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1999 ANNUAL STATISTICS AND HIGHLIGHTS REPORT FOR THE NATIONAL SPACE SCIENCE DATA CENTER

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1999 Annual Report of the National Space Science Data Center

PREFACE

The National Space Science Data Center is pleased to issue this 1999 Annual Report describing (1) the 1999 growth and evolution of NSSDC's data archives, access pathways, and other tools and services, and (2) the 1999 access to those data and services by NSSDC's customer communities. This report has been made WWW-accessible in the hope that readers will avail themselves of the opportunity to link to the services reported herein.

The scope of this report is that of the traditional NSSDC as defined by the NSSDC budget. It should be noted that some of the activities thereby supported are the responsibilities of the Astrophysics and Space Physics Data Facilities, organizational peers of the formal NSSDC within Goddard's Space Science Data Operations Office.

I welcome suggestions for user-benefiting improvements to this Annual Report and to NSSDC services.

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1. INTRODUCTION

This report characterizes NSSDC's data holdings, metadata holdings, access pathways, and value-added data products, tools, and services at the end of 1999, with a focus on the 1999 activities leading to that end-of-year state. In addition, this report characterizes the nature and amount of 1999 access to NSSDC's data and services by its many users from various communities..

2. HIGHLIGHTS

The most important result of NSSDC's 1999 activities is the continuing preservation of growing space science data volumes, ensuring their continuing and future accessibility to the space science, education, and general public communities. The statistics to follow reveal that NSSDC's archive has now grown to 15.3 TB of space science data and an additional 3.3 TB of Earth science data. 2.8 TB of data were added to the archive in 1999 including 1.3 TB of 'backup-mode' data from HEASARC

Next, NSSDC continues to distribute large amounts of data by network to the space science community and general public, and by offline mailings to the general public. Again, following statistics detail the data volumes disseminated via various pathways to various communities. We note here that during 1999, NSSDC's customers downloaded via network just over 2 million data files (a 50% increase over 1998!) and received about 4 TB of data on mailed media.

NSSDC's data dissemination is leading to the publication of significant new science. The Appendix of this Annual Report lists 47 science papers acknowledging NSSDC data or services as contributing to their analyses. These are papers which have come to the attention of our staff. Most science journals in which NSSDC data or services may have been used are not reviewed by our staff routinely, so the list represents a lower limit on papers enabled or benefitted by NSSDC.

Through its NASA/Science Office of Standards and Technology (NOST), NSSDC provides international leadership in providing increasingly effective digital data archiving. During 1999, NOST initiated the Formats Evolution Process assessing community needs of 'standard formats,' further promoted the ISO/CCSDS-sponsored Archive Reference Model, and followed up on the 1998 Digital Archive Directions (DADs) workshop. The activities and results achievements are further discussed in the NOST section of this Annual Report.

Version 2.7 of Common Data Format (CDF) was released in October, 1999, with new Java APIs, GUI-based CDF tools in Java, and a more robust CDF library.

Enhancements to NSSDCs popular multi-source OMNI data set of solar wind parameters included the first addition of solar wind plasma data from the Wind spacecraft and the creation of a 35-year 2x27-day-per-line plot of daily-averaged interplanetary magnetic field (IMF) azimuthal angles. This plot makes the long term evolution of IMF sector structure clear. Finally, options to plot or list 1-day or 27-day averages (in addition to 1-hour averages) were added to OMNIWeb.

Among the items created at and made network accessible from NSSDC during 1999 was the family of WWW pages for the NASA/OSS Space Science Data System.

NSSDCs main space physics WWW page was significantly revised to concurrently serve as a pathway to any of the relevant data and information services and as a pathway to all the data and information relevant to any specific spacecraft. A multi-frame approach is used.

For many years, NSSDC has provided access to downloadable software implementing numerous empirical geophysical models (atmospheric, ionospheric, geomagnetic, trapped particles). In recent years NSSDC has offered users the opportunity to execute many such models on NSSDC computers. We report for the first time statistics on the use of this service. Table 8b shows 55,000 such executions.

NSSDCs Astronomical Data Center (ADC), chartered to acquire, manage, and provide access to astronomical source catalogs, saw user accesses to its catalog server surpass 40,000 accesses/month and to its visualization server surpass 7,000 accesses/ month. The ADC remains at the forefront of eXtensible Markup Language (XML) development as applied to astrophysical and astronomical data. Further details are contained in Section 4.3.

NSSDC provided a leadership to the NASA Sun Earth Connection (SEC) Education Forum (SECEF), sponsored by the NASA SEC enterprise of the Office of Space Science. In particular, SECEF enabled the interaction between the Space Science Institute of the University of Colorado and active NASA SEC missions from which emerged the very popular Space Weather Center which will travel among sites in the U.S.

While NSSDC was making preparations for the retirement of the VMS WORM-disk based NDADS system, the 2 millionth data file was downloaded from the 10-year- old NDADS system by NSSDCs customer community.

Readers are encouraged to exercise the multiple options on the hierarchical array of WWW pages starting with NSSDC's home page. There are several more functionalities beyond those called out in the preceding paragraphs.

3. DATA MANAGED AT NSSDC, AND 1999 INFLOW AND OUTFLOW

There are several ways to characterize the multi-disciplinary NSSDC archive. Byte counts are a common metric for modern archives, and will be reported herein. Numbers and diversity of media volumes managed, and numbers of distinct data sets, are also very important. (In NSSDC's terminology, a data set is typically all the data from a given instrument at a given processing level in a given format.) The diversity of data sets and of media types relate to the intellectual heterogeneity and technical heterogeneity of the archive, respectively, and we shall report on these also.

At the end of 1999, NSSDC had 4,556 distinct data sets and accompanying documentation packages being managed. Table 1 indicates the disciplines from which these data sets come, and a breakout as to whether the data sets are digital or non-digital (film, etc.). The table shows that these data sets come from 1,406 experiments which have flown on 420 mostly-NASA spacecraft. By data set count, space physics is the dominant discipline, accounting for over half NSSDC's data sets. This reflects the fact that in its early years, NASA launched a preponderance of space physics missions and also that space physics spacecraft typically carry more independent experiments than do astrophysics missions.

Note from the table that NSSDC manages roughly equal numbers of digital and non-digital (mostly film) data sets, although it should also be noted that NSSDC has been acquiring almost no non-digital data in recent years.

Table 2 is a different characterization of the NSSDC archive, by byte counts and media volume counts. The table shows 18.6 TB of total data, a 3.0 TB subset which is network-accessible, and 73,279 digital media at NSSDC. The byte counts are estimates, involving for some data sets assumptions about the mean numbers of bytes on various media types.

Note that only astrophysics data and space physics data are network-accessible from NSSDC. That planetary data are not network-accessible is the result of the emphasis of the Planetary Data System (through which virtually all planetary mission data has entered the NSSDC archive for the past several years) on CD-ROM production and dissemination, and because PDS nodes are now making the most important planetary data network-accessible from their nodes. [Exceptions are NSSDC's Photo Gallery and Image Catalog which are WWW-accessible from http://nssdc.gsfc.nasa.gov/planetary/; these are largely oriented towards the general public.] NSSDC's Earth science data are gradually being migrated to the EOSDIS data management infrastructure, hence are not good candidates for network-accessibility from NSSDC.

Tables 3a and 3b better characterize NSSDC's network-accessible astrophysics and space physics data, by project and by whether the data are immediately accessible from magnetic disk (online) or from the robotics-based NDADS system (nearline). Falling prices for magnetic disk is facilitating the expansion of NSSDCs online data stores. Figure 1 shows the growth to 2.8 TB of the nearline data volume over the past nine years, and indicates which projects' data ingest started in which years.

Figure 2 characterizes the 275 GB of data first made network accessible via NDADS during 1999. Most of these data first arrived electronically at NSSDC during this year, while a small amount was promoted to network accessibility from NSSDC's offline archive. Data inflow to NSSDC during 1999 is discussed in more detail subsequently.

This annual report will likely be the last one to report on NDADS, which will be retired during 2000 in favor of a data access system based on RAID magnetic disk in a unix environment. Most NDADS-resident space physics data, plus the long wavelength IRAS astrophysics data, are being migrated to the RAID system. IUE data, with which and for which NDADS was initiated in 1990, will not be migrated to RAID because these data are now accessible from the Multimission Archive at Space Telescope Science Institute (MAST), http://archive.stsci.edu/mast.html

Table 4 characterizes the digital media managed at NSSDC, not including back up copies. This table is an expansion of Table 2 in which total numbers of unique digital media volumes were given. It should be noted that most volumes are replicable and have one backup volume. However, for "CD-ROM (Titles)" which are not locally replicable, NSSDC typically holds between 20 and 200 copies of each title. For these, NSSDC must replenish stock through a commercial vendor as request activity drives NSSDC stock down.

Table 5 characterizes NSSDC's non-digital archive, by disciplines by form factor. Note that NSSDC has large volumes of non-digital data for each of the discipline areas it supports. It should be noted, however, that very little new data have been arriving at NSSDC in non-digital form in recent years. NSSDC has recently begun an effort to systematically convert this film archive to computer-readable form.

