scandinavia, none of these groups provide equivalent ionospheric currents to the community. Ionospheric currents are invaluable for studying magnetosphere-ionosphere coupling. In conjunction with the THEMIS spacecraft mission and ground campaign Weygand et al. [2011] started a project using ground magnetometer data from about 8 ground magnetometer arrays to calculate the equivalent ionospheric currents (horizontal and vertical currents) over North America and Greenland using the Spherical Elementary Currents (SECS) method developed by Amm and Viljanen [1999]. That projected obtained ground magnetometer data from January 1, 2007 to July 31, 2012 and calculated the equivalent currents for approximately 22 months covering mainly the THEMIS spacecraft tail seasons. These data were made available through the Virtual Magnetospheric Observatory and have been used in approximately 10 refereed publications. However, equivalent ionospheric currents for the entire 5 plus years have not been calculated and the available data do not have quick look images. The main goals of this study will be to calculate the equivalent ionospheric currents for the remaining months, produce quick look plots for these data, and make both available through the VMO. These currents could be combined with the SuperDARN/StormDARN network, incoherent scatter radar data, THEMIS all sky images, and many different auroral and magnetospheric spacecraft to provide a state of the art data environment for studies on the full electrodynamics of the ionosphere as well as magnetosphere-ionosphere coupling over a large area with spatial and temporal resolution in more detail than previous studies. We are aware that the AMPERE mission does provide current densities to the community over the entire northern hemisphere, but it does not provide the horizontal equivalent ionospheric currents, it does not cover the entire THEMIS mission period, and the spatial and temporal resolution of that data set is limited.

Our methodology will be simple and will be completed over a 1 year period by the principle investigator, Dr. J.M. Weygand. Our first task will be to calculate the remaining 45 months of spherical elementary currents from Jan 1, 2007 to July 31, 2012 and make these current available through the VMO. The programs to complete this task are complete. Our second task will be to create quick look plots for the spherical elementary currents, write the appropriate meta data for these plots, and submit the plots and meta data to the VMO. Finally, we will write one publication in order to better advertise these data to the community.

The results of our data enhancement will help others address one of NASA s decadal science plan objectives, which is to understand the Sun s effects on the Earth through magnetosphere-ionosphere coupling and understanding how human society and technological systems are affected by magnetosphere-ionospheric coupling. With the regular availability of the THEMIS ground magnetometer network and all sky auroral imagers, the extension of the SuperDARN network to lower latitudes (StormDARN), the availability of total electron content over many years, and the routine operation of the AMPERE network, now is the ideal time to make our data set of spherical elementary currents available to the community for single event studies and large statistical studies.