

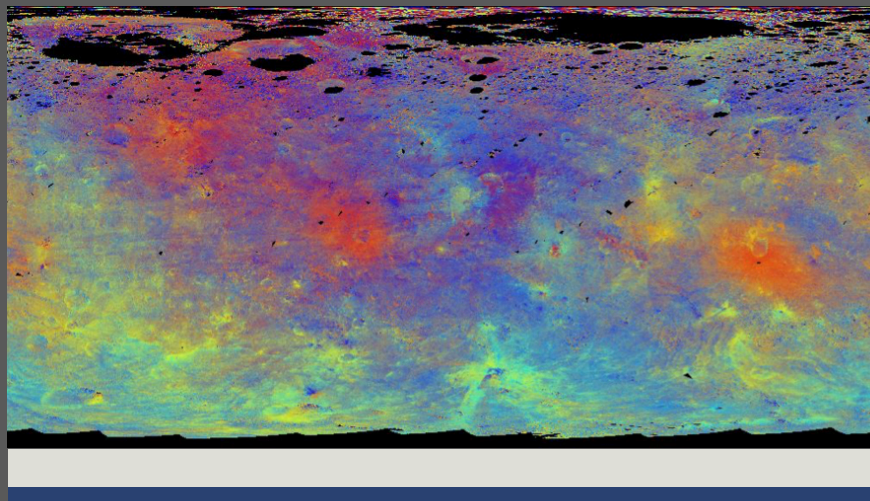
**NASA Space
Science Data
Coordinated
Archive**

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**2015 ANNUAL
STATISTICS AND
HIGHLIGHTS**

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Cover Photo Credit: Global mosaic of Vesta from the Dawn Framing Camera 2 (FC2) using the same color ration used by the lunar Clementine mission. The map, which uses color to show differences in soil mineralogy, was derived from FC2 narrowband images acquired during the High Altitude Mapping Orbits (HAMO, ~420km altitude) in 2011 and 2012. The map is a cylindrical projection centered at 0° latitude, 180° longitude; north is up. The Clementine color ratios are red=750 nm/440 nm, green=750 nm/920 nm, and blue=440 nm/750 nm

Preface

The NASA Space Science Data Coordinated Archive (NSSDCA) serves as the deep archive for NASA's Space Science community. A major component of its mission is to ensure future data accessibility and usability. NSSDCA also provides current data access, complementary to the efforts of other NASA active archives, in support of NASA and international research enterprises. Finally, NSSDCA is a conduit for the general public and education community to acquire NASA space science data that may be of interest to them.

Herein we report on the activities of the NSSDCA for the calendar year 2015. As much as possible, we report the same statistics as in previous years to enable interested parties who wish to compare accomplishments year-to-year. Nevertheless, as NSSDCA evolves, some statistical tables have been updated to better reflect current operations. These are noted in the text.

NSSDCA is pleased to issue this 2015 Annual Report describing the growth and evolution of the data archive and other tools and services, as well as the access to those data and services by NSSDCA's customer communities. This report has been made web accessible in the hope that readers will avail themselves of the opportunity to link to the services reported herein.

We welcome suggestions from users for improvements to this Annual Report and to NSSDCA services.

Edwin J. Grayzeck

Head, NASA Space Science Data Coordinated Archive

Introduction

This report characterizes NSSDCA's data holdings, metadata holdings, access pathways and services at the end of 2015, with a focus on the 2015 activities leading to that end-of-year state. In addition this report characterizes the nature and access to NSSDCA's data and services by its many users from various communities. It is assumed the reader will have a general familiarity with NSSDCA and its mission. For more information see the top level NSSDCA web page at <http://nssdc.gsfc.nasa.gov/>.

Highlights

The most important result of NSSDCA's 2015 continuing activities is the preservation of growing space science data volumes, ensuring their continuing and future accessibility to the space science, education and general public communities. The archive has grown to 400 TB of space science data, a growth of around 130 TB. The largest data contributor was the Planetary Data System (PDS).

