SPA-Solar and Heliospheric Physics

SH51A MCC: Hall D Friday 0830h

Toward an Integrated Solar-Terrestrial Data Environment I
Posters *(joint with A, SA, SM)*

Presiding: **S Wing,** Applied Physics Laboratory**; D Sibeck,** NASA Goddard Space Flight Center

SH51A-0415 0830h POSTER

The Space Physics Archive Search Engine (SPASE) Project for Sun-Earth Connection Data Finding and Retrieval

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The diversity of space physics data available electronically has become so great that it is difficult to keep track of what information exists. With current technology it is possible, however, to provide an easy way to determine the existence and location of data of interest via queries to network services with a relatively simple user interface. An international group of space physics data centers is developing such an interface system, called the Space Physics Archive Search Engine (SPASE).

Many comprehensive lists of URLs have been put together to provide a minimal search capability for space physics data. One recent effort to gather a list of data sources resulted in an assembly of nearly 100 URLs and many important archives had still been missed. These lists are difficult to maintain and change constantly. However, even with these lists it is not possible to ask a simple question such as "where can I find observations near the polar cusp in 1993?" without doing extensive, manual searches on separate data services. The only hope for a comprehensive, automated search service is to have data centers/archives make their own information available to users in a manner that will facilitate multi-archive searching.

Nearly all space physics data providers have WWW services that allow at least a basic search capability, and many also provide more specialized interfaces that support complex queries and/or complex data structures, but each of these services is different. The SPASE effort is creating a simple, XML-based common search capability and a common data dictionary that would allow users to search all participating archives with topics and time frames such as "polar cusp" and "the year 1993". The result would be a list of archives with relevant data. More advanced services at later stages of the project would allow intercomparison of search results to find, for example, overlapping data intervals. Retrieval of the relevant data would also be supported.

The first stages of the project are based on testing existing software applications such as the Object Oriented Data Technology (OODT see http://oodt.jpl.nasa.gov/about.html) for applicability. The initial effort also includes the derivation of a common data dictionary for facilitating the searches. The current state of these efforts and plans for the future will be reviewed.

SH51A-0416 0830h POSTER

An Integrated Web based environment for Space Weather Applications and Event Studies

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Over the past year work has begun at APL on the development of an integrated data system for displaying multiple data sets from multiple sources for use in Space Weather applications.

The system was designed to be simple to implement, easy to maintain and adaptable to other applications. It has since been successfully demonstrated in support of a Sun-Earth Connections workshop held in August at APL, where it acted as the data system available for workshop participants.

This paper will demonstrate the techniques used developing the system and illustrate how a successful product depends on focusing on the requirements of the end user.

URL: http://storms.jhuapl.edu

SH51A-0417 0830h POSTER

A Prototype Scientific Resource Access System for Living With a Star Scientists

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In recent years, there has been a proliferation of scientific resources, including data repositories and analysis tools, available to solar and space physicists for research use. As the Living With a Star satellites begin to collect data and as more analysis tools are created, the data and analysis environment will become increasingly complex. Currently, scientists visit multiple sites and use general-purpose search engines to locate and retrieve data and analysis tools. While this approach currently works within a discipline, as the quantity of data and tools increase, this method of search and retrieval will become increasingly inadequate for both inter-disciplinary and intra-disciplinary research. Data and tool providers may also find it difficult to identify and supply their resources, particularly when supporting multiple scientific disciplines, data formats, and resource sites. At the Johns Hopkins University Applied Physics Laboratory, we are developing a prototype Scientific Resource Access System (SRAS) to allow scientists to discover and access multiple distributed scientific resources from a single interface. In addition, it enables resource providers to identify and make available their resources with a minimum of effort, without having to convert or upload the data. The SRAS will provide a simple and complete method to allow the space science community to gather and share valuable data and analysis tools.