3.1 DATA INFLOW

Tables 6 and 7 characterize the inflow of digital data to NSSDC during 1999. In particular, Table 6 shows that NSSDC received approximately 2.8 TB of new data in 1999, via a combination of networks and hard media. Table 6 shows data volumes by project, with the astrophysics and space physics subsets of ISTP/Wind and Ulysses data attributed to their respective disciplines. Dominating the counts are the Level-0 data from the FAST and ISTP missions and the 'back-up mode' data from the HEASARC.

Table 7 characterizes the inflowing media types by discipline. CD-WO media are the dominant input media type overall.

During 1999, NSSDC received approximately 250 GB of data electronically, in addition to the data arriving on the media reported in Table 7. The electronic inflow was dominated by the ISIS ionogram digitization effort (142 GB), with lesser amounts from a number of spaceflight projects. See Figure 2 for details.

By data set count, which as noted earlier marks the intellectual heterogeneity of NSSDC, increments or totalities of 109 distinct data sets from 74 distinct flight experiments arrived at NSSDC during 1999.

3.2 DATA OUTFLOW

NSSDC provides user access to its data holdings through multiple electronic interfaces and, in addition, through a user support infrastructure for the mailing of offline digital and non-digital data volumes. Most electronic interfaces are accessible through NSSDC's WWW home page and include: (1) special WWW-based interfaces to specific data sets or groups thereof; (2) anonymous/ftp pathways to a range of data files maintained permanently on NSSDC magnetic disk as well as files staged from NSSDC's nearline mass storage environment (NDADS); (3) WWW-based and other interfaces to NDADS (e.g., SPyCAT) for the purpose of selecting data files and having them staged or downloaded.

The dominant special WWW-based data access interfaces that NSSDC offers to the research community relate to: ISTP key parameter and selected other space physics data (CDAWeb); the OMNI and uniformized-COHO solar wind datasets (through OMNIWeb and COHOWeb, respectively); various atmospheric and ionospheric data (ATMOWeb); IRAS; COBE; and the Astronomical Data Center astronomical source catalogs and journal tables.

The OMNI data set is a 36+ year compilation of multi-spacecraft near-earth solar wind magnetic field and plasma data and energetic particle data, while the COHOWeb database is a uniformized set of files of merged magnetic field, plasma, and position data for each of many deep space spacecraft. Table 8a shows annual statistics for the CDAWeb, OMNIWeb, COHOWeb and ATMOWeb systems. Note the continuing steady growth in usage of these systems. In 1999 they were used by NSSDCs customers to produce over 400 plots, listings, and data files every working day.

Table 8b reports for the first time statistics on the usage of NSSDCs executable geophysical models services and its services for magnetospheric and heliospheric orbits.

[Note that the magnetospheric orbits service, SSCWeb, and the previously discussed CDAWeb are joint services of the Space Physics Data Facility and NSSDC.]

These services have been available for some years now. The models service lets users specify a model, a spatial point of interest, and any other parameters on which the model depends, and have the model parameters computed at the point or along a profile through the point. Table 8b shows that there were about 55,000 such computations done by NSSDC customers in 1999, with ionospheric, atmospheric and geomagnetic models dominating. Ftp access to models software is included in ftp access statistics in Table 9, not in Table 8b.

Table 8b also reveals close to 21,000 orbit computations, with about 83% using SSCWeb and the balance using NSSDCs Heliocentric Ephemerides page.

A great many NSSDC data sets and other information services are held permanently on magnetic disk for anonymous/ftp access mainly from NSSDCs unix computers. The reader is invited to review all these services from the FTP link on NSSDC home page. Table 9 gives the annual counts of files downloaded, both overall (over 1.7 million files in 1999) and for selected directories with high activity. Note that the Photo Gallery, of high public interest, dominates the statistics. The researcher-downloading of 113,000 data files from the spacecraft_data subdirectory, which has subsumed the COHO directory previously reported individually, shows the high interest in and great value of this service. These counts do not include data files ftp-downloaded after having been staged from NSSDCs NDADS nearline system; relevant statistics on NDADS access are discussed in the following paragraphs.

Table 10 summarizes the 1999 accesses to NSSDC's nearline mass storage environment (NDADS) through the multiplicity of available interfaces. Note that three measures are offered for each mission supported. A request is the specification of one or multiple "entry ID's" each of which specifies one or more data files. Both request counts and counts of files are reported. Finally as a measure of the breadth of interest in the data from any given mission, we count on a monthly basis, and report annual means of these monthly counts, the numbers of unique electronic addresses (username @ site) accessing each mission's data.

NDADS hosted a totality of 9,225 requests in 1999, for a total of 256 thousand data files. IUE data and the IUE user community continued to be the dominant beneficiary of NSSDC's nearline environment in 1999, although the outflow declined in late 1999 as the STScI/MAST service became fully operational. Other broadly based communities accessed data from IMP 8, ISTP, IRAS and DE.

WWW access statistics are frequently misleading, insofar as they usually individually count the many files (buttons, etc.) that make up a page. Nevertheless, growth in WWW accesses is indicative of continuing and growing use of the WWW-provided services.

Figure 3 shows the raw numbers of WWW hits from NSSDCs two main www servers, nssdc and bolero. In 1999, there were 9.5 million hits monthly! The 1997 peak visible in Figure 3 was due to the great public interest in the July, 1997, excursion of the Mars Pathfinder missions Sojourner rover on the Martian surface. The monthly access rate for 'ordinary' 1999 months continued to build towards the 10 million hits of July 1997.

While the dominant mode of dissemination of data to the astrophysics and space physics research communities is via the internet, NSSDC continues to provide a high level of offline data dissemination. Table 11 shows that NSSDC responded to over 1,400 distinct requests for 'significant' products plus (by footnote) 4000 poster requests. Table 11 also characterizes the user community of NSSDCs offline services. To a very large extent it is the general public, the education enterprise, publishers, etc. and their desire for NASA imagery on CD-ROM and as film products that account for NSSDCs offline request activity.

Table 12 gives the counts of requests for offline data sets from various disciplines in 1999, and as integrated over NSSDC's history. (A small fraction of requests which are multi-disciplinary are double counted in this table.) Note particularly the dominance of planetary data over both time scales. This is largely associated with lunar and planetary image data which are widely requested by the general public. The high level of astrophysical offline activity to a large extent reflects requests by the amateur and professional astronomical communities for ADC catalogs on CD-ROM.

Table 13 shows the most recent 5-year history of NSSDC's offline data request activity by media type. Several points are noteworthy. The dominant mode of offline digital data dissemination is now via CD-ROM. It is of interest to note that every working day of 1999, NSSDC mailed about 28 CD-ROMs to 4 requesters. Magnetic tape dissemination fell significantly in 1999.

Also significant from Table 13 is the fact that requests to NSSDC for film data have not declined over the past 5 years and in fact were up significantly in 1998. NSSDC finished almost one film request every working day.

Finally, very noteworthy is the distribution of over 4,000 copies of the Multi-wavelength Milky Way poster or COBE poster created by the SSDOO/Astrophysics Data Facility as a special education/outreach product. These distributions are not included in the counts of Tables 11 and 12.

4. ADDITIONAL NSSDC SERVICES

In addition to its archive of scientific data characterized in the preceding part of this Annual Report, NSSDC offers a number of additional services which are described in this Section.

4.1 NSSDC Information Systems

The Automated Internal Management (AIM) database identifies virtually all launched spacecraft, the experiments carried by many of those spacecraft, and data sets primarily as archived at NSSDC. Table 14 identifies the numbers of spacecraft, experiments, and data sets described in the AIM File, along with the numbers of new entries made in 1999. The database serves as the source of information for many of NSSDC's WWW information pages. The NSSDC Master Catalog (NMC) and a number of discipline project pages retrieve information from AIM and build WWW pages "on the fly" so that the latest information is presented to the user. Figure 4 shows the continuing rapid growth in WWW-based access to AIM/NMC descriptions over the 1995-1999 interval, with a 1999 monthly access rate of over 153,000. This is a 60% increase over 1998.

The AIM database also serves as a useful source of comparative information about spacecraft, experiments, etc. such as launch dates, time spans of data, orbital characteristics, time resolution, data availability, etc. The presence of comparative information in a consistent format within a single database makes the database especially valuable for survey reports.

The NSSDC Supplementary Data File (NSDF) is similar to AIM, but differs from it in that NSDF tracks non-spacecraft data, multi-source spacecraft or other data, models and programs, and other NSSDC-held data sets that do not fit the AIM spacecraft/experiment/data set hierarchy. See Table 15 for NSDF statistics.

The Technical Reference File (TRF) tracks individual published papers associated with space flight experiments. The NSSDC ID for the experiment is attached to the reference information so lists of papers relevant to a particular experiment can be reported, and/or provided to persons accessing data from a given experiment from NSSDC. Table 16 shows that 1,463 papers were newly identified in TRF during 1999. The TRF was used to generate the Appendix showing NSSDC-acknowledged papers.