In 2015, as in 2014, the major development effort has been preparing to receive and archive data in the new PDS4 format, which some PDS nodes began using operationally in late 2014 starting with the LADEE mission. Nevertheless, the majority of data submitted from the PDS continues to be data in PDS3 format, a large fraction of which was data from the Lunar Reconnaissance Orbiter Camera (LROC).

NSSDCA also continues to provide off-site backup service for selected data submitters' original media. Levels of archive services that are provided by NSSDCA are discussed in more detail at http://nssdc.gsfc.nasa.gov/nssdc/submitting_data.html.

Data Managed at NSSDCA

State of the Archive

There are several ways to characterize the multi-disciplinary NSSDCA archive and we use most of them herein to give a true sense of the archive, *i.e.*, byte counts, numbers of distinct data collections, and numbers of media volumes managed, as well as the diversity of data collections and of media types. For the remainder of this section we will present this variety of statistics mostly in tabular form, similar to prior years' reports as much as possible.

Discipline	Digital	Analog	Total
Astrophysics	231	76	307
Heliophysics	1,320	656	1,976
Planetary Science	1,928	761	2,689
Earth Science	105	37	142
Other	125	429	554
Total	3,709	1,959	5,668

Table 1: Counts of data collections at NSSDCA on 31 December 2015.

Table 1 shows a summary of the variety of data collections held in the archive. Shown in the table are those science discipline areas covered by those collections as well as whether or not the collections are digital or analog. Planetary science continues to be the only discipline in which significant growth in terms of digital data occurs.

There was a significant drop in the number of Earth Science analog collections held by NSSDCA. This was due to the transition of a large fraction of these collections being turned over to the Earth Science Data and Information System (ESDIS) at Goddard as part of an on-going effort to consolidate Earth Science data in one location.

Discipline	Digital Data (TB)
Astrophysics	188.04
Heliophysics	30.11
Planetary Science	181.94
Earth Science	0.00
Other	1.53
Total	401.62

Table 2: Total volume of the NSSDCA digital archive on 31 December 2015.

Table 2 presents a different view of the digital archive. It shows the total volume (in TB) for each discipline. Byte counts for older data collections (and some collections held on media from projects such as the High Energy Astrophysics Science Archive Research Center (HEASARC)) are estimates assuming that the media on which they are held have a mean number of bytes depending on the medium. The totals shown in the table have also been adjusted to take into account any data released due to replacement (*e.g.*, PDS or HEASARC) or any data transferred to ESDIS. For 2015 there was significant growth (about 120 TB) in planetary science

resulting from data submitted by PDS. Figure 1 shows the same information as Table 2, but includes information from 2005-2014 as well.

Digital data are stored in a near-line archive based on an LTO jukebox attached to a Linux server. Data are archived in Archive Information Packages (AIPs) that hold both data files and accompanying attribute files that are media- and platform-independent. These AIPs are defined as per the ISO/CCSDS Open Archival Information System (OAIS) reference model.