SH51A-0418 0830h POSTER

Near-Real-Time Web-based Interactive Data Access

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The technology needed for real-time interactive data acquisition and processing has advanced to the point that data even from remote observatories can be examined using common computers with access to the internet. The hardware on networked server computers can now store high time resolution data spanning years of observations, at minimal cost. Software developed for laboratory analysis of data can now be made available to the general community, using server software that permits dynamic access to the data and software resources.

National Science Foundation sponsored research in the Arctic and Antarctic regions has produced an extensive database dating from January, 1982, from multiple observatories, and incorporating measurements from induction (searchcoil) and fluxgate magnetometers, band-pass filtered very-low-frequency (VLF) radio wave receivers, photometers, and multiple-frequency broadbeam and imaging riometers, at time resolutions as short as 0.1 s. Internet access to the remote data acquisition servers via satellite has enabled the database to be updated nearly in real-time. Plans are now being implemented to acquire additional data using Iridium communications channels, which permit actual real-time data access from multiple remote observatories.

We describe a developing web-based system that permits data from this database to be plotted interactively using common web browsers, and which includes the capability for accessing processed data files in multiple formats that enables the data to be incorporated easily into other applications.

SH51A-0419 0830h POSTER

Interoperable Data Delivery in Solar-terrestrial Applications: CEDARWEB and OpENDAP.

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The High Altitude Observatory (HAO) division of NCAR investigates the sun and the earth's space environment, focusing on the physical processes that govern the sun, the interplanetary environment, and the earth's upper atmosphere.

We present details on how a set of data systems supported by HAO and collaborators has driven the implementation of services around the Data Access Protocol (DAP) originating in the Distributed Oceanographic Data System (DODS) project. The outgrowth of this is the OpENDAP - an open source project to provide reference implementations of the DAP and its core services.

We will present the recent design and development details of the CEDARWEB (NSF program for Coupled Energetics and Dynamics of Atmospheric Regions) service built around the DAP, including interfaces to common application programs, like the Interactive Data Language, the web, and server side data format translation and related services.

We also present examples of how the interoperability in the assembly of this system is being used in other science discipline and technology areas: the Radiative Inputs from Sun to Earth program, the Earth System Grid II project, and the Space Physics and Aeronomy Collaboratory.

SH51A-0420 0830h POSTER

The Collaborative Sun-Earth Connector

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The Collaborative Sun-Earth Connector fuses data from a variety of instruments, including images, spectra and in situ measurements, to unveil the essential elements of space weather. We demonstrate a prototype system for such coordinated, distributed data analysis based upon software agent technologies and SolarSoft (Freeland and Handy 1998). Researchers use the system to develop process maps which merge distributed data archives and servers into a virtual data analysis system. Sophisticated image and time-series processing can be coordinated between data centers while minimizing the amount of data transferred between them and optimizing the delivery of pertinent and refined data to the requestor. We describe how CoSEC relates to and can leverage related efforts from the Virtual Solar Observatory and the European Grid of Solar Observatories and examine how it can transition to a comprehensive data analysis system for upcoming LWS and SEC missions.

Freeland, S. and Handy, B., 1998 Sol. Phys. 182,497

This research is funded by NASA through grant NAG5-10784.

URL: http://www.lmsal.com/cosec

SH51A-0421 0830h POSTER

Services and Perspectives Towards the Future SEC Data Environment

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The next advances in Sun-Earth Connections (SEC) / Solar-Terrestrial science require an increasingly integrated and transparent data environment, where data can be easily accessed and used across the boundaries of both missions and traditional disciplines. The Coordinated Data Analysis [Workshop] Web (CDAWeb) and Satellite Situation Center Web (SSCWeb), critically supported by the Common Data Format (CDF) effort, are important current examples suggestive of the scope and functionality needed in the future and are among the first working prototypes for delivering the class of integrated, multi-mission data view essential to the programs like Living with a Star (LWS). CDAWeb supports graphics and data retrieval from a unique database of current multi-mission Sun-Earth-Connections (SEC) data. The Satellite Situation Center Web (SSCWeb) serves satellite orbits and various multi-mission conjunctions queries. Both are supported by CDF as the underlying standard format and a range of working utilities.

