

**Heliophysics Data Environment Enhancements**  
**Abstracts of Selected Proposals**  
**(NNH17ZDA001N-HDEE)**

Below are the abstracts of proposals selected for funding for the Heliophysics Data Environment Enhancements program. Principal Investigator (PI) name, institution, and proposal title are also included. Nine proposals were received in response to this opportunity. On December 6, 2017, 9 proposals were selected for funding.

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**Christian Bethge/Universities Space Research Association, Columbia**  
**Preparation, documentation, and public release of CLASP data**

On 3 September 2015, the Chromospheric Lyman Alpha Spectropolarimeter (CLASP) on-board a NASA/MSFC sounding rocket successfully observed the Sun in Hydrogen Lyman Alpha (121.6 nm) for about 5 minutes. The CLASP observations represent a unique dataset, as the instrument captured measurements of the solar Lyman Alpha linear polarization for the first time. The line is formed in the upper chromosphere/lower transition region, a crucial region for understanding where coronal structures are rooted and how energy is released into the outer atmosphere. The linear polarization signal in Lyman Alpha is generated by scattering processes and is sensitive to the Hanle effect, i.e. the modification of the polarization state in the presence of magnetic fields. The data provide unique insight into the thermal and magnetic structuring in the upper chromosphere. Additionally, future assessments of predictions from MHD simulations will benefit from including the CLASP measurements.

The CLASP data were taken with three cameras: a slit-jaw context imager and two spectrograph cameras recording the linear polarization simultaneously at perpendicular angles. During the flight, the instrument first pointed to a reference location at disk center for 20 seconds, and then pointed near the limb for the remainder of the observation to cover a wide range of heliocentric angles with the 400 arcsec long slit. The CLASP data have been calibrated (dark subtraction, flat fielding and gain correction, co-alignment, polarization demodulation) and written out as FITS files for internal use within the CLASP science team. In order to publish the data and to make it accessible, usable, and comprehensible for the community, the following tasks need to be carried out and are proposed for this submission: a) additional calibration steps b) extension and improvement of the metadata contained in the FITS headers, in particular regarding the compliance for the Space Physics Archive Search and Extract (SPASE) Data Model, the NASA Heliophysics data centers (SPDF/SDAC), and the Virtual Solar Observatory (VSO); c) inclusion of the data into the aforementioned archives for public dissemination; d) development of instrument-specific software routines for external users to read in the data and produce higher level data products; e) in-depth photon error-budget analysis, which will also be applicable to the funded successor mission CLASP2; f) documentation for all preceding tasks.

CLASP is an important step in assessing suitable spectral lines for use in a potential future satellite mission to detect and measure the chromospheric magnetic field. Scientific advancement through analysis and comparison to simulations is already underway within the extended CLASP team, but the utility of the data can be enhanced when released to the community. This HDEE proposal will result in a well-coordinated release of data products that are easy to access and comprehend. We will carefully record the calibration steps taken and the error associated with each measurement, simplifying the interpretation of the data for external users for a quicker science return.

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## **Linton Floyd/Space Systems Research Corporation SUSIM UARS Data and Metadata Enhancements**

The goal of this proposal is the improvement of the solar UV irradiance dataset as originally measured by the NASA-supported SUSIM UARS experiment. The Solar Ultraviolet Spectral Irradiance Monitor (SUSIM) aboard the Upper Atmosphere Research Satellite (UARS) gathered solar UV irradiances on nearly a daily basis for nearly 14 years (1991-2005). As has been typical of NASA experiments operating on extended missions, the SUSIM program funding was ended abruptly providing for only marginal post-mission data processing. Accordingly, although the resulting SUSIM dataset has proved to be a valuable addition to the overall set of solar irradiance measurements gathered over the past 3 decades, the SUSIM observations can be substantially improved via a modest effort.