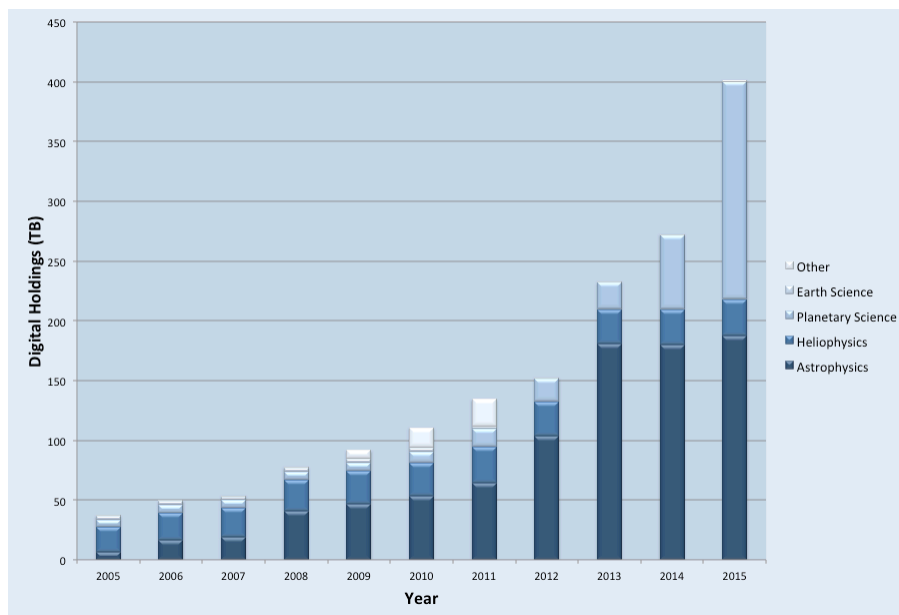


Figure 1: Total volume of the NSSDCA digital archive (2005-2015).

	2012 (GB)	2013 (GB)	2014 (GB)	2015 (GB)
Legacy Data	75.82	19.17	15.58	13.42
Data Conversion	0	0.65	0	0
Gravity Probe-B	0	0	326.84	3.74
PDS	3,096.60	3,093.75	50,558.88	119,698.75
RHESSI	586.82	591.61	617.01	616.02
TWINS	241.18	0	0	0
Wind	0.21	0.21	0.20	0.11
Total	4,000.63	3,705.39	51,518.51	120,332.04

Table 3: Data ingested to near-line permanent archive.

Table 3 shows the volume of data ingested to this portion of the archive for the years 2012-2015. The total volume of data ingested as AIPs in 2015 was over twice as much as 2014. This is due to the fact that much of the data taken into the archive during 2015 was on very large data volumes from PDS.

Media Type	Astrophysics	Heliophysics	Planetary Science	Earth Science	Total
4-mm Tape	1,194	94	3	0	1,291
8-mm Tape	205	199	77	0	481
9-track Tape	531	4,795	1,401	33	6,760
3480 Cartridges	474	1,983	1,155	10	3,622
DLT	84	101	2	0	187
LTO	74	0	0	0	74
CD	519	23,183	2,533	0	26,235
DVD	1,012	1,047	206	0	2,265
12-in WORM	0	4	0	0	4
Total	4,093	31,406	5,377	43	40,919

Table 4: Counts of media volumes at NSSDCA on 31 December 2015. Backup volumes and those not attributable to the four disciplines listed are not included.

Table 4 presents a characterization of the various off-line media that are managed within NSSDCA. These are data that are not a part of the near-line system. These data are replicable. Data on tape media generally have one backup volume. The items listed under Earth Science represent a negligible amount of the overall data holdings, so 0.0 TB was entered into Table 2 above. A decrease from 2014 in the number of Astrophysics Linear Tape-Open (LTO) tapes resulted from a replacement of LTO5 tapes from HEASARC with higher-density LTO6 tapes. Legacy data on tape continues to be migrated into AIP form as well and will result in a decrease in media from this table in the future when those volumes are released.

Table 5 lists the analog holdings at NSSDCA by discipline and by form. Reels of uncut sequences of still photos are

Media Type	Astrophysics	Heliophysics	Planetary Science	Earth Science	Other	Total
Microfilm (reels)	2,382	34,915	2,095	38	3,061	42,651
Microfiche (cards)	5,963	30,507	13,492	548	3,620	54,565
Film (feet)	100	580	409,081	0	3,785	426,613
Film (frames)	11,971	6,173	333,218	31,368	6,206	422,140
Movie (reels)	0	2	181	4	20	207
Maps	0	0	1,773	0	0	1,773
Slides	62	36,893	768	0	2,112	39,835

Table 5: Counts of analog products by form at NSSDCA on 31 December 2015.

listed as Film (feet). Photographic stills are also held as cut frames. No images are double-counted nor are backup or extra copies counted. The entries are unchanged from last year despite the decrease noted in Table 1 for Earth Science collections. The decrease in Table 1 was due to updating the database information for those collections that were transferred to ESDIS in 2014.

Data Inflow

In previous years we reported on data arriving on various media types. With the sole exception of those entities for which NSSDCA is holding data as a backup function (*e.g.*, HEASARC), all data are now being put in the near-line archive as AIPs and any media on which they arrive is treated as transfer media. In 2015 41 tapes (HEASARC) were received by NSSDCA for archive.