As one part of this paper, we will present the capabilities, accomplishments and evolutionary directions for CDAWeb and SSCWeb and their technologies. But building on this background and our overall role as a center for SEC active science data archiving, we will also review a broader range of issues and challenges towards a more comprehensive approach to data management and data services planning across the disciplines and missions of SEC

Supported by the NASA Office of Space Science, CDAWeb, SSCWeb and CDF are joint efforts of the NASA GSFC Space Physics Data Facility (SPDF) and the National Space Science Data Center (NSSDC). Please also see related presentations in this session on CDF and the new TIPSOD SOAP-based enhancements to SSCWeb.

URL: http://spdf.gsfc.nasa.gov

SH51A-0422 0830h POSTER

XML Web Services and 3D Orbit Viewer Application of SSCWeb

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The Satellite Situation Center Web (SSCWeb) is a browser-based service to provide geocentric spacecraft location information and cast it into a framework of (empirical) geophysical regions and mappings of spacecraft locations along lines of the Earth's magnetic field. While backed by a substantial and maintained database of spacecraft orbit information and extensive software logic, several shortcomings in the present service are the inability of the architecture to support externally-developed clients and limitation of the orbit graphics to static, 2-D plots. This talk introduces a new distributed programming interface to the SSCWeb software based on the SOAP (Simple Object Access Protocol), a modern, industry standard technology. This interface, SSC XML Web Services, allows systems to communicate with SSC over the open protocols of the Internet. This flexible architecture will enable new SPDF developed client applications, as well as externally developed clients, to access the SSCWeb data and logic to bring new services and capabilities to the SEC community.

The first such client application is TIPSOD (Tool for Interactive Plotting, Sonification and 3-D Orbit Display). Implemented in Java 3D, TIPSOD extends the existing SSCWeb 2-D static orbit graphics with 3-D interactive and animated displays linking set of spacecraft positions as a function of time. Additional capability and functional enhancements to SSCWeb services and TIPSOD, as well as the extension of this technology to the CDAWeb service, are being considered to further the relevance and usefulness of this work to the science community.

SSCWeb is a joint effort of the NASA GSFC Space Physics Data Facility (SPDF) and the National Space Science Data Center (NSSDC).

URL: http://sscweb.gsfc.nasa.gov

SH51A-0423 0830h POSTER

Comparing Emerging XML Based Formats from a Multi-discipline Perspective

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This paper analyzes the similarity and differences among several examples of an emerging generation of Scientific Data Formats that are based on XML technologies. Some of the factors evaluated include the goals of these efforts, the data models, and XML technologies used, and the maturity of currently available software. This paper then investigates the practicality of developing a single set of structural data objects and basic scientific concepts, such as units, that could be used across discipline boundaries and extended by disciplines and missions to create Scientific Data Formats for their communities. This analysis is partly based on an effort sponsored by the ESDIS office at GSFC to compare the Earth Science Markup Language (ESML) and the eXtensible Data Format(XDF), two members of this new generation of XML based Data Description Languages that have been developed by NASA funded efforts in recent years. This paper adds FITSML and potentially CDFML to the list of XML based Scientific Data Formats discussed. This paper draws heavily a Formats Evolution Process Committee (http://ssdoo.gsfc.nasa.gov/nost/fep/) draft white paper primarily developed by Lou Reich, Mike Folk and Don Sawyer to assist the Space Science community in understanding Scientific Data Formats. One of primary conclusions of that paper is that a scientific data format object model should be examined along two basic axes. The first is the complexity of the computer/mathematical data types supported and the second is the level of scientific domain specialization incorporated. This paper also discusses several of the issues that affect the decision on whether to implement a discipline or project specific Scientific Data Format as a formal extension of a general purpose Scientific Data Format or to implement the APIs independently.

