CDDIS 2000 Global Data Center Report

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1 Introduction

The Crustal Dynamics Data Information System (CDDIS) has supported the International GPS Service (IGS) as a global data center since 1992. The CDDIS activities within the IGS during 2000 are summarized below; this report also includes any changes or enhancements made to the CDDIS during the past year. General CDDIS background and system information can be found in the CDDIS data center summary included in the *IGS 1994 Annual Report* (Noll, 1995) as well as the subsequent updates (Noll, 1996, Noll, 1997, Noll, 1998, Noll, 1999, and Noll, 2001).

2 System Description

The CDDIS archive of IGS data and products are accessible worldwide through anonymous ftp. The CDDIS is located at NASA's Goddard Space Flight Center (GSFC) and is accessible to users 24 hours per day, seven days per week.

2.1 Computer Architecture

The CDDIS is operational on a dedicated Compaq AlphaServer 4000 running the UNIX operating system. All GPS data and product files are archived in a single filesystem, accessible through anonymous ftp, and are stored in UNIX compressed format. At present, nearly 100 Gbytes of on-line magnetic disk space is devoted to the storage of daily GPS tracking data and products.

The CDDIS staff continues to archive older GPS data, not currently on-line, to CD-ROM for eventual access through a 600-platter CD-ROM jukebox. Thus far, GPS data from 1992 through 1999 have been archived to CD, at least one week per CD. These data are migrated from magneto-optical disks (in VAX/VMS format) to the UNIX system where a CD-ROM image is created. After mounting the resulting CDs in the jukebox, users can access the data contained on these CDs in a transparent fashion, i.e., the jukebox software creates a filesystem similar to on-line magnetic disk filesystems.

3 Archive Content

As a global data center for the IGS, the CDDIS is responsible for archiving and providing access to both GPS data from the global IGS network as well as the products derived from the analyses of these data.

3.1 GPS Tracking Data

The GPS user community has access to the on-line and near-line archive of GPS data available through the global archives of the IGS. Operational and regional data centers provide the interface to the network of GPS receivers for the IGS global data centers. The following operational or regional data centers make data available to the CDDIS from selected receivers on a daily (and sometimes hourly) basis:

> Australian Survey and Land Information Group (AUSLIG) in Belconnen, Australia
> Alfred Wegener Institute (AWI) for Polar and Marine Research in Bremerhaven, Germany
> Bundesamt für Kartographie und Geodäsie (BKG) in Frankfurt, Germany
> Chinese Academy of Surveying and Mapping (CASM) in Beijing, China
> Centre National d'Etudes Spatiales (CNES), France
> Deutsches Geodätisches ForschungsInstitut (DGFI) in Munich, Germany
> European Space Operations Centre (ESOC) in Darmstadt, Germany
> GeoforschungsZentrum (GFZ) in Potsdam, Germany
> Geographical Survey Institute (GSI) in Tsukuba, Japan
> Jet Propulsion Laboratory (JPL) in Pasadena, California
> Korean Astronomy Observatory (KAO) in Taejeon, Korea
> National Geography Institute (NGI) in Suwon-shi, Korea
> National Imagery and Mapping Agency (NIMA) in St. Louis, Missouri
> NOAA's Geosciences Laboratory (NOAA/GL) Operational Data Center (GODC) in Rockville, Maryland
> Natural Resources of Canada (NRCan) in Ottawa, Canada
> Pacific Geoscience Centre (PGC), NRCan in Sidney, Canada
> Regional GPS Data Acquisition and Analysis Center on Northern Eurasia (RDAAC) in Moscow, Russia
> University NAVSTAR Consortium (UNAVCO) in Boulder, Colorado
> United States Geological Survey (USGS) in Reston, Virginia

In addition, the CDDIS accesses the other two IGS global data centers, Scripps Institution of Oceanography (SIO) in La Jolla California and the Institut Géographique National (IGN) in Paris France, to retrieve (or receive) data holdings not routinely transmitted to the CDDIS by an operational or regional data center. Table 1 lists the data sources and their respective sites that were transferred daily to the CDDIS in 2000. Over 62K station days from 199 distinct GPS receivers were archived at the CDDIS during the past year; a complete list of these sites can be found at URL *ftp://cddisa.gsfc.nasa.gov/pub/reports/gpsdata/cddis_summary.2000*.