Table 6 lists by project the volume of data received by NSSDCA in 2015, nearly 187 TB of data via a combination of electronic deliveries as well as on media. As in 2014, deliveries in Astrophysics and Planetary Science dominate new data. The HEASARC delivery was a full replacement of previously delivered data, a complete backup of their entire archive. As specified in the MOU with HEASARC all previously delivered media were released from NSSDCA and returned to them.

Discipline/Project	GB	Totals by
Astrophysics		110,900.00
Fermi	8,400.00	
HEASARC	102,500.00	
Planetary Science		119,698.75
PDS Atmospheres	1,655.99	
PDS Geosciences	13,924.99	
PDS Imaging	88,063.45	
PDS NAIF	436.44	
PDS PPI	10,947.44	
PDS PSI	4,670.43	
Heliophysics		616.13
RHESSI	617.01	
Wind/Wave	0.20	
Miscellaneous		17.16
Gravity Probe-B	3.74	
Legacy Data	13.42	
Grand Total		186,875.55

Table 6: Data arriving at NSSDCA during 2015.

Data Dissemination

NSSDCA also responds to *ad hoc* requests for data. Such requests are now provided in digital form (including digital forms of previously analog materials) and are staged for retrieval on a server.

Affiliation Category	Requests
No Affiliation (General Public)	1
Non-US	1
US Academic Institutions	3
US Private Industry	0
NASA/GSFC	60
NASA Centers (excluding GSFC)	3
Other Government Agencies	0
Total	68

Table 7: NSSDCA off-line request user community for 2015.

Requests for data come from a wide user community. Table 7 shows the number of requests for 2015. The large number of requests for NASA/GSFC is the result of continuing to transfer Heliophysics data collections to the Space Physics Data Facility (SPDF). Of the 60 requests originating at GSFC, 56 of them were from this transfer of data. Excluding these, there was a total of 12 requests for off-line data in 2015.

Requests for off-line data are also tracked by science discipline. Table 8 presents the number of requests by science discipline for 2015. The total number of requests by discipline (69) exceeds the requests by affiliation (68) because requests can include data associated with more than one discipline. In addition, some requests are requests for documentation or other forms that are not included in Table 8. Finally, as with

Table 7, the large number of requests supporting the transfer of data to SPDF greatly reduces the number of requests, not only in Heliophysics, but in the other disciplines as well. Excluding these requests reduces the overall total discipline requests to 13, eliminating all but two in Astrophysics, one in Heliophysics and the 10 in Planetary Science.

One noted request involved the Gas Chromatograph Mass Spectrometer (GCMS), an instrument flown on the Viking 1 and 2 Landers that began operations in 1976. The instrument examined samples of Martian soil scooped from the surface. Researchers at NASA's Ames Research Center requested GCMS data to search for a signature for the presence of chlorobenzene in the Martian regolith. This is of interest for comparison with detections of chlorobenzene by the Sample Analysis at Mars (SAM) instrument on the Mars Science Laboratory, *Curiosity*, which suffered from high contamination. Initially 32 files were staged from four different soil analysis data collections, all archived on magnetic tape. In addition, a total of 1,030 frames of microfilm containing plots of readouts from the GCMS instrument were digitized for samples of interest. This effort is on-going as the researchers examine certain sample runs and, based on the results, request further data.

In 2015 all data distribution was via electronic distribution. Table 9 presents the distribution of requested data by discipline for recent years. The information provided does not include any repeat requests for data previously made available electronically, but only data that were newly posted in response to a request.

Discipline	Requests
Astrophysics	3
Earth Science	0
Heliophysics	55
Planetary Science	10
Ephemeris	1

Table 8: Number of off-line requests for data by discipline for 2015.