The Interactive Request and Name Directory (IRAND) tracks people who have interacted with NSSDC over the years. It includes full names, one or more addresses, telephone and email information, and what NSSDC distribution lists they are on. The database contains approximately 56,000 entries. This information is also accessed and made available through the PIMS interface on the NSSDC WWW Home Page. Further

IRAND statistics are available as Table 17. Note especially that over 15% of the records were updated in 1999, reflecting volatility of such information items as Internet addresses. IRAND also tracks individual staff-involved requests, now more than 80,000 over the years.

The Interactive Data Archive (IDA) is another database of interest. IDA tracks the inventory of NSSDC's digital data volumes (tapes, disks, etc.). IDA had 161,702 records at the end of 1999, with 2,897 records having been added during 1999.

4.2 NASA/Science Office of Standards and Technology (NOST)

NOST's mission is to facilitate the recognition and use of standards to reduce cost/benefit ratios in the exchange and management of scientific data among NASA entities and the scientific communities they serve. NOST's Web Home Page is at http://ssdoo.gsfc.nasa.gov/nost/.

The NOST strategy is to play a coordinating role in helping the science disciplines identify new standards requirements. NOST participates in partnerships with them, other agencies, and industry on facilitating the adoption of leading-edge technologies with national or international visibility that can be tailored to meet NASA science information management and exchange requirements, and it assists in the process of moving these technologies toward standards with commercial support.

4.2.1 Formats Evolution Process (FEP)

Scientific progress continues to be impeded within some science communities, and across the boundaries of traditional discipline domains, by the lack of, or excessive multiplicity of, available standards for data formats and structures. A somewhat more subtle adverse effect of this situation is that the commercial software sector is unable to perceive what formats/structures it should support (e.g., with applications software). This leads to the situation whereby developers and/or users of the many available "standard" formats must develop/maintain/evolve tools that the commercial sector might otherwise do.

NOST has established a Formats Evolution Process to address these issues. It involves an open dialogue with the relevant communities and the publication of materials and comments via the Web at http://ssdoo.gsfc.nasa.gov/nost/fepc/. Descriptions of many formats and usage experience from researchers, archives, and projects are included. Views from tool developers are also available, and there is a Web based forum by which comments may be posted. This activity is guided by a Formats Evolution Process Committee which is charged with providing synthesis materials to stimulate community consensus.

4.2.2 Consultative Committee for Space Data Systems (CCSDS)

NOST operated NASA's highest level Control Authority office in accordance with the applicable Consultative Committee for Space Data Systems (CCSDS) and ISO standards to formally archive data descriptions for interchange and long term preservation. New descriptions were added for Interball, and for NSSDC data sets being migrated into archival packages on new media. Currently there are 350 registration entries.

NOST participated in the development of draft CCSDS/ISO standards applicable to multi-discipline and sub-discipline information interchange. The primary standards and their usage categories were:

Data Entity Dictionary Specification Language (DEDSL): This draft standard addresses the problem of providing a standard way to document and exchange the various attributes needed to fully define data elements. It has been harmonized with the conceptual data element standard from ISO known as ISO 11179 and the ANSI X3.L8 standard known as X3.285. The DEDSL draft has been split into two documents - one addressing the conceptual model and one addressing an interchange form using ISO Parameter Value Language (PVL). This will allow a follow on interchange standard using XML. Liaison activities with X3.L8 continue for updating ISO 11179 and an XML interchange form. This should support publication and exchange of data elements leading to more automated access and understanding of data across science disciplines and among organizations. These documents will be under formal review in the summer of 2000.

Reference Model for an Open Archival Information System (OAIS): The reference model draft (Red Book version 1) has undergone formal agency reviews, and will be released as an ISO Draft International Standard in the Spring of 2000. It provides a conceptual model of a digital archive,

including a functional view and an information view, and it provides a framework for discussing migration issues and interactions among archives. The model establishes initial criteria for recognition of a true archival function and should lead to improved archival implementations, provide a basis for further standardization, and provide more cost-effective vendor support. It has already been picked up by a number of communities for study, evaluation, and prototyping, and it has served as a template for the upgrade of NSSDC's data ingest and management functions associated with NSSDC's archival holdings. It can be found at

http://ftp.ccsds.org/ccsds/documents/pdf/CCSDS-650.0-R-1.pdf.

Archival Workshop on Ingest, Identification, and Certification Standards (AWIICS):

NOST organized and lead the AWIICS workshop, held at the National Archives, to build upon the OAIS Reference Model by identifying the level of interest in additional archival standards. Attended by participants from a variety of government, academia, and industry organizations, including some from the UK, strong interest was expressed for developing a Data Submission Methodology standard, for developing an Archive Certification standard, and for additional work on identification of archival information. Currently leads are being sought for these efforts. The AWIICS report is available at
http://ssdoo.gsfc.nasa.gov/nost/isoas/awiics/

4.2.3. Flexible Image Transport System (FITS) Technical Panel and Support Office

The Flexible Image Transport System (FITS) is the standard format for astronomical data interchange, endorsed and supervised by the International Astronomical Union (IAU). NOST participates in the evolution of FITS by commenting on proposed new FITS extensions and conventions and by the development of a formal FITS specification document using the NOST standards accreditation process. The FITS Support Office (FSO) of NSSDC/ADF supports the NOST-convened FITS Technical Panel (including Goddard and extra-Goddard FITS experts) in its work and supports the community by providing a number of services, such as current versions of all documents and WWW information pages.

During 1999, The FITS Technical panel completed its work on the draft version of NOST FITS Standard 100-1.2. Comments received from the community have been considered in the latest draft. After a formal NOST review, the final document was released by NOST as FITS Standard 100-

2.0. The new standard incorporates the image and binary table extensions and the blocking agreement endorsed by the IAU FITS Working Group, and is now in the hands of that group for declaring as a new IAU standard.

4.3. Astronomical Data Center

In the Astronomical Data Center (ADC) (http://adc.gsfc.nasa.gov), over 3000 astronomical source catalogs and journal tables are maintained online for easy access. Entire catalogs and tables can be retrieved via FTP. Web-based visualization tools (http://tarantella.gsfc.nasa.gov/adf/visualization/design.html) are available for browsing, plotting, and subsetting the contents of the catalogs and tables before download. Users can query interactively for information on individual plotted data points and search for observations made by NASA missions. To enable interoperability with other data facilities, a programmer's interface (http://tarantella.gsfc.nasa.gov/viewer/AEQdoc.html) has been developed to allow external software to directly access the ADC catalogs without going through the Web browser. During 1999, the ADC catalog server experienced over 40,000 accesses per month. The server for visualization tools was accessed over 7000 times per month. The outflow of data averaged 3.2 GB and over 200,000 files per year.

The ADC is currently involved in a research project to define the metadata of an astronomical repository in eXtensible Markup Language (XML) (http://tarantella.gsfc.nasa.gov/xml/). An XML toolbox is being developed for importation, enhancement, and distribution of data tables and their metadata documents. The objective is to enable a more focused search of the ADC data holdings and better support of data exchanges with other data centers.

4.4. Common Data Format

The NSSDC Common Data Format (CDF) is a self-describing data abstraction for the storage and manipulation of multidimensional data in a discipline-independent fashion. CDF is comprised of three parts, the CDF data files that contain both the actual data values and metadata, the CDF software library that is used to create, access, manage, manipulate, etc. CDF files, and a well-defined Applications Programming Interface (known as the CDF Interface) that provides transparent access to underlying software and data. CDF provides the essential framework for which generic applications (e.g., visualization, statistical) can easily be created.

The International Solar Terrestrial Physics (ISTP) Project is NASA's single largest user of CDF. The ISTP Project is using CDF to store its Key Parameter data. The NASA IMAGE mission, launched in 2000, will use CDF extensively. In addition, CDF is used heavily by the international community through the IACG projects associated with the ISTP project. This effort provides a consistency among data formats and structures and

allows data to be shared transparently among a variety of projects and applications. We also note that CDF underlies NSSDCs OMNIWeb, COHOWeb, CDAWeb and SSCWeb services.

During 1999, NSSDC's CDF office released CDF 2.7 to the general public in mid October. With the advent of the CDF Java APIs, the users have a choice of developing CDF applications in C, Fortran, or Java. The advent of the CDF Java APIs significantly benefits the CDF user community since a CDF application can now be written in platform-independent Java language and can run on any of the

Java-supported platforms (Java is supported virtually on all platforms today) without any modifications. This encourages sharing of scientific data analysis code among scientists and promotes science.

CDF 2.7 is backward compatible with the previous CDF releases, and it includes a more robust CDF library and some features that weren't available in CDF 2.5.x and 2.6.x such as ability to copy a variable with or without data.

The CDF office also made the CDF documents available in Portable Document Format (PDF) besides the PostScript format. The PDF files are about 45% smaller than their counterpart PostScript files and their resolution is as good as PostScript files. People with low speed connection (i.e. 56 Kbps or less) to the Internet particularly appreciate the availability of the PDF files since the document download time is considerably reduced.