3.1.1 Daily GPS Data Files

Once the daily RINEX data files arrive at the CDDIS, these data are quality-checked, summarized, and archived to public disk areas in daily subdirectories; the summary and inventory information are also loaded into an on-line data base.

The CDDIS daily GPS tracking archive consists of observation, navigation, and meteorological data, all in compressed (UNIX compression) RINEX format. Furthermore, summaries of the observation files are generated by the UNAVCO quality-checking program

Table 1: Sources of GPS data transferred to the CDDIS in 2000

Source	Sites								No. Sites
AUSLIG	ALIC KARR	CAS1 MAC1	CEDU MAW1	COCO STR1	DARW *TID1*	DAV1 TOW2	HOB2 *YAR2*	JAB1	15
AWI	GOUG	VESL							2
BKG	EBRE	HOFN*	NVSK	*ORID*	TUBI	UZHL	WTZT	*YEBE**	8
CASM	BJFS^m								1
CNES	GRAS	HARB	KERG	*NKLG*	THTI				5
DGFI	BRAZ								1
ESA	KIRU*	KOUR*	MALI	MAS1*	PERT*	VILL*			6
GFZ	KIT3^m ZWEN*^{m}	KSTU	LPGS	OBER*	POTS*^{m}	RIOG*	*UNSA**	URUM^m	9
GSI	SYOG	TSKB							2
IGN	ANKR HERS*^{m} (KSTU) NOUM (THTI)	BOR1* (HOFN*) LHAS^m NTUS TRO1	BRUS*^{m} IRKT (LPGS) NYA1 TROM	(EBRE) JOZE (MAS1) NYAL WSRT	GLSV (KERG) MATE*^{m} OHIG WTZR*^{m}	(GRAS) (KIRU) MDVO ONSA* ZECK	GRAZ^m (KIT3) METS^m (POTS) ZIMM*^{m}	(HARK/B) KOSG NICO REYK*^{m} (ZWEN^m)	27 (40)
JPL	AOA1* CRO1* GUAM* KWJ1* PIE1* SUTH*	AREQ* DGAR HARV* MAD2* PIMO* THU1	ASC1 EISL* HRAO* MADR* QUIN* TID2*	AUCK*^{m} FAIR*^{m} IISC MCM4* RBAY* TIDB*	CASA GALA* JPLM* MDO1*^{m} (RIOP) USUD*	CHAT^m GODE* KOKB*^{m} MKEA* SANT* YAR1	CIC1* GOL2* KRAK NLIB* SEY1	CORD* GOLD* (KUNM) NSSP* SHAO	44 (45)
KAO	DAEJ								1
NGI	SUWN								1
NIMA	BAHR^m								1
NOAA/GL	AMC2 *GUAT** *TEGU**	AOML^m HNPT USNA	BARB JAMA USNO^m	BARH* KELY WES2^m	BRMU *MANA** WUHN	EPRT* *SLOR*	*ESTI** SOL1^m	FORT *SSIA**	21
NRCan	(ALBH^m) (NANO) (WILL)	ALGO*^{m} NRC1*^{m} (WSLR)	CHUR*^{m} NRC2* YELL*^{m}	(CHWK) PRDS*^{m}	(DRAO*) SCH2*^{m}	(DUBO) STJO*^{m}	(FLIN) (UCLU)	(HOLB) (WHIT)	8 (19)
PGC	ALBH*^{m} WHIT*	CHWK WILL	DRAO*^{m} WSLR	DUBO	FLIN	HOLB	NANO	UCLU	11
RDAAC	ARTU YSSK	BILI	MAG0	*NRIL*	PETP^m	TIXI	YAKA	YAKZ	9
SIO	AMMN RAMO	BAKO SIO3^m	*DRAG* VNDP^m	INEG^m	*KODK*	MONP	PIN1	PVEP/3	11
UNAVCO	CHUM RIOP	KAYT SELE	KAZA SHAS	KUMT SUMK	KUNM TALA	NSSP TVST	*PODG*	POL2	14
USGS	AMUN	PALM							2
Totals:				199 sites from 21 data centers during 2000					