URL: http://ssdoo.gsfc.nasa.gov/nost/fep/

SH51A-0424 0830h POSTER

Common Data Format: New XML and Conversion Tools

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Common Data Format (CDF) is a self-describing platform-independent data format for storing, accessing, and manipulating scalar and multidimensional scientific data sets. Significant benefit has accrued to specific science communities from their use of standard formats within those communities. Examples include the International Solar Terrestrial Physics (ISTP) community in using CDF for traditional space physics data (fields, particles and plasma, waves, and images), the worldwide astronomical community in using FITS (Flexible Image Transport System) for solar data (primarily spectral images), the NASA Planetary community in using Planetary Data System (PDS) Labels, and the earth science community in using Hierarchical Data Format (HDF).

Scientific progress in solar-terrestrial physics continues to be impeded by the multiplicity of available standards for data formats and dearth of general data format translators. As a result, scientists today spend a significant amount of time translating data into the format they are familiar with for their research. To minimize this unnecessary data translation time and to allow more research time, the CDF office located at GSFC National Space Science Data Center (NSSDC) has developed HDF-to-CDF and FITS-to-CDF translators, and employed the eXtensible Markup Language (XML) technology to facilitate and promote data interoperability within the space science community.

We will present the current status of the CDF work including the conversion tools that have been recently developed, conversion tools that are planned in the near future, share some of the XML experiences, and use the discussion to gain community feedback to our planned future work.

URL: http://nssdc.gsfc.nasa.gov/cdf/cdf_home.html

SH51A-0425 0830h POSTER

Mission Independent Analysis for Energetic Particle Data

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A software methodology is presented which enables a new level of interoperability between analysis tools and energetic particle data from multiple spacecraft . Based on PI team experience, a mission independent representation for the highest time resolution (sub-second) particle and field data has been created. Data in any format can be converted to this representation using a relatively thin software conversion layer. Analysis tools written to only rely on the mission independent representation will work with any instrument for which a converter can be written. Currently, three high-time resolution particle datasets that have never been available outside the instrument team (ISEE-1, ISEE-2, AMPTE/MEPA) can be instantantly analyzed or downloaded at our web site (http://sd-www.jhuapl.edu/MIDL), and two more datasets (GEOTAIL, IMP-8) will be added by December. The LWS Science Data System Planning Team report encourages PI teams to develop tools which can support their own needs as well as distributing the highest time-resolution data to the community at large. Our approach fits well in this framework. Finally, an approach like ours could also help reduce the common duplication of effort in writing data access software for magnetospheric data.

URL: http://sd-www.jhuapl.edu/MIDL

SH51A-0426 0830h POSTER

The HIRAAS Infobase

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The High Resolution Airglow and Aurora Spectroscopy (HIRAAS) experiment was successfully launched on the USAF Advanced Research and Global Observation Satellite (ARGOS) and remotely sensed the thermospheric and ionospheric airglow from May 1999 to April 2002 using three ultraviolet spectrographs. The HIRAAS "Infobase" is a scientific data management system that relationally links data products, processing software, and parent data sets for full heritage tracking. The HIRAAS Infobase breaks from the traditional catalog/flat-file approach, instead storing all data products internally in the relational database. Thus all data and data products may be searched by user-defined queries over the entire mission period and returned to the user without the hindrance of file boundaries. Custom code provides for direct delivery of data products to science users' IDL sessions for reduction, modeling and analysis. The greatest difficulties encountered concerned data quality problems from the satellite bus itself, which required extensive work-arounds and several schema modifications. The paradigm appears to have wide applicability to a number of remote-sensing and ground based datasets being acquired by NRL in the near future.