The SUSIM data consists of absolutely calibrated UV solar spectral irradiances and integrated UV irradiances for wavelengths 115-410 nm at 1.1 nm resolution. These data were calibrated through sophisticated and complex algorithms based on coincident solar and onboard lamp measurements by redundant optical channels.

More specific scientific data improvements provided through this proposal include: 1) reduction in the noise in the solar UV irradiance time series, 2) removal of artifacts that represent uncorrectable errors or problems in the underlying measurement data, 3) recalculation of calibration data where these had been adversely affected by data errors and artifacts, and improved metadata which, for example, describes how the irradiances are calculated.

The data products resulting from this work will be a new version ("23") of the solar UV integrated and spectral irradiances reprocessed with an updated calibration. These data comprise 1) Level 3 irradiances integrated into 1 nm bins, level 2 spectral irradiances presented on (varying) instrumental wavelengths, 3) integrated irradiances onto irregular 5-10 nm regions optimized for noise reduction, and 4) solar indices, e.g. Ly- $\alpha$  line irradiance and a MgII index. These data products will have more specific and accurate error estimates specifically associated with them. Documentation will include (for the first time) a detailed description of how the data were processed from the raw telemetry to final product.

Each of the irradiance data products will be made available in several forms, thus providing users with data access options. Specifically, the irradiance data will be provided in the forms of CDF, netCDF, and ASCII files. Documentation will be embedded into the data when practical and we will aggressively take advantage of self documentation features and opportunities. These files will be submitted to the SDAC for general data access and archival storage. We also will work with HDMC and NASA HQ, as well, to develop an acceptable SUSIM data plan.

The SUSIM data has seen wide usage both in the US and abroad and continues to do so today. Notably, it overlaps with similar data from the SORCE mission providing a basis

for intercomparisons and validation. Currently, NASA sponsors an effort to calibrate solar UV irradiances from the NOAA-16 and -17 satellite SBUV2 instruments both of which gathered UV irradiance data for 10+ years. The PI of this proposal participates in the current Solar Irradiance Science Team (SIST) that has met in 2016 and 2017. The SUSIM calibration data is playing an important role in this effort especially in intercomparisons among the SORCE, NOAA, and SUSIM instruments.

This proposed work provides important support of NASA's heliophysics science goals. Among these is to understand the Sun and its variability. It also supports our understanding of the impact of solar activity on the Earth and solar system. Third, it enables research on the connections among the Sun, Earth, and solar system supporting both our scientific knowledge and human exploration. The improved and more accessible solar UV irradiance record resulting from this work supports these listed goals.

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**Shukirjon Kholikov/Association Of Universities For Research In Astronomy, Inc.  
An unique data set to investigate deep solar meridional flow using time-distance technique**

Science goals and objectives

This proposed work will create a specific data set for studying deep meridional flow profile from 30 Mm below the solar surface up to tachocline region and will use HMI/SDO data.

An important goal of solar physics is the understanding of the mechanisms of solar activity, as a problem in its own right and for its importance in determining space weather. Some clues to the puzzle should arise from studying the physical processes in the deep convection zone since it is the motions in this region that are thought to regenerate the poloidal magnetic field from the toroidal magnetic field, an essential process that allows the solar cycle to continue. While substantial progress has been achieved in understanding solar convection-zone dynamics and its relation to surface activity, some important problems still remain, such as the nature of the deep meridional flow that drives the dynamo.

Recent measurements of Equatorward component of the meridional flow from HMI and GONG data show similar pattern of general picture of the flow profile. However, there are some controversial results as well. For example multi-cell structure of the meridional flow (in depth and latitude) is different in two independent measurements. Most of the disagreements may be due to the fact that these measurements are not from standard HMI or GONG data product. They are derived using different processing and measurement techniques. Standard pipelines does not produce such type of data. Moreover, deep flow measurements are very sensitive to analysis methods and parameters of data processing e.g. projection, filtering etc.