Notes: Sites in () indicate backup delivery route
Sites in *italics* indicate sites new to the CDDIS in 2000
* Indicates site also providing hourly data to the CDDIS in 2000
^{m} Indicates site providing meteorological data to the CDDIS in 2000

TEQC (Estey 1999) and are used for data inventory and quality reporting purposes. During 2000, the CDDIS archived data on a daily basis from an average of 170 stations. Each site produces approximately 0.8 Mbytes of data per day (compressed RINEX, compressed compact RINEX, navigation, meteorological, and summary); thus, one day's worth of GPS tracking data totals nearly 130 Mbytes. Although the "compact RINEX" data format is the operational format for exchange of GPS data between the IGS and analysis centers, the CDDIS continues to archive and make data available in the compressed RINEX format for use by the general user

community. In 2000, the CDDIS GPS data archive totaled over 50 Gbytes in volume; this figure represents data from nearly 62K observation days. Of the 170 or more sites archived each day at the CDDIS, not all are of "global" interest; some, such as those in Southern California, are regionally oriented. The CDDIS receives data from these sites as part of its NASA archiving responsibilities.

The ephemeris data files for a given day are decompressed and then merged into a single file that contains the orbit information for all GPS satellites for the day. This daily ephemeris data file, named *brdcddd0.yyn.Z* (where *ddd* is the day of year and *yy* is the year), is then copied to the ephemeris subdirectory as well as a general directory of all merged ephemeris files (*/gps/gpsdata/brdc*). Users can thus download this single daily file instead of all broadcast ephemeris files from the individual stations.

At this time, the CDDIS on-line archive of daily GPS data contains data from January 1998 through the present. Prior to early 2001, these data are available in compact RINEX only; later data are archived in both compact RINEX and uncompacted RINEX formats. As the disks supporting this archive fill up, older uncompact RINEX observation data are deleted. The CD-ROM jukebox contains GPS data from 1992 through 1997; it is hoped the software interface to this device will be operational in mid-2001.

The majority of the data delivered to and archived in the CDDIS during 2000 was available to the user community within six hours after the observation day. As shown in Figure 1, nearly fifty percent of the data from the global sites delivered to the CDDIS were available within three hours of the end of the observation day; over twenty percent were available within one hour. These statistics were derived from the results of the daily archive report utilities developed by the IGS Central Bureau and executed several times each day on the CDDIS.

3.1.2 Hourly GPS Data Files

By the end of 2000, seven operational/regional data centers (BKG, ESOC, JPL, NOAA, GFZ, PGC, and NRCan) were transmitting hourly data files to the global data centers. Each file of observation (in compact RINEX format only), navigation, and meteorological data contains a single hour's worth of thirty-second data. These individual hourly files are labeled by incrementing the sequence number digit in the RINEX file naming convention; e.g., the file *mmmmddd*a.*yy*o.Z contains the observation data for the first hour of day *ddd* (or the first file transmitted for day *ddd*) in year *yy* for site *mmmm*. Within minutes of receipt, the files are archived to separate subdirectories (*/gps/nrtdata*) by day and hour on the CDDIS. These data are retained on-line for three days. After that time, the hourly data files are deleted; the daily file, transmitted through normal channels with a typical delay of one to two hours, will have been received and archived already and thus the hourly data are of little use. Furthermore, to ensure the most rapid delivery of these data to the user community, no validation or checks on data quality are performed. As shown in Figure 2, in 2000, fifty percent of these hourly data files were available to the user community within 15 minutes of the end of the hour; nearly eight-five percent were available within thirty minutes. GPS sites supplying hourly data to the CDDIS in 2000 are denoted by an * in Table 1; over seventy sites transmitted hourly data files to the global data centers in 2000.
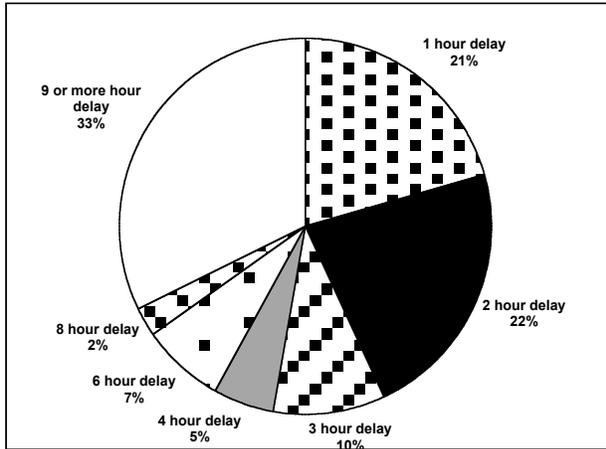
Figure 1: **Average delay in delivery of GPS daily data files to the CDDIS in 2000**
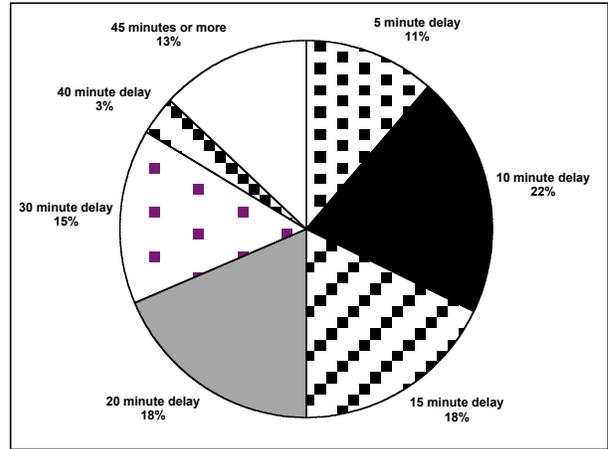
Figure 2: Average delay in delivery of GPS hourly data files to the CDDIS in 2000