URL: http://tipweb.nrl.navy.mil

SH51A-0427 0830h POSTER

Software Radar Technology and the Open Radar Initiative

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We have recently implemented a Software Radar System as the production data taking and control system for the Millstone Hill Incoherent Scatter Radar. In a Software Radar the traditional real-time hardware control and signal processing elements of a radar system are replaced by software systems running on general purpose computer systems and interconnected by a high speed and low latency multicast network. From our efforts to develop this system we have identitified a number of architectural patterns which are important for achieving performance, modularity, and scalability in distributed systems for managing experimental instrumentation and the many terabytes of information that are produced. The most important of these patterns concern information organization and management in the system and they are general far beyond their application to ionospheric radar systems. After discussing our system and these patterns we will describe the Open Radar Initiative. This effort is an open source project to make Software Radar technology widely available and to ready it for use as the foundation of a ground based Global Space Weather Network.

URL: http://www.openradar.org

SH51A-0428 0830h POSTER

Software Radar Data Architectures for Optimal Science Yields

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Recent advances in computing power and data acquisition fidelity, combined with the availability of low-latency multicast data transports, have made the Software Radar concept practical as a robust data taking and control system for incoherent scatter observations of the upper atmosphere. Careful design of the data flows and signal processing architecture of such a system can pay off in enabling parallel data processing, optimal spatial and temporal resolution, and full utilization of a radar's power-aperture product. In the design process, several well-defined software patterns emerge as unifying concepts not only applicable to incoherent scatter but also to radar processing tasks in general. The work is being done in close conjunction with the Open Radar Initiative, an open source project dedicated to making this technology widely available.

We present specific details of our recent work with Software Radar as a production system at the Millstone Hill US mid-latitude facility, focusing on signal processing and data management. In particular, our flexible signal chain architecture combined with multiple-listener data flows allows production systems and experimental analysis paths to coexist, and allows processing to be tailored to specific scientific observation goals. The ability to automatically manage processing elements and data transports, using data encapsulated in rigorously defined objects, facilitates remote operations and system redundancy, while laying the foundations for true distributed instrument networks. We present signal processing configurations for the production Software Radar, and illustrate the system's flexibility with examples of multi-resolution observations.

URL: http://www.openradar.org

SH51A-0429 0830h POSTER

The Space Weather Reanalysis

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The objective of this project is to generate a complete 11 year space weather representation using physically consistent data-driven space weather models. The project will create a consistent, integrated historical record of the near Earth space environment by coupling observational data from space environmental monitoring systems archived at NGDC with data-driven, physically based numerical models. The resulting product will be an enhanced look at the space environment on consistent grids, time resolution, coordinate systems and containing key fields allowing an interested user to quickly and easily incorporate the impact of the near-Earth space climate in environmentally sensitive models. Currently there are no easily accessible long term climate archives available for the space-weather environment. Just as with terrestrial weather it is crucial to understand both daily weather forecasts as well as long term climate changes, so this project will demonstrate the ability to generate a meaningful and physically derived space weather climatology.

The results of this project strongly support the DOD's Environmental Scenario Generator (ESG) project. The ESG project provides tools for intellegent data mining, classification and event detection which could be applied to a historical space-weather database. The two projects together provide a suite of tools for the user interested in modeling the effect of the near-earth space environment. We will present results and methodologies developed during the first two years of effort in the project.

SH51A-0430 0830h POSTER

Virtual Global Magnetic Observatory - Concept and Implementation

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The existing World Data Centers (WDC) continue to serve excellently the worldwide scientific community in providing free access to a huge number of global geophysical databases. Various institutions at different geographic locations house these Centers, mainly organized by a scientific discipline. However, population of the Centers requires mandatory or voluntary submission of locally collected data. Recently many digital geomagnetic datasets have been placed on the World Wide Web and some of these sets have not been even submitted to any data center. This has created an urgent need for more sophisticated search engines capable of identifying geomagnetic data on the Web and then retrieving a certain amount of data for the scientific analysis. In this study, we formulate a concept of the virtual global magnetic observatory (VGMO) that currently uses a pre-set list of the Web-based geomagnetic data holders (including WDC) as retrieving a requested case-study interval. Saving the retrieved data locally over the multiple requests, a VGMO user begins to build his/her own data sub-center, which does not need to search the Web if the newly requested interval will be within a span of the earlier retrieved data. At the same time, this self-populated sub-center becomes available to other VGMO users down on the requests chain. Some aspects of the Web "crawling" helping to identify the newly "webbed" digital geomagnetic data are also considered.