We propose to create very unique and specialized data products which will cater to all interested Heliophysics community with a uniformly processed and well accepted processing parameters since standard HMI pipeline does not produce such type of data. Further, processing of such data sets is computationally intensive. Thus, availability of these data will facilitate many research groups to work on uniform data even if they do not have the processing capabilities to produce such data.

## Methodology

We will use time-distance technique to produce the data for measuring the deep meridional flow from 30 Mm below the solar surface up to tachocline region. As demonstrated, time-distance based deep meridional flow measurements do not require original full resolution HMI velocity Dopplergrams. Measurements for near surface layers (upper 5% convection zone) are produced by standard time-distance and ring diagram pipelines. In this project we will use Spherical Harmonic coefficient time series with maximum spherical harmonic degree,  $L$ , values up to 300. These time series are the best product to derive deep flow measurements. All necessary steps on quality check, apodization and CCD to heliographic projections, SH decomposition are done with well accepted concepts. The key point would be performing phase speed filtering procedure to the coefficients and measuring acoustic travel time measurements in spherical geometry.

Our technique works well and has been tested using simulation data to recover both, poleward and return components of the meridional flow. Also we have already applied our processing tools to the first two years of HMI data. We have demonstrated that these measurements are obtained with 4-6 times smaller error-bars in comparing to unfiltered measurements which is very important for deep flow structure recovery.

Travel time differences will be archived by organizing as a function of latitude-depth and time. Parameters of filtering process, travel time measurement scheme, weighted averages, averaging error-bars and involved solar disk areas will be listed on attached tables.

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## **Rudolf Komm/Association Of Universities For Research In Astronomy, Inc. Subsurface Zonal and Meridional Flow from Big Rings: a Dataset for Studying the Long-Term Evolution of Magnetic Flux and the Dynamics of the Convection Zone**

Science goals and objectives:

We propose to create a dataset (derived from SDO/HMI) of the corrected zonal and meridional flow in sub-photospheric layers including the near-surface shear layer (NSSL) for scientific investigations by the Heliophysics community. The zonal and meridional flow play important roles in a broad range of solar phenomena from the dynamo to the evolution of polar magnetic fields and the prediction of the solar cycle. The structure and

the strength of the meridional flow sets the timing of the solar cycle in flux-transport dynamo models and greatly influences the polar field evolution. The zonal flow (residual rotation rate) varies with the solar cycle and the cycle-related flow patterns appear several years before magnetic activity of the next cycle is apparent in the photosphere. The flows and their temporal variation are thus crucial in predicting the solar cycle. The NSSL is of importance since it is a region where downward convective pumping expels the horizontal magnetic field in dynamo models and it might be a transition region for the rotational impact on convective motions and thus vital for understanding the large-scale dynamics of the convection zone. Since the amplitude of the meridional flow is comparably small (two orders smaller than the solar rotation rate) and the solar-cycle variations of the meridional and zonal flow are even smaller (by about a factor of four), these flows are susceptible to systematics and robust measurements are not easily available. We propose to create an upgraded data product that is corrected for systematics and is consistent during different phases of the solar cycle. The proposed data product can thus be used as input data in modeling efforts or as a benchmark to compare model predictions against. Making the corrected subsurface zonal and meridional flow available as a data resource to the Heliophysics community will greatly enhance the scientific return from SDO/HMI and will be crucial for understanding the poleward transport of magnetic activity and predicting the solar cycle.