3.2 Meteorological Data

The CDDIS currently receives meteorological data from over thirty sites, as noted in Table 1. The meteorological data provided are dry temperature, relative humidity, and barometric pressure at thirty minute sampling intervals. These data are stored on CDDIS with the daily GPS observation and navigation data files in parallel subdirectories.

3.3 IGS Products

The seven IGS data analysis centers (ACs) retrieve the GPS tracking data on a daily basis from the global data centers to produce daily orbit and clock products as well as weekly Earth rotation parameters (ERPs) and station position solutions; the seven IGS associate analysis centers (AACs) also retrieve IGS data and products to produce station position solutions. The CDDIS archives the products generated by both types of IGS analysis centers. These files are delivered to the CDDIS by the IGS analysis centers to individual user accounts, copied to the central disk archive, and made available in compressed format on the CDDIS by automated routines that execute several times per day. The IGS Analysis Coordinator then accesses the CDDIS (or one of the other global analysis centers) on a regular basis to retrieve these products and derive the combined IGS orbits, clock corrections, and Earth rotation parameters as well as to generate reports on data quality and statistics on product comparisons. Users interested in obtaining precision orbits for use in general surveys and regional experiments can also download the IGS products. The CDDIS currently provides on-line access through anonymous ftp or the web to all IGS products generated since the start of the IGS Test Campaign in June 1992.

Regional Network Associate Analysis Centers (RNAACs) routinely generate station position solutions for regional networks in Software INdependent EXchange (SINEX) format. The three Global Network AACs (GNAACs) perform a comparison of these files and submit the resulting SINEX files to the CDDIS. The GNAACs also access the SINEX files from the IGS ACs and RNAACs and produced comparison and combined, polyhedron station position solutions. The CDDIS provides "short-SINEX" files, designated with an *.ssc* extension, for all AC and AAC SINEX files. These files contain the site information from the SINEX file but no matrices. All RNAAC solution files are also stored in the weekly IGS product subdirectories. The official IGS

combined weekly SINEX solutions and cumulative combined SINEX solutions generated by the IGS Reference Frame Coordinator are also available in the weekly IGS product subdirectories.

Both the rapid (designated IGR) and the predicted orbit, clock and ERP (designated IGP) combined products generated by the IGS Analysis Coordinator continued to be available through 2000. Furthermore, a new product, the IGS ultra-rapid combination (designated IGU) were made available twice daily (at 03:00 and 15:00 UTC) starting in September 2000 (GPS week 1080). The IGS global data centers, including the CDDIS, download the rapid, predicted, and ultra-rapid products from the Analysis Coordinator and made them available in a timely fashion to ensure their usefulness to the user community.