URL: http://maggy.engin.umich.edu/mist/

SH51A-0431 0830h POSTER

NSSDC's Array of Solar Terrestrial Value-added Products and Services

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Over the years, NSSDC has received many data sets from investigators and has made them network-accessible through a variety of interfaces. For some of these data sets, NSSDC has performed "value added processing" of the data, producing multi-source data products from them and making these available via simple ftp and via higher functionality interfaces. These include (1) OMNIWeb-accessible OMNI data involving 18 spacecraft, cross-normalizations of parameters and time shifts of data from L1 to near-Earth and (2) COHOWeb-accessible spacecraft-specific files of coordinate-system-uniformized merged IMF/plasma/position data. Lessons learned from the creation of these data products and their interfaces will be discussed.

Additional NSSDC-provided Solar Terrestrial (ST) value-added services, including the organizing and promotion of ionospheric data from many older missions, access to and executability of empirical geophysical models, the FTPBrowser interface to selected ASCII data sets otherwise only ftp-accessible and the Formats Evolution Process intended to help transcend data sharing impediments arising from today's formats multiplicity, will also be discussed.

NSSDC has recently reorganized and simplified several of its higher level ST web pages, including giving them a common layout, for added user effectiveness. NSSDC's ST data and services are accessible through http://nssdc.gsfc.nasa.gov/space/

SH51A-0432 0830h POSTER

Solar Synoptic Maps as a Means to Study the Global Sun

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Solar synoptic maps (often referred as Carrington maps) are maps of the Sun in latitude versus longitude built by merging together solar observations taken during one solar rotation. They are an efficient method to represent the Sun as it appears during a rotation yielding a global view of solar structures, such as active regions, coronal holes, and helmet streamers. They provide a clear and effective way to study evolutionary patterns on the Sun and to compare different solar datasets over long periods of time.

Because of their ability to display a large number of data in a concise way, solar synoptic maps have been popular for many years. The availability of modern instruments (both in space and on the ground) that can provide consistent and calibrated measurements for many years has renewed the interest in this data format. We believe there is a need for the solar-terrestrial community to agree on a standard format for synoptic maps of the Sun. Such a format should be discussed and defined in parallel with the effort of the Solar Virtual Observatory.

At the High Altitude Observatory (HAO), we are developing a public database of solar synoptic maps for the solar observations made at Mauna Loa Solar Observatory (MLSO). The database will include observations of the solar corona in visible light and of the solar chromosphere in the HeI 1083nm and Hα lines. In this paper, we present examples of MLSO solar synoptic maps and compare them with other solar synoptic maps to illustrate the scientific use and flexibility of this data format.

SH51A-0433 0830h POSTER

Auroral Image Classification via Machine Vision

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Modern ground-based auroral imaging instruments produce vast amounts of data. Increased temporal and spatial resolution allow for more detailed studies, but typically only a fraction of the data is utilised due to the extreme manual labour required for analysing all images. Full analysis of all images is only possible through the use of machine vision, in which classification of image contents is performed automatically. Our recent research has resulted in a content-based image retrieval system, which can be used to locate similar auroral images in the CANOPUS all-sky image set consisting of over 200000 images. The retrieval is initiated by a user supplied image, after which supervised learning techniques are utilised to refine the search for similar images. Based on the automatically classified auroral data, we discuss the occurrence of arcs and patchy aurora within the context of auroral precipitation boundaries, and the local time distribution of other space physical phenomena which are likely related to the formation of these auroral shapes (eg., Pc5 pulsations).