#### Methodology:

We will produce the following upgraded data product: the zonal and meridional flow in the subsurface layers from the surface to a depth of about 40 Mm as a function of latitude and time for Solar Cycle 24 covered by SDO/HMI data. The input measurements are the daily full-disk subsurface flow maps derived from SDO/HMI Dopplergrams analyzed with the ring-diagram (RD) technique using big patches of 30 degree diameter (in contrast to the standard RD technique using 15 degree patches). This data set allows us to determine horizontal flows in the upper convection zone including the NSSL. Even though the daily flows are routinely produced by the RD pipeline, they remain underused. To upgrade the input data, we will improve their quality by removing systematic effects present in the subsurface flow measurements, such as systematic variations with disk position and annual variations due to the B0 angle. We will create synoptic maps of the corrected flows and averages over each Carrington rotation to improve their utility and make the data products available in FITS format for accessibility. Our method works well with subsurface flow data derived from the standard 15-degree RD pipeline. We will adapt the technique to existing (archived) horizontal flows from big RD inversions and create these datasets first including their calibration and documentation. We will then create new data products as soon as full Carrington rotations of subsurface flow measurements become available from SDO/HMI (via JSOC), and will add them to the dataset. In this way, we will create a dataset that can be used for studies of the solar cycle as well as for modeling latitudinal flux transport of the current Sun and the large-scale dynamics of the convection zone.

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**Aimee Norton/Stanford University**  
**Data Upgrade: HMI Data Corrected for Stray Light**

We propose to improve the Helioseismic Magnetic Imager (HMI) data quality by removing stray light from the full-disk solar images. To that purpose, a point spread function (PSF) has been developed in the form of an Airy function convolved with a Lorentzian. The parameters are bound by analysis of ground-based testing of the optics before launch, and off-limb light curves, lunar eclipse and Venus transit data obtained after launch. The PSF correction is programmed in the C computing language and runs within the standard data processing pipeline of HMI. The deconvolution uses a Richardson-Lucy algorithm which is an iterative procedure for recovering a blurred image using a known PSF. A single, full-disk, HMI intensity image can be deconvolved in less than one second.

We intend to provide improved HMI products, at least once a day, for the duration of the HMI mission. The improved data include the full-disk ( $4096 \times 4096$  pixels), line-of-sight products of Doppler velocity, continuum intensity, line-of-sight magnetic field, line depth and line width ( $vDop$ ,  $I_c$ ,  $MLOS$ ,  $L_d$ ,  $L_w$ ) and also the Milne-Eddington atmospheric inversion products of the vector magnetic field including field strength, inclination angle, azimuthal angle, Doppler velocity of the magnetic component, Doppler width, center-to-continuum absorption coefficient, source continuum and source gradient ( $B$ ,  $\hat{O}$ ,  $\hat{A}$ ,  $vBLOS$ ,  $\hat{D}$ ,  $\hat{A}$ ,  $\hat{O}$ ,  $\hat{I}$ ). The deconvolution algorithm can be applied to the original filtergram images obtained by HMI prior to the processing and combination of these images into calibrated data products with physical units. We have also shown that deconvolution of scattered light from the Stokes profile data is equivalent to deconvolution from every filtergram, and is less computationally expensive.

Testing on select HMI data has shown that deconvolution of stray light results in the following:

- " a decrease in umbral intensity corresponding to  $\sim 200$  K cooler,
- " a doubling of the intensity contrast of granulation from 3.6 to 7.2%,
- " an increase in field strengths in plage by  $\sim 1.4$ ,
- " faculae brightening and network darkening,
- " and a partial correction for the convective blueshift.

The science goals that this data upgrade would enable include:

- " improve quality of solar irradiance reconstruction by providing full disk, daily data with increased photometric and magnetic contrast accuracy, i.e. improved modeling results produced by the SATIRE code using HMI data,
- " increase accuracy of co-alignment for high-spatial resolution instruments, such as IRIS, IBIS, etc., that use HMI for greater context of solar dynamics, including magnetic connectivity and dynamics of nearby regions,
- " decrease tracking errors by providing larger intensity contrasts of features,
- " improve magnetic field measurements for pores, plage and other small magnetic features since previous HMI field parameters were contaminated by stray light,

" partial removal of the convective blueshift allows for improved studies such as motion along the polarity inversion line in active regions, and

" improve helioseismic measurements of correlations between sunspot umbra and surrounding photosphere leading to better knowledge of the subsurface structure of sunspots.