Since January 1997, the IGS has conducted a pilot experiment on the combination of troposphere estimates. Using a sampling rate of two hours, the zenith path delay (ZPD) estimates generated by the IGS analysis centers were combined by GFZ to form weekly ZPD files for approximately 150 global GPS sites. As of early 1998, these troposphere products are available through the IGS global data centers; at the CDDIS the files are in a subdirectory of the weekly GPS products directories (i.e., */gps/products/wwww/trop,* where *wwww* is the GPS week number).

As of June 1, 1998, several IGS Analysis Centers began supplying daily, global ionosphere maps of total electron content (TEC) in the form of IONEX (an official format for the exchange of ionosphere maps) files. These products are also available from the IGS global data centers. At the CDDIS, the IONEX files are located in daily subdirectories of the main product area (e.g., */gps/products/ionex/yyyy* where *yyyy* is the four-digit year), rather than under the weekly subdirectory structure, since the files are produced daily.

3.4 Supporting Information

Daily status files of GPS data holdings, reflecting timeliness of the data delivered as well as statistics on number of data points, cycle slips, and multipath continue to be generated by the CDDIS. By accessing these files, the user community can receive a quick look at a day's data availability and quality by viewing a single file. The daily status files are available through the web at URL *ftp://cddisa.gsfc.nasa.gov/pub/reports/gpsstatus/*. The daily status files are also archived in the daily GPS data directories.

Ancillary information to aid in the use of GPS data and products are also accessible through the CDDIS. Weekly and yearly summaries of IGS tracking data archived at the CDDIS are generated on a routine basis and distributed to the IGS user community through IGS Report mailings. These summaries are accessible through the web at URL *ftp://cddisa.gsfc.nasa.gov/pub/reports/gpsdata*. The CDDIS also maintains an archive of and indices to IGS Mail, Report, and Network messages.

4 GLONASS Data and Products

In early 2000, the IGS Governing Board approved the International GLONASS Pilot Project (IGLOS-PP) as a formal working group within the service. The CDDIS proposed to continue its role as a global data center for GLONASS data and products to the IGLOS-PP Call for Participation issued in 2000. The CDDIS archived GLONASS data from over forty sites totaling nearly 10K station days of data; the data centers and sites active during 2000 are shown in Table 2. GLONASS products from four analysis centers (BKG, CODE, ESA, and MCC) as well as

the Analysis Coordinator (at the Technical University of Vienna) were also made available to the public. GLONASS data and products are accessible via anonymous ftp to host *cddisa.gsfc.nasa.gov*, in the filesystem */igex*. At present, the CDDIS continues to archive both GLONASS data and products in a filesystem separate from IGS data and products.

Table 2: Sources of GLONASS data transferred to the CDDIS in 2000

Source	Sites								No. Sites
AUSLIG	*DARR*	DAVR	LINR	*STR2*	YARR				5
BKG	BORG	BRUG	DLFT	*GJOV*	GOPE	GRAB	HERP	KR0G	22
	LHAZ	METZ	MR6G	MTBG	OS0G	REYZ	THU2	*TIGZ*	
	VS0G	VSLD	*WROC*	WTZZ	ZIMJ	ZIMZ			
CSIR	CSIR								1
DLR	NTZ1								1
DNR	SUNM								1
ENRI	MTKA								1
GSFC	GODZ								1
GSI	TSKA								1
D. Hogarth	*DWH1*ᵐ								1
IGN	BIPD	GRAC	REUN						3
IMVP	IRKZ	KHAB							2
NPL	NPLC/*E*								1
UFI	GATR								1
USGS	CRAR								1
USNO	USNX								1
Totals:				43 sites from 15 data centers during 2000					

Notes: Sites in *italics* indicate sites new to the CDDIS in 2000
ᵐ Indicates site providing meteorological data to the CDDIS in 2000

4 System Usage

Figures 3 through 5 summarize the monthly usage of the CDDIS for the retrieval of GPS and GLONASS data and products for February through December 2000. Figure 3 illustrates the amount of GPS data retrieved by the user community during 2000. Over fourteen million files were transferred in 2000, with an average of 1.3 million files per month. The chart in Figure 4 shows the number of product files retrieved from the CDDIS in 2000; these files are categorized by type, the orbit, clock, ERP, and SINEX product files, ionosphere product files, and troposphere product files. Figure 5 shows the amount of GLONASS data and products retrieved from the CDDIS in 2000. Figures 6 and 7 illustrate the profile of users accessing the CDDIS IGS archive during 2000. Most accesses were through network gateways that did not yield sufficient information about the user. Both education and government users constituted the next largest user category of CDDIS users of GPS data and products.   Figure 7 displays the usage information by geographic region; the majority of CDDIS users are from hosts in North America.