Discipline	2011 (items)	2012 (files)	2013 (files)	2014 (files)	2015 (files)
Astrophysics	124	48	0	8,674	0
Heliophysics	57	10,517	11,512	15,643	6,568
Planetary Science	31,891	453	32,387	5,216	6,136
Other	463	1,376	0	34	1
Total	32,535	12,394	43,899	29,567	12,705

Table 9: NSSDCA off-line data dissemination statistics, 2011-2015. Note that for years prior to 2012 that "items" were reported, which included not only files, but also hard media (e.g., CD-ROMs, etc.). For the years 2012-2015 data distribution has been of electronic files.

Additional Services and Activities

In addition to its archive of scientific data, NSSDCA offers a number of additional services that are described below.

NSSDCA Information Management System (NIMS)

The NSSDCA Information Management System (NIMS) encompasses most of the separate databases that have been used to track data and information through the years. Table 10 summarizes pertinent statistics for NIMS for 2015. NIMS identifies virtually all launched spacecraft, the experiments carried by many of these spacecraft, and data collections from these spacecraft, primarily as archived at NSSDCA. This portion of the database is the source of information for many of NSSDCA's web pages. The NSSDCA Master Catalog (NMC) dynamically generates web pages so that the latest information is presented to the user. A number of discipline and project pages are also based on information derived from NIMS or utilize the NMC to generate such information. The counts of new records are also detailed, but because of routine database maintenance do not exactly predict the totals from year to year.

Partition	Records	Records Added
Spacecraft	7,393	155
Experiment	5,547	73
Data Collection	6,643	45
Total	19,583	273

Table 10: NIMS database statistics for 2015. Also of note: Spacecraft with experiments (1,099); Experiments with collections (1,677); Data collections associated with only spacecraft, not experiments (819); and, Data collections not associated with spacecraft/experiments (535).

PDS4 Support

NSSDCA staff continued to work toward a model for archiving data in PDS4 form. Staff met periodically, mostly via teleconference, with PDS Engineering node personnel to resolve a number of technical issues with data to be submitted to the deep archive. This process has been iterative but is expected to be resolved early within the next calendar year.

Meanwhile, staff continued to define requirements and develop designs for software as well as a provisional data model for the identification and archive of PDS4 data. A prototype database to support analysis and requirements definition for the ingest of PDS4 data was deployed and a process flow for ingesting such products that avoids multiple transfers of the same product was developed.

SPASE Data Model and Virtual Observatories (VOs)

NSSDCA staff has been involved in the Heliophysics Data and Model Consortium for many years. This organization, composed of a wide representation of the Heliophysics data holding and archiving community, is attempting to unify and facilitate access to Heliophysics data for the research community. A key aspect of this work is the development of a common data description model named the Space Physics Archive Search and Extract (SPASE) Data Model. NSSDCA staff has been involved with it since it was proposed in 1998, providing coordination of the development of the SPASE Data Model.

The latest version (2.2.6) of the SPASE Data Model was released 09 September 2015. The basic model has been stable for more than a year. Work on SPASE continues, however, with a goal toward extending the data model to support modeling and simulation data through an API Reference Implementation Subgroup. Version 1.0.0 of the Simulation extension was released on 30 July 2015. Finally, near the end of 2015 the Australian Space Weather Service (ASWS) decided to adopt SPASE as a format for describing their data. For more information on the model, see <http://www.spase-group.org/>.

Data Recovery Support

NSSDCA continued to support an effort to recover the time-ordered data (TOD) from the Diffuse Infrared Background Experiment (DIRBE) instrument on the Cosmic Background Explorer (COBE) mission. Additional magnetic tapes were read and two data products were recovered as a consequence. First, the last processing run of the cold-era TOD was recovered in total. Second, a subset of the warm-era data (obtained after COBE's cryogen supply was exhausted) was also identified and recovered. At the end of 2015 some additional tapes with COBE DIRBE data on them were identified and will be reviewed in an attempt to recover the remainder of the warm-era data.