A World Wide Web (WWW) page located at http://nssdc.gsfc.nasa.gov/cdf/ on the Internet provides a description of CDF, access to the software distribution, documentation, papers, a list of Frequently Asked Questions, and facilitates interaction with the CDF support group at the NSSDC.

Approximately 15,900 files were FTP-downloaded from the CDF directory of NSSDCs anonymous account during 1999, an increase of 47% over 1998. These were mostly files describing CDF, software tools from the CDF library, etc. In addition, a great many users browse the CDF pages identified above.

Glossary

ACE	Advanced Composition Explorer
ADC	Astronomical Data Center
ADF	Astrophysics Data Facility
AE	Atmospheric Explorer
AEROS	AERONomy Satellite
AIM	Automated Internal Management
ANSI	American National Standards Institute
API	Applications Programming Interface
ARCAD	ARC Aurorale et Densite
ATMOWEB	Web interface for ATMOspheric data
CCSDS	Consultative Committee for Space Data Systems
CD-ROM	Compact Disk-Read Only Memory
CD-WO	Compact Disk-Write Once
CDAW	Coordinated Data Analysis Workshop
CDF	Common Data Format
CGRO	Compton Gamma Ray Observatory
COBE	Cosmic Background Explorer
COHO	Coordinated Heliospheric Observations
DADs	Digital Archive Directions
DE	Dynamics Explorer
DEDSL	Data Entity Dictionary Specification Language
DLT	Digital Linear Tape
EOSDIS	Earth Observing System Data and Information System
EUVE	Extreme Ultraviolet Explorer
FAST	Fast Auroral SnapshoT
FEP	Formats Evolution Process
FIRAS	Far Infrared Absolute Spectrophotometer
FITS	Flexible Image Transport System
FSO	FITS Support Office
FTP	File Transfer Protocol
GB	Gigabyte

GOES	Geostationary Observational Environmental Satellite
GSFC	Goddard Space Flight Center
HEAO	High Energy Astrophysics Observatory
HEASARC	High Energy Astrophysics Science Archive Research Center
HST	Hubble Space Telescope
HUT	Hopkins Ultraviolet Telescope
IAU	International Astronomical Union
IDA	Interactive Data Archive
IMF	Interplanetary Magnetic Field
IMP	Interplanetary Monitoring Platform
IRAND	Interactive Request and Name Directory
IRAS	Infrared Astronomical Satellite
ISEE	International Sun-Earth Explorer
ISIS	International Satellite for Ionosphere Studies
ISO	International Standards Organization
ISTP	International Solar-Terrestrial Physics
IUE	International Ultraviolet Explorer
KP	Key Parameters
LANL	Los Alamos National Laboratory
MAST	Multimission Archive at STScI
M-O	Magneto-optic
MSU	Moscow State University
NASA	National Aeronautics and Space Administration
NDADS	NSSDC Data Archive and Distribution System
NMC	NSSDC Master Catalog
NOST	NASA/Science Office of Standards and Technology
NRAO	National Radio Astronomy Observatory
NSDF	NSSDC Supplementary Data File
NSSDC	National Space Science Data Center
OAIS	Open Archival Information System
OGLE	Optical Gravitational Lensing Experiment
OMNI	Interplanetary Medium Data

OSO	Orbiting Solar Observatory
OSS	Office of Space Science
PDF	Portable Document Format
PDS	Planetary Data System
PIMS	Personnel Information Management System
PVL	Parameter Value Language
PVO	Pioneer Venus Orbiter
RAID	Redundant Array of Independent Disks (originally, 'I' was 'Inexpensive')
ROSAT	ROentgen SATellite
RXTE	Rossi X-ray Timing Explorer
SAMPEX	Solar Anomalous and Magnetospheric Particle Explorer
S/C	Spacecraft
SEC	Sun Earth Connection
SECEF	SEC Education Forum
SPyCAT	Space Physics CATalog
SSC	Satellite Situation Center
SSDOO	Space Science Data Operations Office
SSDS	Space Science Data Service
STScI	Space Telescope Science Institute
TB	Terabyte
TRF	Technical Reference File
UIT	Ultraviolet Imaging Telescope
UK	United Kingdom
WDC	World Data Center
WDC-A-R&S	World Data Center A for Rockets and Satellites
WDC-SI A-R&S)	WDC for Satellite Information (formerly WDC-A-R&S)
WORM	Write-Once, Read-Many
WUPPE	Wisconsin Ultraviolet Photopolarimetry Experiment
WWW	World Wide Web
XML	eXtensible Markup Language

Table 1.
Counts of NSSDC Data Sets and Data Set Sources as of 12/31/99

Discipline	Digital	Non-Digital	Totals	Experimiments with Data	Spacecraft with Data
Astronomy	227	112	339	128	39
Space/Solar Physics	1,471	1,059	2,530	788	189
Planetary	562	730	1,292	298	93
Earth	113	94	207	180	99
Other	44	144	188	12	0
Totals	**2,417**	**2,139**	**4,556**	**1,406**	**420**

Table 2.
State of the NSSDC Archive as of 12/31/99

Discipline	No. of Terabytes	No. of Terabytes Network-Accessible	No. of Media (Digital)*
Astro	4.9	1.68	4,022
Space Physics	6.9	1.35	19,758
Planetary	3.5	0	23,147
Earth	3.3	0	26,352**
Total	**18.6**	**3.03**	**73,279**

* See Table 4 for detail; not counted is large quantity of data on microfilm, microfiche, etc.
** Awaiting transfer to EOSDIS

Table 3a.
Astrophysics Data Electronically Accessible from NSSDC
as of December 31, 1999

Project	Online	Nearline
ADC	17 GB	
Astro		
HUT		0.6 GB
UIT		35
WUPPE		20
CGRO		1
COBE	21	
GINGA		1
HEAO-1		13
HEAO-2		4
HEAO-3		1
HST		3
IRAS		84
IUE		1,395
NRAO		1
OGLE		43
ORFEUS		0.3
OSO 8		23
Vela 5B		21
Totals	**38 GB**	**1,646 GB**

Table 3b.
Space Physics Data Electronically Accessible from NSSDC
as of December 31, 1999

	Online		Nearline
	CDAWeb	Anon/FTP	NDADS
ACE	0.3 GB		
AE C,D,E		0.51 GB	
AEROS		0.01	
ARCAD		0.88	
CDAW 9	0.05		
DE	18	0.24	209 GB
Equator-S	0.5		0.4
FAST	21		8
Geotail	3.8		*
GOES	0.7		0.5
Ground-bsd	2.2		
Hawkeye			20
Helios 1&2		0.03	
Hinotori		0.14	
IMP 8	0.5	0.32	43
Interball	0.3		0.2
ISEE			9
ISIS 1&2	7		384
ISTP	*		168
LANL	2.8		2.4
OMNI		0.25	
Pioneer 10&11		0.41	1
PVO		0.03	
Polar	82		*
Russian_MSU		0.56	
SAMPEX	3.1		46
San Marco		0.15	0.1
Skylab			7
SOHO	0.32		0.3
Ulysses	1.7	1.58	24
Voyager 1&2		0.52	22

	Online		Nearline
	CDAWeb	Anon/FTP	NDADS
Wind	2.9		*
Yohkoh			253
Totals	**150**	**5.63**	**1198**
* Counting differences in CDAWeb and NDADS lead to grouping Wind, Polar, and Geotail as "ISTP" in the NDADS column.			

Table 4.
Counts of Volumes at NSSDC Archive as of 12/31/99

Media	Astro-physics	Space Physics	Planetary Science	Earth Science	Total
4-mm Tape	449	23	2	0	**474**
8-mm Tape	221	403	79	0	**703**
9-Track Tape	2,687	10,425	20,749	26,352	**60,213**
CD-ROM (Titles)	39	200	909	0	**1,148**
CD-WO	184	8,276	1,405	0	**9,868**
12" WORM (Offline)	0	56	0	0	**56**
12" WORM (NDADS)	288	208	0	0	**496**
M-O Disk	0	158	0	0	**168**
DLT	154	9	0	0	**163**
Totals	**4,022**	**19,758**	**23,147**	**26,352**	**73,279**
Backup volumes not included					

Table 5.
Photographic Data Products at NSSDC by Discipline

Discipline	Micro-film	Micro-fiche	Film (feet)	Film (frames)	Reels	Slides
Astrophysics	6,020	18,524	100	63,459		121
Earth Science	1,430		4,200	236,066		
Planetary Science	3,294	6,345	143,214	392,122	259	5
Space Physics	20,188	14,669	4,640	4,379		41,502
Communications	183					
Other	162					
Totals	**31,277**	**39,538**	**152,154**	**696,026**	**259**	**41,528**