The figures referenced above present statistics for routine access of the on-line CDDIS GPS data archives. The CDDIS staff continues to satisfy special requests from the user community for data from the off-line archive as well as field routine questions about the system and the IGS in general. Table 3 summarizes the type and amount of special requests directed to the CDDIS staff during 2000. To satisfy requests for off-line data, the CDDIS staff must copy data from the optical disk archive to an on-line magnetic disk area. As CD-ROMs of older data become available through the on-line jukebox this process will become easier for both the user and the CDDIS staff.
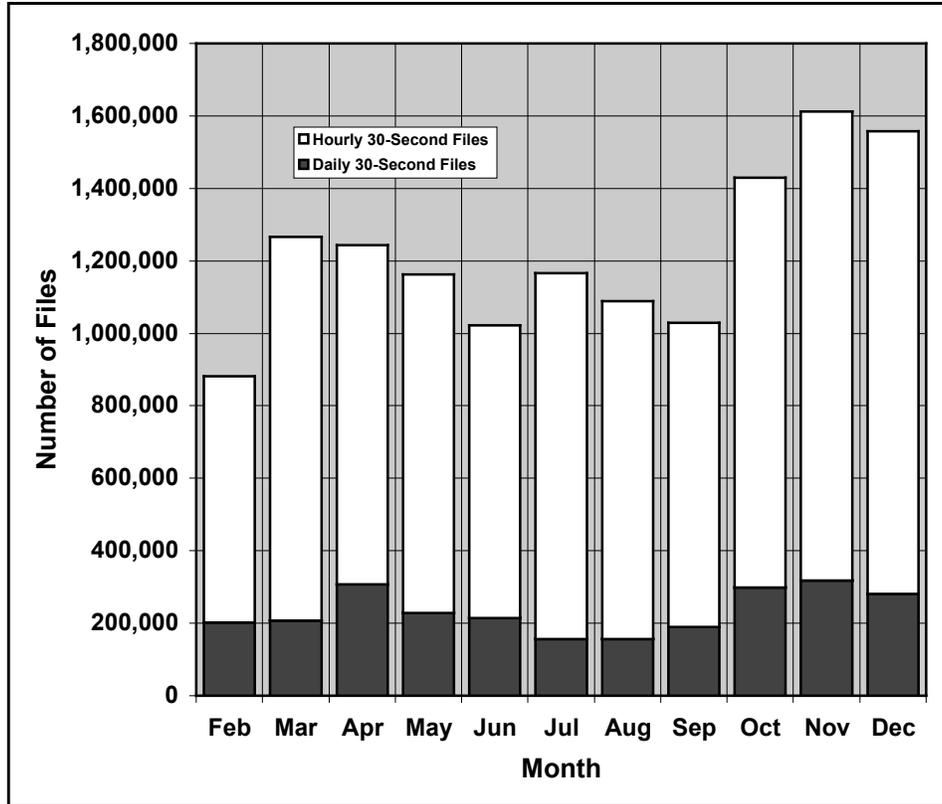
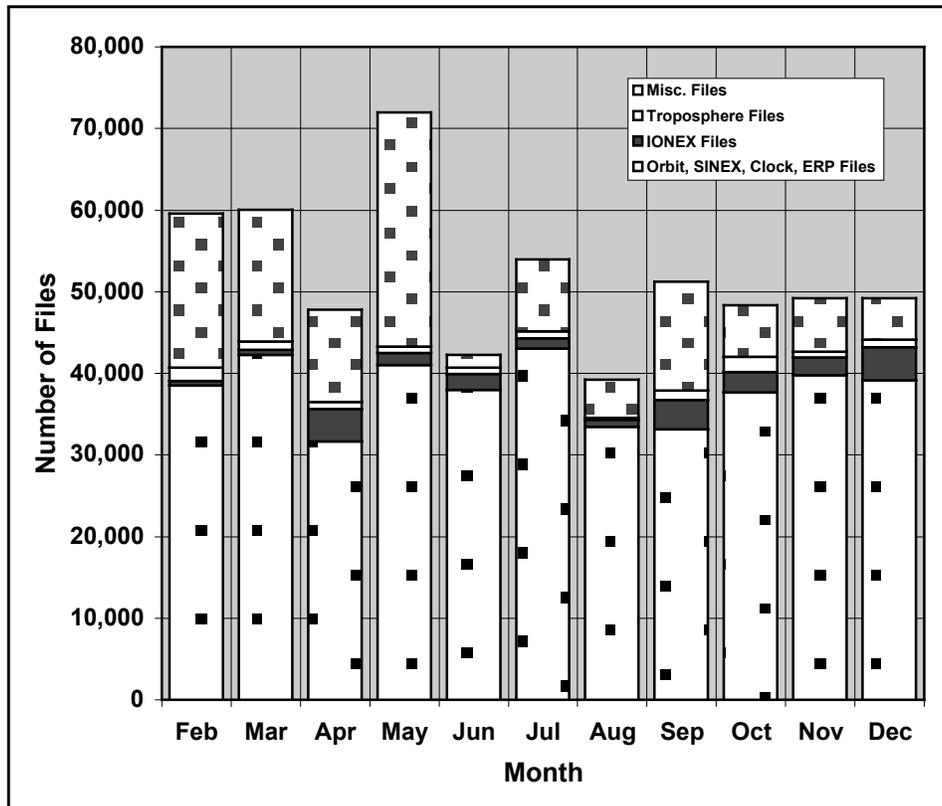**Figure 3: Number of GPS data files transferred from the CDDIS in 2000**