All routine HMI data products will be upgraded for at least one full-disk image per day with higher temporal cadences provided on request and as possible. The funding will enable the development of routine scripts to run the codes, modification of dependent algorithms affected by stray light removal, such as the location of the solar limb, disk center and other image metadata, as well as modification of the PSF in time and azimuth as needed. The upgraded data will be stored in the final archive in fits format, have physical units, with all metadata and keywords in tact as described within the HMI data manual. The data will be available to the public.

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**Alexei Pevtsov/Association Of Universities For Research In Astronomy, Inc.  
Preservation of early full-disk magnetograms from MWO.**

Science goals this proposal will enable: Full disk photospheric magnetograms are one of the most important datasets of modern research in solar physics. The magnetograms are invaluable for understanding and modeling of practically all solar phenomena including solar cycle, corona, solar eruptive activity, heliosphere, and space weather. Two major limitations of historical magnetograph data, which are currently in public domain, include (1) their limited time coverage (mid-1970-present) and (2) possible uncertainties in calibration of magnetic fields of early magnetograms, which could be alleviated via comparison with multiple instruments. The proposed project will address these two limitations by recovering magnetograph data from early periods (1967-mid-1970) and by putting magnetograms from additional (Mount Wilson Observatory) magnetograph in public domain.

A brief description of the methodology: One of the longest synoptic data sets currently in use for modelling of solar phenomena is comprised of data from three instruments that were operating at the National Solar Observatory at Kitt Peak (KP) beginning early 1970. After 2003, this data set continues using observations from Vector Stokes Magnetograph (VSM) on Synoptic Optical Long-term investigation of the Sun (SOLIS). Early KP data suffer from several artifacts and the recalibration work is still in progress (Harvey & Munoz-Jaramillo 2015). The earliest synoptic magnetograms were taken with the full disk magnetograph at Mount Wilson Observatory (MWO) from mid-1950s. Starting in 1996, the Mount Wilson 150 foot tower telescope system began taking observations in several spectral lines, and continued through January 2013. Unfortunately, a data server failure led to a loss of public access to this important dataset. Recently, our team located several copies of the MWO data set covering the period 1974-2013. They contain about 13,000 individual magnetograms, observed using Na I 589.6 nm or Fe I 525.0 nm spectral lines with 12.5 arcsec or 20.0 arcsec spatial sampling. Notably, magnetograms observed using Cr II 523.7 nm spectral line after 1988 are absent from this data set. As

part of this project, we will analyze the data at hand for completeness; convert all files into a modern (FITS) format with appropriate metadata information for each observation; and make the data public. We will consult the remaining staff of MWO observatory (including Dr. R. Ulrich) about the information pertinent to the observations and calibration of this data. A complete dataset including accompanying documentation will be made public via SDAC at GSFC and the Digital Library at the National Solar Observatory (NSO).

In addition to MWO magnetograms from 1974–2013, there are also older observations stored in various formats. The quality of some of these subsets is unclear and would require additional investigation. The original full-disk observations from 1954–1967 are stored in oscilloscope images on film reels and so-called pen plots. Both formats may be challenging to digitize. Still, these are the earliest known full disk magnetograms, and as part of this project, we propose to evaluate their status and create a description of data and their quality for any future recovery attempts. Observations from 1967–1974 are stored using machine-readable (IDR) format. Our early tests show that these data are still readable. As our second task, we will convert these data to FITS format and make them public.

Finally, we would like to emphasize extreme timeliness of this project. As the scientists involved with MWO magnetographic observations are retiring from active research, the knowledge about the earliest full disk magnetograms could be permanently lost unless we preserve it now. The development of MWO magnetograph and early years of its operations were funded predominantly by NASA grants, and thus, should be considered as NASA data.