Table 6.
Data Arriving at NSSDC During 1999

Astrophysics		Planetary		Space Physics	
ADC	2.5 GB	**Clementine**	0 GB	**ACE**	23 GB
COBE	5.9	**Galileo**	8.8	**FAST**	564
EUVE	5.8	**Magellan**	8.0	**IMP-8**	4.5
IUE	3.3	**Mariner 4-9**	5.1	**ISEE**	28
Ulysses	0.2	**Pioneer Venus**	3.6	**ISIS**	142
Wind	3.1	**Viking 1 & 2**	12	**ISTP**	
		Voyager 1&2	114	**KPs**	110
From HEASARC:		**Mars Observer**	0	**Geotail L0**	153
		Mars Global Surveyor	18	**Polar L0**	291
RXTE	514	**Apollo 8**	0	**Wind L0 +**	45
ASCA	352	**Giotto**	0	**ATS-6**	5.9
CGRO	145	**Lunar Prospector**	5.1	**SAMPEX**	19
Exosat	81	**Lunar Surveyor 5-7**	0.1	**Ulysses**	10
ROSAT	68	**SL-9/Jupiter**	2.9	**DE**	19
EUVE	39			**Yohkoh**	14
Other	93			**S3-2, S3-3**	3.7
Subtotal	**1313**	**Subtotal**	**178**	**Subtotal**	**1340**
Grand Total	**2,831**				

- 109 new data sets from 74 experiments arrived in 1999
- First data from 60 experiments arrived in 1999

Table 7.
Media Arriving at NSSDC During 1999

Media	Astro-Physics	Space Physics	Planetary Science	Total
4-mm Tape	1	0	0	**1**
8-mm Tape	6	0	0	**6**
9-Track Tape	0	11	0	**11**
CD-ROM (Titles)	0	105	87	**192**
CD-WO	169	2,215	252	**2,636**
Magneto-Optic Disk	0	24	0	**24**
DLT	102	0	0	**102**
Total	**278**	**2,355**	**339**	**2,972**

Table 8a.
Annual Access Statistics for Special Space Physics Systems

	1997	1998	1999
CDAWeb	36,606/8,481*	58,786/23,483	68,127/26,558
OMNIWeb	7,325/3,621	8,784/3,042	9,203/3,349
COHOWeb	1,219/621	1,005/650	1,299/468
ATMOWeb			2,774 **

* For first three rows, first member of each pair is the number of plots created. Second member is the sum of numerical screen listings plus user-created-ASCII files or CDF files downloaded.

** ATMOWeb count is number of executions of the ATMOWeb software yielding plots, listings, or ASCII files. The count is annualized based on August-December statistics.

Table 8b.
1999 Access Statistics to Geophysical Models and Ephemerides Services

Geophysical Models	
International Reference Ionosphere	18,837
MSIS Atmospheric Model	15,317
International Geomagnetic Reference Field (includes Corrected Geomagnetic Coordinate Transformations)	17,899
Tsyganenko 1989, 1996 Magnetic Field	1,243
Trapped Particles	2,507
Total, Geophysical Models	**55,803**
Satellite Situation Center/SSCWeb (magnetosphere and near-magnetosphere spacecraft orbits)	
Plots	10,739
Tabular and "Query"	6,603
Total, SSCWeb	**17,342**
Heliocentric Spacecraft, Planets, Comets Orbits	3,427

These counts are software executions, yielding results for user-specified criteria. They do not include ftp-downloads of corresponding software

Table 9.
Number of Files Downloaded from ANON/FTP, Excluding NDADS

	1996	1997	1998	1999
Photo_Gallery	26,000	59,000	504,000	1,381,000
Spacecraft_Data (= "COHO" through 1998)	15,000	11,000	10,000	113,000
All Others	75,000	114,000	151,000	229,000
Total	**116,000**	**184,000**	**665,000**	**1,723,000**

Table 10.
NDADS 1999 Access Stats - Missions with >10 Unique Sites
Accessing Data Monthly

		Number Requests	Mean Monthly E-addresses Accessing	Number Files
Astrophysics				
	IUE	2,861	46	130,636
	IRAS	383	15	3,675
Space Physics				
	IMP 8	944	19	28,077
	ISTP	743	17	17,022
	DE	1,908	11	46,229
All Others		2,366		29,857
Grand Totals		**9,225**		**255,596**

Table 11.
NSSDC User Community (Offline Requests) [CY 1999]

Affiliation Category	Total Requests	Percent of Total
No Affiliation [GeneralPublic]	680	48.4
Non-US	426	30.3
US Universities/Colleges	90	6.4
US Private Industry	101	7.2
NASA/GSFC	35	2.5
NASA Centers, Excluding GSFC	36	2.6
Other Government Agencies	27	1.9
Miscellaneous	11	0.8
Total	**1,406***	**100**

* Requests for 2,710 Milky Way posters and 1,311 COBE posters are not included in this total.

Table 12.
Number of Requests for Offline Satellite Data from NSSDC by Discipline *

Discipline	Data Set Requests 1968 - 1999	Offline Data Set Requests 1999
Astrophysics	10,630	476
Earth Science	7,128	20
Planetary Science	42,856	2,075
Space Physics	8,296	198
Ephemeris	86	0
Other	20	0
Total	**69,016**	**2,769**

* One request for all or parts of two distinct data sets adds two to these Table 12 statistics, but only one to the Table 11 statistics.

Table 13.
NSSDC Offline Data Dissemination Statistics as of December 31, 1999

Offline	1995	1996	1997	1998	1999
Number of Requests for Tapes	67	30	25	24	12
Number of Tapes Mailed	676	401	428	925	66
Number of Requests for CDs	814	1,233	1,297	1,079	1,013
Number of CDs Mailed	10,469	4,804	6,220	6,825	7,014
Number of Film Requests	128	177	192	300	230
Number of Film Volumes Mailed	894	1,733	2,383	2,353	1,520

Table 14.
AIM Partition Statistics for CY 1999

	Number of Records	Number Added
Subpartition	**as of 12/31/99**	**in 1999**
Spacecraft	5,616	292
Experiment	5,669	246
Data Set	5,618	171
Totals	**16,903**	**709**

Number of spacecraft with experiments - 1,061
Number of experiments with data sets - 1,441

Table 15.
NSDF Partition Statistics for CY 1999

Discipline	Number of Data Sets
Astrophysics	1,037
Space Physics	441
Earth Science	65
Planetary	43
Other	28
Total	1,614

Table 16.
TRF Partition Statistics as of 12/31/99

Total Number of Records	41,306
Number of Records Inserted	1,463

Table 17.
IRAND Partition Statistics as of 12/31/99

Record Type	Total Records	Records Inserted	Records Updated
Personnel	55,767	991	8,267
Request	80,408	1,386	

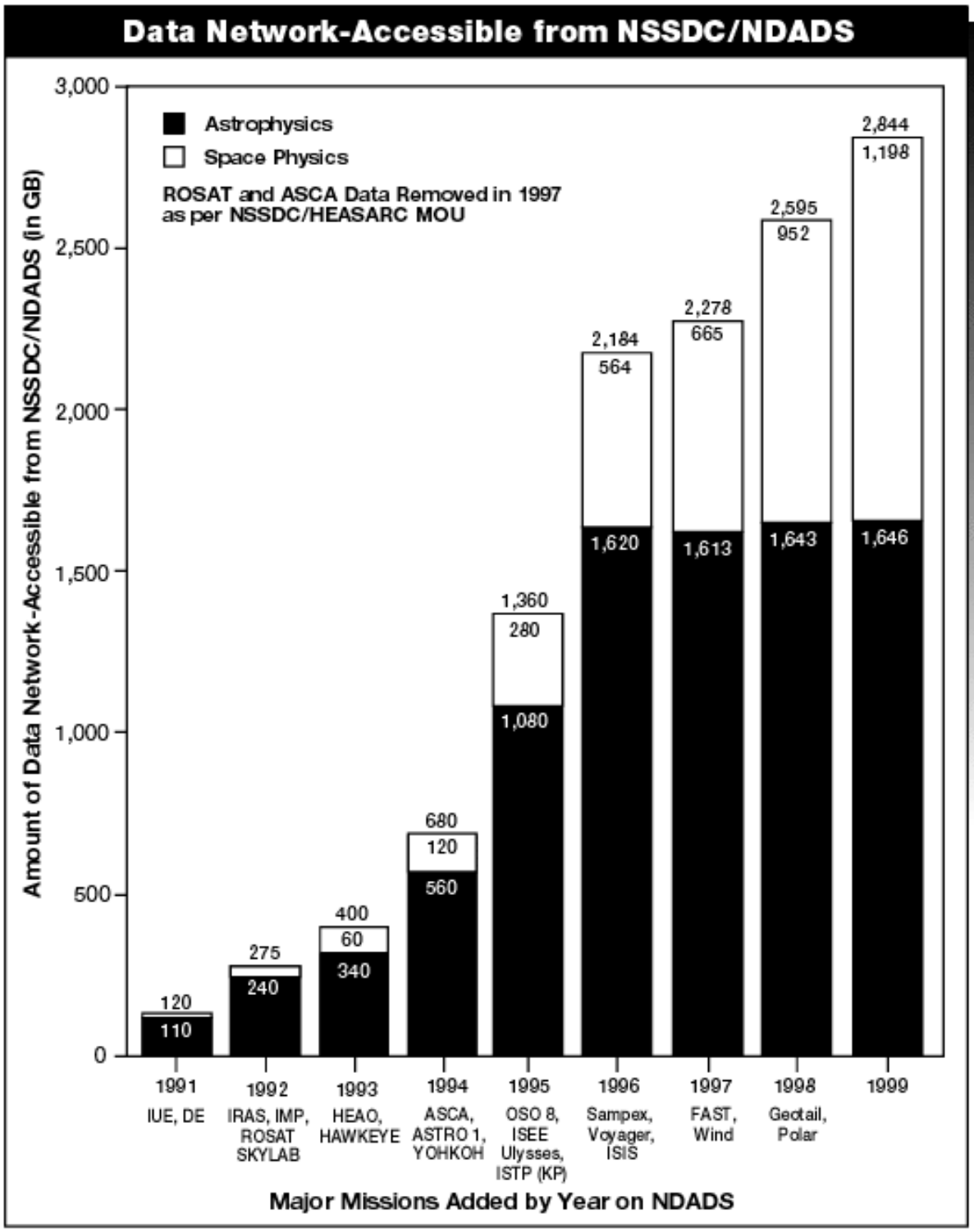
Data Network-Accessible from NSSDC/NDADS
Astrophysics
Space Physics
ROSAT and ASCA Data Removed in 1997
as per NSSDC/HEASARC MOU
Amount of Data Network-Accessible from NSSDC/NDADS (in GB)
3,000
2,500
2,000
1,500
1,000
500
0
120
110
275
240
400
60
340
680
120
560
1,360
280
1,080
2,184
564
1,620
2,278
665
1,613
2,595
952
1,643
2,844
1,198
1,646
1991
IUE, DE
1992
IRAS, IMP, ROSAT SKYLAB
1993
HEAO, HAWKEYE
1994
ASCA, ASTRO 1, YOHKOH
1995
OSO 8, ISEE Ulysses, ISTP (KP)
1996
Sampex, Voyager, ISIS
1997
FAST, Wind
1998
Geotail, Polar
1999
Major Missions Added by Year on NDADS