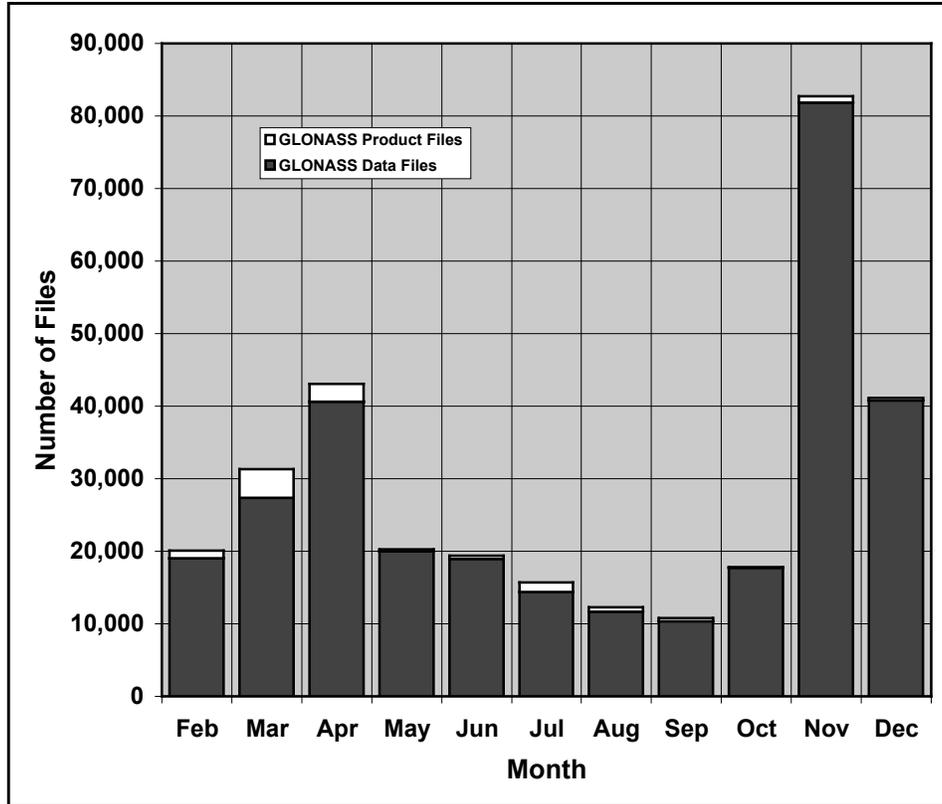**Figure 4: Number of GPS product files transferred from the CDDIS in 2000**