SH51A-0434 0830h POSTER

The Beginnings of a Space Physics Virtual Observatory

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We present a Visual System for Browsing, Analysis, and Retrieval of Data (ViSBARD) that provides the core for what we will extend to a Space Physics Virtual Observatory (SPVO). This presentation is largely intended to obtain feedback from the community on what features are most important. The project will provide open-source software to encourage contributions from everyone. As currently configured (this should be much further advanced by the time of the meeting) the software is capable of reading data (ASCII/CDF) for many existing missions. ViSBARD can be extended to interpret any number of ASCII and CDF formats through XML definitions, and we intend to add other formats. The program features extensive 3-D viewing capabilities coupled with 2-D displays for browsing and/or analyzing the data as viewed on the orbits of the spacecraft. ViSBARD can display the SSC database that gives orbits of most currently operating SEC-related satellites as well as the COHOWeb database that contains most of the hourly averages of interplanetary spacecraft. A combine tool allows the user to assemble, e.g., plasma, magnetic field, and orbit data from separate files for a single satellite into a one data set at any desired resolution. ASCII output makes it possible to save subsets or combined datasets for later or other use. Currently, data files must be downloaded separately, so building a true virtual observatory will require linking this system to databases at many locations on the Web. We will start with the NSSDC and add others when this is working well. Future plans include linking to solar images (ultimately via the Virtual Solar Observatory) and magnetospheric and ionospheric images, as well as including model output in the visualization.

URL: http://lep694.gsfc.nasa.gov/visbard

SH51A-0435 0830h POSTER

SDO: A Systems Challenge

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The Solar Dynamics Observatory, scheduled to launch in August 2007, presents several significant challenges to the Systems Engineering team. The spacecraft will be built, tested and integrated in-house at the NASA Goddard Space Flight Center, with four instruments to be developed by three Principal Investigator teams. Though few new technologies are required in developing a robust, reliable and versatile spacecraft, the combination of numerous requirements (scientific and otherwise) require a significant effort to ensure complete mission success. The presentation will include a discussion of the SDO subsystems and the status of the SDO Systems Engineering team efforts.

SH51B MCC: 124 Friday 0830h

Particle Populations Upstream of the Earth's Bow Shock: Observations, Theory, and Simulations I *(joint with SM)*

Presiding: **A Posner,** University of Kiel**; J Dwyer,** Florida Institute of Technology

SH51B-01 0830h INVITED

Coupled Ion Acceleration and Wave Excitation at Earth's Bow Shock

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A brief observational and theoretical history of coupled ion acceleration and wave excitation at Earth's bow shock is presented including the "reflected" (R), "intermediate" (I), and "diffuse" (D) ion populations, the ultra-low-frequency (ULF) waves upstream of Earth's bow shock, and the spatial structure of the wave and ion "foreshock". Emphasis is placed on the spatial transition of the bow shock from "quasi-perpendicular" to "quasi-parallel". In addition, the origin of the ions, the acceleration of electrons, the downstream "thermalization" of ions at weak quasi-perpendicular portions of the shock, and the foreshocks observed at other planets are reviewed. The current understanding of these phenomena is assessed. Finally, a few issues which remain unresolved or controversial since the era of the ISEE 1, 2, and 3 spacecraft are discussed including the origin of the exponential ion energy spectra, the ion "injection" mechanisms at the shock, and the relative contribution of magnetospheric ions to the diffuse ion population.