Figure 1

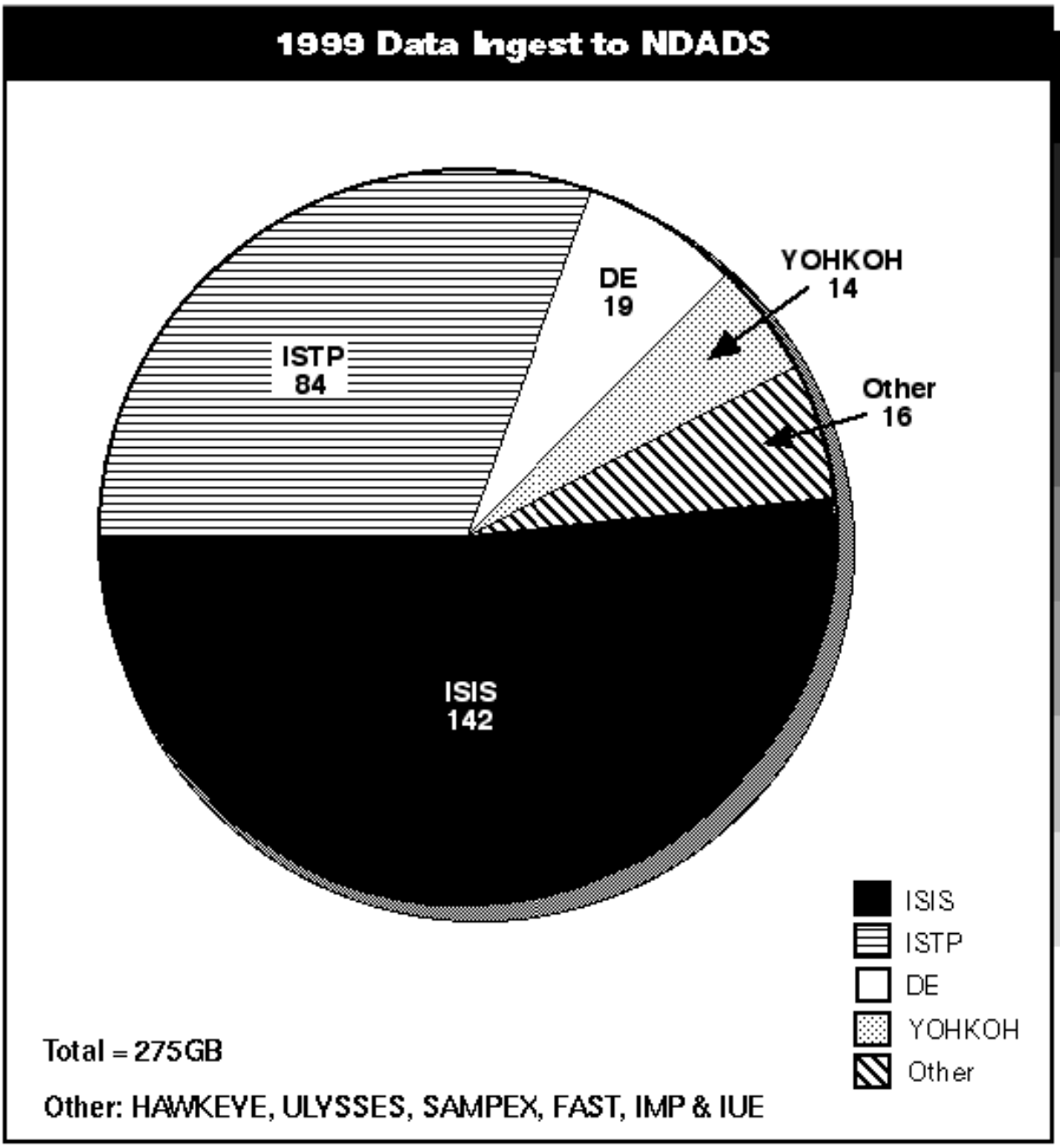
1999 Data Ingest to NDADS
YOHKOH
14
DE
19
ISTP
84
Other
16
ISIS
142
ISIS
ISTP
DE
YOHKOH
Other
Total = 275GB
Other: HAWKEYE, ULYSSES, SAMPEX, FAST, IMP & IUE

Figure 2

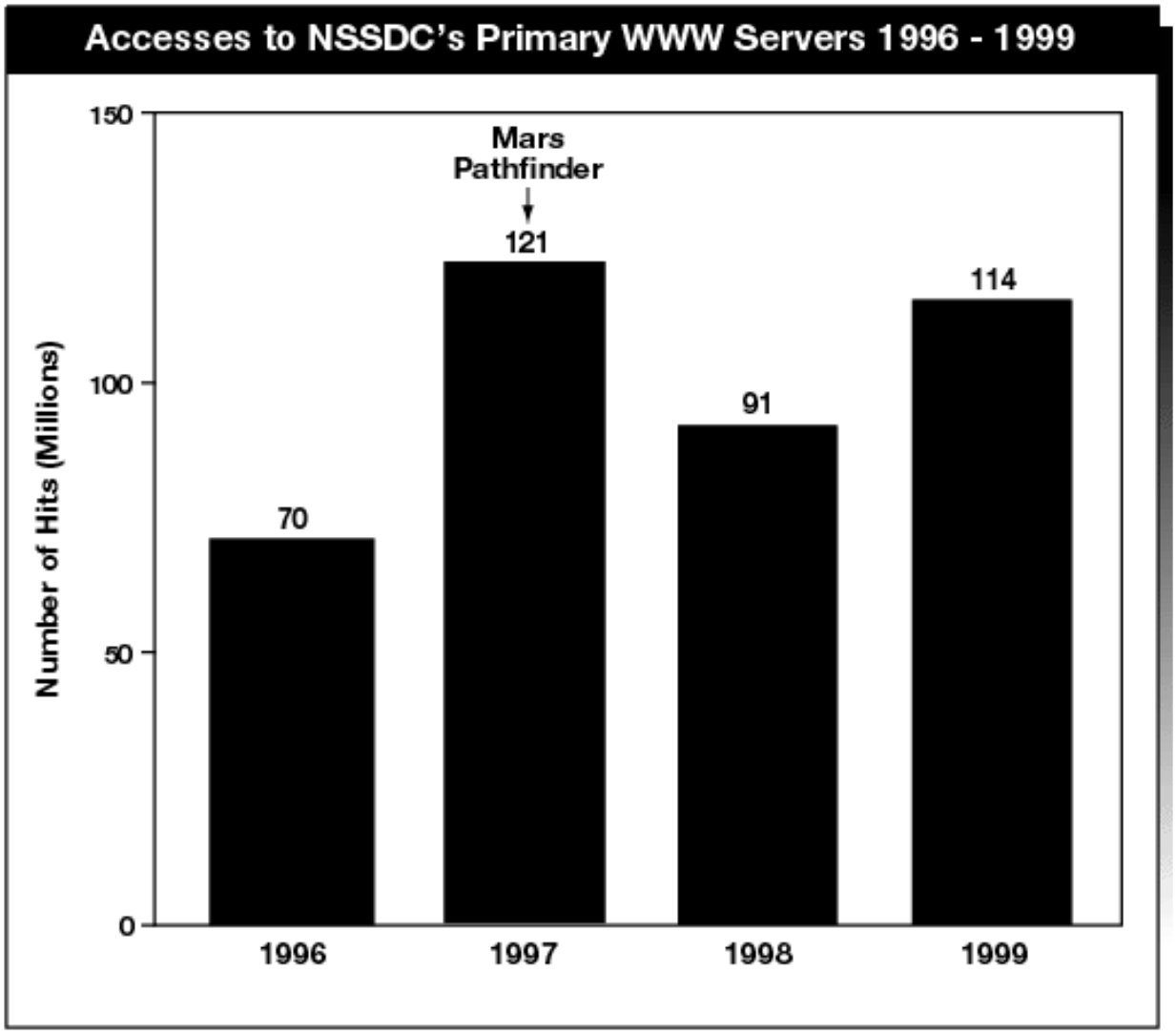
Accesses to NSSDC's Primary WWW Servers 1996 - 1999
Number of Hits (Millions)
150
100
50
0
Mars
Pathfinder
70
121
91
114
1996
1997
1998
1999