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**Chadi Salem/University of California, Berkeley**  
**Reanalyzing, Reprocessing and Upgrade of HELIOS 1 & 2 Solar Wind Plasma**  
**Proton, Alpha-Particle and Electron data**

Helios 1 & 2 rank among the most important missions in Heliophysics, and the more than 11 years of data returned by its spacecraft remain of paramount interest to researchers. Their unique trajectories which brought them closer to the Sun than any spacecraft before or since, enabled their diverse suite of in-situ instruments to return measurements of unprecedented scientific richness. The Helios data continue, to date, to be of prime interest to the Space Physics community. This dataset played a key role in the planning of the upcoming Solar Orbiter (SolO) and Solar Probe Plus (SPP) missions, and continue to do so.

Under a past two-year NASA HDEE grant, we have been working on aggregating, analyzing, evaluating, documenting all the available Helios 1 & 2 in-situ data with the goal of creating a single comprehensive archive of the dataset to be made publicly available to the entire community for use in preparation of SolO and SPP and beyond. It has been a very tedious work but the archive is online (<http://helios-data.ssl.berkeley.edu>) although being a work in progress, and will be publicly open by mid June 2017.

A careful, detailed, analysis of the Helios fluxgate and search coil magnetic field data has revealed numerous issues and problems with the available, processed, datasets, that we are still working to solve. This task is not trivial as the original, raw, data are gone forever. Similarly, a careful analysis of the plasma data has also revealed issues with the accuracy of the available plasma moments (ion/electron density, velocity and temperature etc), as well as other issues with the processing of the various more developed products such as 1D (reduced) particle distributions and 3D distribution functions from the raw data. The plasma data, in particular, the ion and electron moments, have been widely used in the past and continue to be used to date, without knowledge or understanding of their issues and limitations. Having reliable and accurate plasma measurements will be of tremendous help to the SPP and SO community who strongly rely on foreknowledge of the variety of solar wind conditions that their mission will encounter.

We started looking very closely at the various ion and electron datasets and old documents in German that we gathered. We translated the plasma instrument blue book and other related documentation from the 80s with pertinent information concerning the processing of the plasma data. This helped us tremendously to sort through the more detailed datasets, i.e. 1D and 3D ion distribution functions from the I1a instrument, 1D ion current measurements from the I1b instrument, 3D ion distribution functions from the I3 instrument, as well as 2D electron distribution functions from the I2 instrument. We came up with a very detailed plan to reprocess the ion and electron distribution function data using modern fit techniques instead of the previously used moment calculations. By fitting a model distribution function to the measured distributions, we will be able to accurately characterize the different components of the ion and electron distribution functions.

We will derive new and more accurate parameters of solar wind core and beam protons, core and beam alphas as well as electron core, halo and strahl parameters. These parameters will include density, velocity, temperature, temperature anisotropy, and heat flux. These new parameters will be added to our single Helios data archive hosting all the in-situ Helios data, along with valuable documentation and software.

Prior studies of ion data from Helios, Ulysses, Wind, and other mission have demonstrated the complexity of solar wind kinetics. Besides being of prime interest to SPP and SolO teams, the new, high-accuracy dataset of Helios ion parameters will enable the community to make exciting new investigations into the processes that affect the evolution of solar wind plasma as it expands through the inner heliosphere.

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**Keiji Yoshimura/Montana State University, Bozeman**  
**Cross calibration of multiple solar observational instruments for coalignment**

The coalignment of solar images from various observational instruments is an important step to study solar features and phenomena when using data acquired from multiple telescopes or wavelengths.

Solar researchers face several problems in their coalignment step. For example:

- (1) While each instrument team usually provides values for the coalignment parameters,
  - (a) the provided values may not be accurate enough for some applications,
  - (b) estimates of error are rarely available.
- (2) It is time consuming and difficult for many researchers to correct the coalignment parameters, and the effort is then duplicated by many researchers independently.

We propose to solve the coalignment problem accurately and efficiently for five major solar missions, and distribute the results in a timely and convenient manner to the entire community.

In a recent paper, Yoshimura and McKenzie (Solar Physics, vol.290, p.2355, 2015), we reported the results of our successful calibration for the coalignments between the X-Ray Telescope (XRT) onboard Hinode and two instruments onboard Solar Dynamic Observatory (SDO), i.e., the Helioseismic and Magnetic Imager (HMI) and the Atmospheric Imaging Assembly (AIA).