SH51B-02 0850h INVITED

Heavy Ion Composition of Upstream Events: New Challenges for Old Models

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Enhancements in the intensities of energetic ions above a few keV nucleon^{-1} have been routinely observed upstream of the Earth$'$s bow shock since the 1960$'$s. Such upstream events were typically attributed either to the leakage of ionospheric ions accelerated inside the Earth$'$ magnetosphere into the upstream region or to the acceleration of solar wind ions via a first-order Fermi process occurring at the bow shock. Although studied extensively until the early 1990$'$s, the origin of upstream ions remained controversial primarily due to the lack of composition measurements in the suprathermal energy range i.e., from the thermal solar wind energy through the tens of keV nucleon^{-1}. However, the launch of the Wind spacecraft in 1994 with mass spectrometers such as the SupraThermal through Energetic Particle (STEP) instrument has offered new opportunities to investigate the origin of upstream ions. In this talk, we will focus on results of a comprehensive survey of the heavy ion composition and energy spectra above $\sim$30 keV nucleon^{-1} measured by the STEP instrument during more than a thousand upstream events. Our results show that energetic ions during such events originate primarily from the solar wind, and occasionally from ^{3}He-rich impulsive solar flares and corotating interaction regions. Recently, measurements from the SupraThermal Ion Composition Spectrometer (STICS) have shown that ionospheric species such as O^+ and N^+ can also be present simultaneously during some of these events, indicating that the ionosphere can also be an important source of ions in upstream events. We will also present a detailed analysis of some events when both ionospheric and solar wind ions are present simultaneosuly and compare our new results with predictions of the above two models, namely, magnetospheric leakage and Fermi acceleration at the bow shock.

SH51B-03 0910h

Ion Events Observed by Wind far Upstream From the Bow Shock and by Geotail / Imp-8 Near the Bow Shock and Within the Plasma Sheet

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Mason et al. (1996) reported characteristics of short duration energetic (>$\sim$30 keV/neucleon) heavy ion enhancements observed by the WIND spacecraft at large distances upstream from the bow shock during two periods of high speed streams (Jan. 20, 1995 Feb. 19, 1995) and Desai et al (2000) extended their study and presented results from a statistical analysis of upstream events rich in CNO species as observed by the WIND spacecraft between 1994 day 325 to 1999 day 92. Desai et al. suggested that some ion characteristics (as for instance, the fact that the majority of the events were observed in the dawn-noon sector, the solar-wind-like ion composition and the heavy ion dominance of the total energy ion spectrum above $\sim$0.5 MeV) appear to pose severe problems for the leakage model, while other characteristics appear to pose serious challenges for the Fermi acceleration model. In this paper we compare the statistical results of Desai et al. with the results from previous statistical and case studies and we show that the Wind observations are in general consistent with the leakage model. Furthermore, we examine simultaneous multispacecraft observations during time periods of some typical events presented by the authors (Mason et al., 1996; Desai et al., 2000) and we compare them with predictions from the leakage and bow shock acceleration models. In particular: (a) we present observations by WIND far upstream from the bow shock and by Geotail and IMP-8 within the magnetosphere and we infer that particle acceleration within the plasma sheet and subsequent leakage to the upstream region are responsible for the generation of these upstream ion events, and (b) we compare the upstream WIND observations with observations obtained by Geotail and IMP-8 near the bow shock, and we infer that the near bow shock observations do not fit with major predictions of Fermi acceleration models.

SH51B-04 0925h INVITED

Evidence for a Cusp Source of Upstream Energetic Particles

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The present debate about the source of upstream particles has traditionally centered on the role of the bow shock versus leakage from the magnetosphere as the source for providing the energetic (> 20 keV) component of these upstream particles. With the advent of the Polar and Cluster satellite programs with their modern mass and charge state compositional capabilities, a third possibility has been established. The Polar satellite has discovered that the shocked solar wind plasma enters the weak field region of the polar cusps and produces diamagnetic cavities of tremendous size within the traditional magnetosphere. Within these cavities the local magnetic field is greatly depressed and turbulent and usually carries the remnant signature of the upstream interplanetary magnetic field (IMF) in the two transverse components, By and Bz. Measurements, which demonstrate that ions of recent solar wind origin that have been energized to energies associated with the Earth's ring current, are observed inside these cavities will be presented and discussed. On occasions there are also ions of ionospheric origin that appear to be energized at the same time showing the same spectral and time variations as those ions originating in the solar wind. The Cluster suite of satellites has observed a layer of energetic particles to be continually present at the high latitude magnetopause but these particles are seen upstream more infrequently. Logically the condition for the energetic particles to be seen upstream from this cusp-associated source is the same IMF orientation as that ascribed to the quasi-parallel bow shock. Results of an ongoing study of