Figure 3

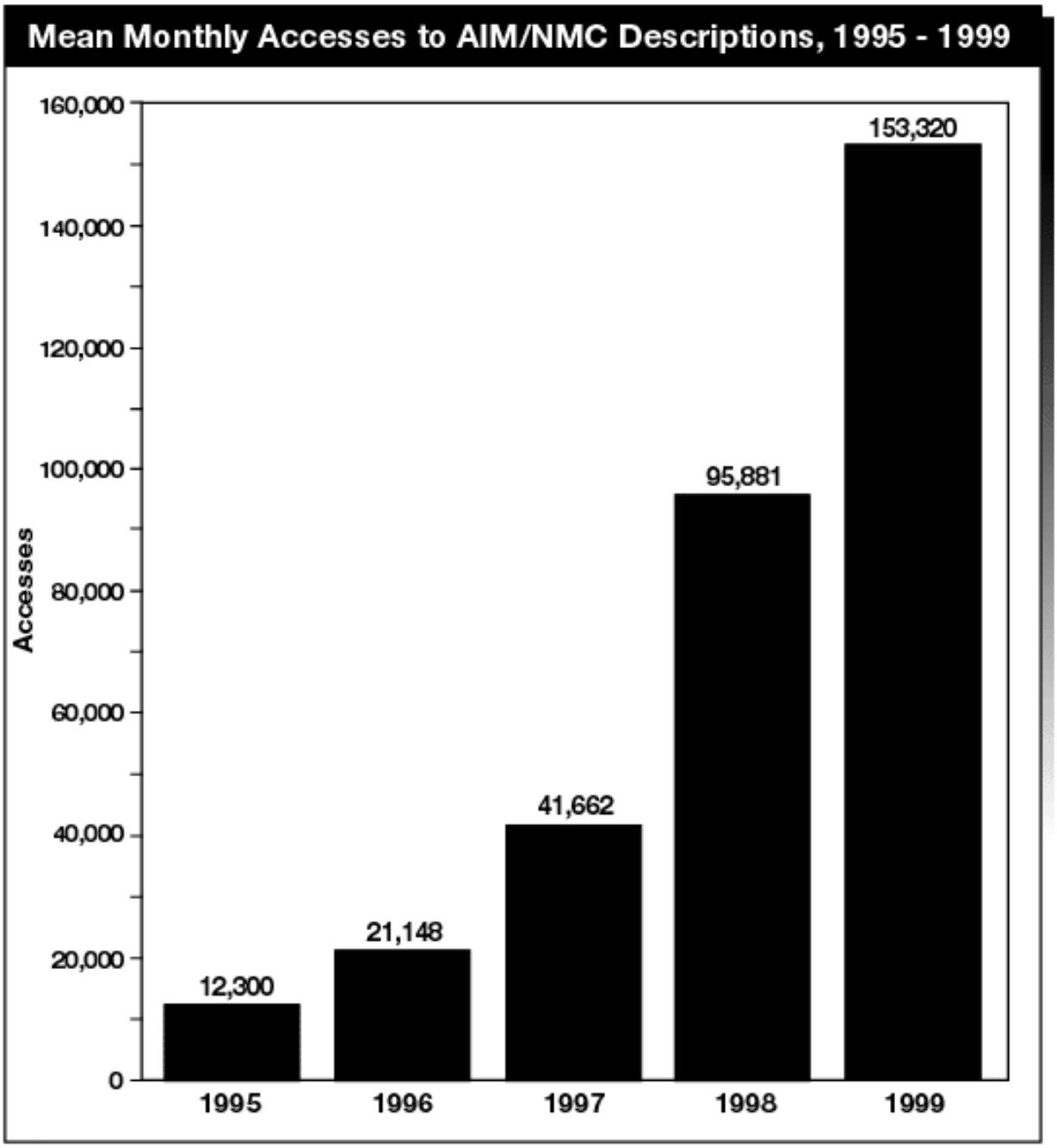
Mean Monthly Accesses to AIM/NMC Descriptions, 1995 - 1999
Accesses
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
12,300
21,148
41,662
95,881
153,320
1995
1996
1997
1998
1999

Figure 4

Appendix. Listing of Selected 1999 NSSDC-Acknowledged 1999 Papers

This listing identifies published papers in which authors cite NSSDC as a source of data or services used. The papers were identified as NSSDC-involved mainly by NSSDC staffers scanning the Journal of Geophysical Research and the Geophysical Research Letters. As such this listing represents a lower limit on the scientific research coming to fruition with NSSDC help in 1999.

Amm, O., Engebretson, M. J., Greenwald, R. A., Luehr, H., Moretto, T., Direct determination of IMF By-related cusp current systems, using SuperDARN radar and multiple ground magnetometer data: A link to theory on cusp current origin, *J. Geophys. Res.,* 104, No. A8, 18187-17198, Aug. 1999.

Bale, S. D., Observation of topside ionospheric MF/HF radio emission from space, *Geophys. Res. Lett.,* 26, No. 6, 667-670, Mar. 1999.

Berdichevsky, D., Thejappa, G., Fitzenreiter, R. J., Lepping, R. P., Yamamoto, T., Kokubun, S., McEntire, R. W., Williams, D. J., Lin, R. P., Widely spaced wave-particle observations during GEOTAIL and Wind magnetic conjunctions in the Earth's ion foreshock with near-radial interplanetary magnetic field, *J. Geophys. Res.,* 104, No. A1, 463-382, Jan. 1999.

Brandt, J. C., Caputo, F. M., Hoeksema, J. T., Niedner, M. B., Jr., Yi, Y., Snow, M., Disconnection events (DEs) in Halley's Comet 1985-1986: The correlation with crossings of the heliospheric current sheet (HCS), *Icarus,* 137, 69-83, 1999.

Bravo, S., Blanco-Cano, X., Lopez, C., Characteristics of interplanetary magnetic clouds in relation to their solar association, *J. Geophys. Res.,* 104, No. A1, 581-591, Jan. 1999.

Cahill, L. J., Jr., Winckler, J. R., Magnetopause crossings observed at 6.6 RE, *J. Geophys. Res.,* 104, No. A6, 12229-12237, June 1999.

Green, J. L., Boardsen, S. A., Confinement of nonthermal continuum radiation to low latitudes, *J. Geophys. Res.,* 104, No. A5, 10307-10316, May 1999.

Kahler, S. W., Crooker, N. U., Gosling, J. T., A magnetic polarity and chirality analysis of ISEE 3 interplanetary magnetic clouds, *J. Geophys. Res.,* 104, No. A5, 9911-9918, May 1999.

Kahler, S. W., Crooker, N. U., Gosling, J. T., The polarities and locations of interplanetary coronal mass ejections in large interplanetary magnetic sectors, *J. Geophys. Res.,* 104, No. A5, 9919-9924, May 1999.

Keady, J. P., Heelis, R. A., Regional, scale size, and interplanetary magnetic field variability of magnetic field and ion drift structures in the high-latitude ionosphere, *J. Geophys. Res.,* 104, No. A1, 199-212, Jan. 1999.

Kessel, R. L., Quintana, E., Peredo, M., Local variations of interplanetary magnetic field at Earth's bow shock, *J. Geophys. Res.,* 104, No. A11, 24869-24878, Nov. 1999.

Kubyshkina, M. V., Sergeev, V. A., Pulkkinen, T. I., Hybrid Input Algorithm: An event-oriented magnetospheric model, *J. Geophys. Res.,* 104, No. A11, 24977-24993, Nov. 1999.