Consultative Committee for Space Science Data Systems (CCSDS)

NSSDCA previously provided the lead for the Data Archive Ingest (DAI) Working Group (WG) within the Consultative Committee for Space Data Systems (CCSDS) and also the deputy chair of the Repository Audit and Certification (RAC) WG, but due to funding limitations NSSDCA participation in these committees was reduced and transferred to an outside consultant. The remaining effort was concentrated within the Data Archive Ingest group, which has been finalizing the Producer Archive Interface Specification (PAIS). PAIS provides a way to capture the logical model and internal associations for a data collection using Collection and Transfer Object descriptors, which specify occurrences and sizes of transfer objects. The reader is referred to <http://www.ccsds.org/> for more specifics on the CCSDS activities.

Solar System Exploration and Integration

NSSDCA staff supported solar system education through community talks, social media offerings, conference presentations, undergraduate curriculum offerings, K-12 educational programs, and participation in existing NASA education efforts. Highlights included "Small Worlds Week", a social media program highlighting the New Horizons Pluto encounter, and reaching 1.5 million through social media conversations with planetary scientists from around the country. In addition, staff supported the White House in planning for the October 19 White House Astronomy Night, collaborated on robotic observatories for education, developed planetary observing challenges, and gave numerous talks and trainings on planetary science.

Other Staff Projects

NSSDCA staff was also involved in the coordination of the Radio Jove program that enables students, informal education groups, and other interested individuals to learn about radio astronomy by building their own radio telescope for observing radio emissions from the Sun, Jupiter, the galaxy and the Earth itself. More than 2,000 kits have been distributed by the project worldwide and amateur radio observers continue to contribute the results of their observations through email to a general distribution list as well as to a general archive of observations. In 2015 several Radio Jove project activities were included in the Planetary Plasma Interactions (PPI) node proposal to the PDS and in the Heliophysics Education Consortium proposal to the NASA Science Mission Directorate Science Education Cooperative Agreement Notice. Both proposals were funded. The activities resulting from the funding include archiving of Radio Jove data at the PPI node and also at the Paris Astronomical Data Center (PADC). There are also plans to supplement standard Radio Jove single-frequency observations with several multi-frequency spectrographs and to use this network to provide ground-based data for augmenting the Juno mission's study of Jovian radio emission.

Staff continues to analyze Jupiter decametric radio emission data, both professional and amateur, to better understand the characteristics of the emission mechanism. Drs. Masafumi and Kazumasa Imai are working with the Radio Jove staff to analyze Jovian short duration bursts (S-bursts) and determine the effects of the plasma environment along the ray path to the observer on the S-Bursts received by different observers.

Glossary

AIP	Archive Information Package
ASWS	Australian Space Weather Service
CCSDS	Consultative Committee for Space Data Systems
COBE	Cosmic Background Explorer
DAI	Data Archive Ingest
DIRBE	Diffuse Infrared Background Experiment
DLT	Digital Linear Tape
DVD	Digital Versatile Disk (originally, V = video)
ESDIS	Earth Science Data and Information System
GB	Gigabyte
GCMS	Gas Chromatograph Mass Spectrometer
GSFC	Goddard Space Flight Center
HEASARC	High Energy Astrophysics Science Archive Research Center
ISO	International Organization for Standardization
LADEE	Lunar Atmosphere and Dust Environment Explorer
LROC	Lunar Reconnaissance Orbiter Camera
LTO	Linear Tape-Open [i.e. open standard]
MOU	Memorandum of Understanding
NAIF	Navigation and Ancillary Information Facility
NIMS	NSSDCA Information Management System
NMC	NSSDCA Master Catalog
NSSDCA	NASA Space Science Data Coordinated Archive
OAIS	Open Archival Information System
PADC	Paris Astronomical Data Center
PAIS	Producer Archive Interface Specification
PDS	Planetary Data System
PPI	Planetary Plasma Interactions
PSI	Planetary Science Institute (PDS Asteroid/Dust Subnode)
RAC	Repository Audit and Certification
RHESSI	Reuven Ramaty High Energy Solar Spectroscopic Imager
SAM	Sample Analysis at Mars
SPASE	Space Physics Archive Search & Extract
SPDF	Space Physics Data Facility
TB	Terabyte
TOD	Time Ordered Data
TWINS	Two Wide-angle Imaging Neutral-atom Spectrometers
VO	Virtual Observatory
WG	Working Group
WORM	Write-Once, Read-Many