The project we are proposing is an extended cross calibration, which covers multiple solar observational instruments:

- (1) the Interface Region Imaging Spectrograph (IRIS),
- (2) the Solar Optical Telescope (SOT) onboard Hinode,
- (3) AIA/HMI, and
- (4) Transition Region and Coronal Explorer (TRACE)

The same methodology used in the previous study (Yoshimura and McKenzie, 2015) will be applied, after some improvements and optimization for the new instruments. The cross calibration of roll angle and plate scale, for example, will be done by the local correlation tracking method. The usefulness of the method is proved in the previous study.

The goal of the project is to provide all solar physics researchers with well calibrated parameters for coalignment, with error estimates. By using the calibrated parameters provided via Solar Software users can easily coalign the data sets from different instruments with higher accuracy. The easy and accurate coalignment that we provide will increase the efficiency and activity of solar research using data from multiple instruments.

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**Yongliang Zhang/Johns Hopkins University**  
**Net radiance of atomic nitrogen emission at 149.3 nm from TIMED/GUVI**

1. Objectives:

We propose to provide the community a unique product, the net radiances of the atomic nitrogen emissions at 149.3 nm in the thermosphere from the TIMED/GUVI spectrographic data. The product (2008-present and beyond, the period when GUVI is operated in spectrographic mode) will be provided as NetCDF files with a metadata documentation and stored at the TIMED/GUVI website (<http://guvitimed.jhuapl.edu/>) and transferred to the NASA Space Physics Data Facility (SPDF) for public to use. The N-149.3 nm product is beyond the scope of the original TIMED/GUVI science data products.

2. Science importance

The net N-149.3 nm radiances represent the population of atomic nitrogen (e.g. N(2D), N(4S)) which are directly related to the fundamental photo-chemical processes of N<sub>2</sub>, O<sub>2</sub>, and NO. Initial study shows the N-149.3 nm radiances are significantly enhanced in the region with O/N<sub>2</sub> depletion and NO enhancement. The simultaneous specification of the new net N-149.3 nm radiance with the existing GUVI data products (net NO  $\mu$  band radiances and O/N<sub>2</sub> ratio) will further improve our understanding storm-time dynamics of thermospheric composition (NO, N<sub>2</sub>, O<sub>2</sub>, O/N<sub>2</sub>), improving the specification of the related photo-chemical cross sections, and provide unique validation data sources for physics based models. The N-149.3 nm radiance together with the NO  $\mu$  band radiance may help to solve the controversy in NO production at sub-auroral latitude (local production versus transport from high latitude). The unique GUVI net N-149.3 nm radiance data product is also expected to enable the community to further test our ability to model storm-time response of the thermosphere and thus improve the accuracy of space weather forecast and benefit the LEO satellite operation through accurate drag estimation.

3. Methodology

It is straightforward to extract the net N -149.3 nm radiance from the TIMED/GUVI spectrograph data by subtracting the N<sub>2</sub> LBHS spectra (modeled by matching the simulated LBH bands with GUVI observations in the wavelength ranges with pure LBH bands). The associated time, geolocation and errors are also estimated and stored in NetCDF files which are self-explained and popular in the ionosphere and thermosphere research communities.

4. Relevance to NASA goals

This proposal directly addresses the goal of 2017 NASA Heliophysics Data Environment Enhancements Program by extracting new science data from existing NASA TIMED/GUVI data. The resulting dataset also significantly benefits the researches that address 2014 NASA's Heliophysics science strategy Improve our understanding of fundamental physical processes in the solar system from the Sun's interior to Earth's upper atmosphere, interplanetary space and the edges of the heliosphere and 2013

Heliosphere decadal survey goal #2: determine the dynamics and coupling of Earth's magnetosphere, ionosphere and atmosphere and their response to solar and terrestrial inputs .

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