Lindsay, G. M., Russell, C. T., Luhmann, J. G., Predictability of Dst index based upon solar wind conditions monitored inside 1 AU, *J. Geophys. Res.,* 104, No. A5, 10335-10344, May 1999.

Lindsay, G. M., Luhmann, J. G., Russell, C. T., Gosling, J. T., Relationships between coronal mass ejection speeds from coronagraph images and interplanetary characteristics of associated interplanetary coronal mass ejections, *J. Geophys. Res.,* 104, No. A6, 12515-12523, June 1999.

Lu, G., Tsyganenko, N. A., Lui, A. T. Y., Singer, H. J., Nagai, T., Kokubun, S., Modeling of time-evolving magnetic fields during substorms, *J. Geophys. Res.,* 104, No. A6, 12327-12337, June 1999.

Lyatsky, W. B., Sofko, G. J., Kustov, A. V., Andre, D., Hughes, W. J., Murr. D., Traveling convection vortices as seen by the SuperDARN HF radars, *J. Geophys. Res.,* 104, No. A2, 2591-2601, Feb. 1999.

Mende, S. B., Frey, H. U., Geller, S. P., Doolittle, J. H., Multistation observations of auroras: Polar cap substorms, *J. Geophys. Res.,* 104, No. A2, 2333-2342, Feb. 1999.

Nakai, H., Kamide, Y., Russell, C. T., Dependence of the near-Earth magnetotail magnetic field on storm and substorm activities, *J. Geophys. Res.,* 104, No. A10, 22701-22711, Oct. 1999.

Ohtani, S., Rostoker, G., Takahashi, K., Angelopoulos, V., Nakamura, M., Waters, C., Singer, H., Kokubun, S., Tsuruda, K., Hughes, W. J., Potemra, T. A., Zanetti, L. J., Gary, J. B., Lui, A. T. Y., Williams, D. J., Coordinated ISTP satellite and ground observations of morningside Pc5 waves, *J. Geophys. Res.,* 104, No. A2, 2381-2397, Feb. 1999.

Oieroset, M., Yamauchi, M., Liszka, L., Hultqvist, B., Energetic ion outflow from the dayside ionosphere: Categorization, classification, and statistical study, *J. Geophys. Res.,* 104, No. A11, 24915-24927, Nov. 1999.

Osherovich, V. A., Fainberg, J., Stone, R. G., Solar wind quasi-invariant as a new index of solar activity, *Geophys. Res. Lett.,* 26, No. 16, 2597-2600, Aug. 1999.

Papitashvili, V. O., Rich, F. J., Heinmann, M. A., Hairston, M. R., Parameterization of the Defense Meteorological Satellite Program ionospheric electrostatic potentials by the interplanetary magnetic field strength and direction, *J. Geophys. Res.,* 104, No. A1, 177-184, Jan. 1999.

Parkinson, M. L., Breed, A. M., Dyson, P. L., Morris, R. J., Signatures of the ionospheric cusp in digital ionosonde measurements of plasma drift above Casey, Antarctica, *J. Geophys. Res.,* 104, No. A10, 22487-22498, Oct. 1999.

Posch, J. L., Engebretson, M. J., Weatherwax, A. T., Detrick, D. L., Hughes, W. J., Maclennan, C. G., Characteristics of broadband ULF magnetic pulsations at conjugate cusp latitude stations, *J. Geophys. Res.,* 104, No. A1, 311-331, Jan. 1999.

Pulkkinen, T. I., Baker, D. N., Cogger, L. L., Frank, L. A., Sigwarth, J. B., Kokubun, S., Mukai, T., Singer, H. J., Slavin, J. A., Zelenyi, L., Spatial extent and dynamics of a thin current sheet during the substorm growth phase on December 10, 1996, *J. Geophys. Res.,* 104, No. A12, 28475-28490, Dec. 1999.

Raghavarao, R., Suhasini, R., Mayr, H. G., Hoegy, W. R., Wharton, L. E., Equatorial spread-F (ESF) and vertical winds, *J. Atmos. Solar-Terres. Phys.,* 61, 607-617, 1999.

Rash, J. P. S., Rodger, A. S., Pinnock, M., The morning sector for northward IMF and motion of the convection reversal HF radar observations of the high-latitude ionospheric convection pattern in boundary, J. Geophys. Res., 104, No. A7, 14847-14866, July 1999.

Richardson, I. G., Cane, H. V., Wibberenz, G., A 22-year dependence in the size of near-ecliptic corotating cosmic ray depressions during five solar minima, *J. Geophys. Res.,* 104, No. A6, 12549-12561, June 1999.

Saur, J., Bieber, J. W., Geometry of low-frequency solar wind magnetic turbulence: Evidence for radially aligned Alfvenic fluctuations, *J. Geophys. Res.,* 104, No. A5, 9975-9988, May 1999.

Schwadron, N. A., Zurbuchen, T. H., Fisk, L. A., Gloeckler, G., Pronounced enhancements of pickup hydrogen and helium in high-latitude compressional regions, *J. Geophys. Res.,* 104, No. A1, 535-547, Jan. 1999.

Shepherd, S. G., Greenwald, R. A., Ruohoniemi, J. M., A possible explanation for rapid, large-scale ionospheric responses to southward turnings of the IMF, *Geophys. Res. Lett.,* 26, No. 20, 3197-3200, Oct. 1999.

Sitar, R. J., Clauer, C. R., Ground magnetic response to sudden changes in the interplanetary magnetic field orientation, *J. Geophys. Res.,* 104, No. A12, 28343-28350, Dec. 1999.

Smith, J. P., Thomsen, M. F., Borovsky, J. E., Collier, M., Solar wind density as a driver for the ring current in mild storms, *Geophys. Res. Lett.,* 26, No. 13, 1797-1800, July 1999.

Smith, P. R., Dyson, P. L., Morris, R. J., Comparison of an ionosonde drift model at a single station with polar convection patterns, *J. Geophys. Res.,* 104, No. A12, 28089-28099, Dec. 1999.

Stamper, R., Lockwood, M., Wild, M. N., Clark, T. D. G., Solar causes of the long-term increase in geomagnetic activity, *J. Geophys. Res.,* 104, No. A12, 28325-28342, Dec. 1999.

Thejappa, G., Goldstein, M. L., MacDowall, R. J., Papadopoulos, K.,

Stone, R. G., Evidence for Langmuir envelope solitons in solar type III burst source regions, *J. Geophys. Res.,* 104, No. A12, 28279-28293, Dec. 1999.

Trattner, K. J., Fuselier, S. A., Peterson, W. K., Chang, S.-W., Comment on: "Correlation of cusp MeV helium with turbulent ULF power spectra and its implications," *Geophys. Res. Lett.,* 26, No. 10, 1361-1362, May 1999.

Trattner, K. J., Fuselier, S. A., Peterson, W. K., Sauvaud, J.-A., Stenuit, H., Dubouloz, N., Kovrazhkin, R. A., On spatial and temporal structures in the cusp, *J. Geophys. Res.,* 104, No. A12, 28411-28421, Dec. 1999.

Tsyganenko, N. A., Le, G., Russell, C. T., Iyemori, T., A study of the inner magnetosphere based on data of Polar, *J. Geophys. Res.,* 104, No. A5, 10275-10283, May 1999.

Tsyganenko, N. A., Russell, C. T., Magnetic signatures of the distant polar cusps: Observations by Polar and quantitative modeling, *J. Geophys. Res.,* 104, No. A11, 24939-24955, Nov. 1999.

Vacaresse, A., Boscher, D., Bourdarie, S., Blanc, M., Sauvaud, J. A., Modeling the high-energy proton belt, *J. Geophys. Res.,* 104, No. A12, 28601-28613, Dec. 1999.

Vennerstrom, S., Dayside magnetic ULF power at high latitudes: A possible long-term proxy for the solar wind velocity, *J. Geophys. Res.,* 104, No. A5, 10145-10157, May 1999.

Vorobjev, V. G., Yagodkina, O. I., Sibeck, D. G., Newell, P., Daytime high-latitude auroral pulsations: Some morphological features and the region of the magnetospheric source, *J. Geophys. Res.,* 104, No. A5, 10135-10144, May 1999.

Voronkov, I., Friedrich, E., Samson, J. C., Dynamics of the substorm growth phase as observed using CANOPUS and SuperDARN instruments, *J. Geophys. Res.,* 104, No. A12, 28491-28505, Dec. 1999.

Weimer, D. R., Substorm influence on the ionospheric electric potentials and currents, *J. Geophys. Res.,* 104, No. A1, 185-197, Jan. 1999.

Wintoft, P., Lundstedt, H., A neutral network study of the mapping from solar magnetic fields to the daily average solar wind velocity, *J. Geophys. Res.,* 104, No. A4, 6729-6736, Apr. 1999.

Zong, Q.-G., Wilken, B., Bursty energetic oxygen events in the dayside magnetosheath: GEOTAIL observations, *Geophys. Res. Lett.,* 26, No. 22, 3349-3352, Nov. 1999.