Figure 5: Number of GLONASS data and product files transferred from the CDDIS in 2000
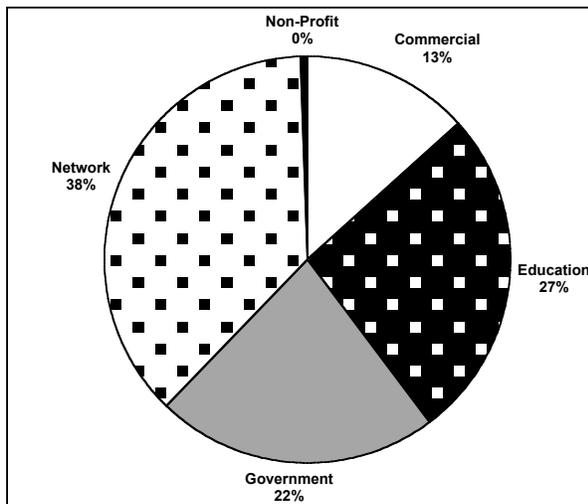

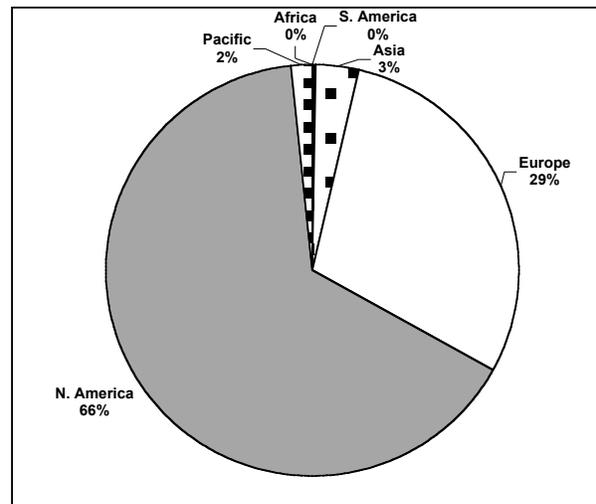
Figure 6: Distribution of IGS users of the CDDIS in 2000

Figure 7: Geographic distribution of IGS users of the CDDIS in 2000

Table 3:   Summary of special requests for GPS data and information in 2000

Type of Request	Totals
General IGS/CDDIS information	~160 requests (phone, fax, e-mail)
Off-line GPS data	~25 requests (phone, fax, e-mail)
Amount of off-line data requested	~10,000 station days†
Volume of off-line data requested	~7.5 Gbytes

Notes: †In this context, a station day is defined as one day's worth of GPS data (observation and navigation file in RINEX format)

5 Other Activities

The CDDIS staff assisted in the preparation and editing of the proceedings from the 1999 IGEX Workshop.

6 Publications

The CDDIS staff attended several conferences during 2000 and presented papers on or conducted demos of their activities within the IGS, including:

"1999 IGS Data Center Reports" (Carey Noll) for 1999 IGS Annual Report (submitted in 2000, to be published in 2001)

"CDDIS 1999 Global Data Center Report" (Carey Noll) for 1999 IGS Technical Report (submitted in 2000, to be published in 2001)

"Current Status of and Backup Plans for Flow of IGS Data and Products" (Carey Noll) was presented at the IGS Network Workshop in July 2000

"The IGS Global Data Center at the CDDIS – An Update" (Carey Noll and Maurice Dube) was presented at the IGS Network Workshop in July 2000

"IGS Data Centers" (Carey Noll) was presented as part of the IGS Forum during the ION GPS 2000 Meeting in September 2000

Electronic versions of these and other publications can be accessed through the CDDIS on-line documentation page on the web at URL *http://cddisa.gsfc.nasa.gov/reports.html*.

7 Future Plans

7.1 Computer System Enhancements

The AlphaServer 4000 computer supporting the CDDIS has been operational for over three years. Additional RAID disk space will be procured in 2001, as well as a dedicated tape backup system.

7.2 Changes in the Data Archive

In early 2000, the IGS Governing Board approved the International GLONASS Pilot Project (IGLOS-PP) as a formal working group within the service. The IGLOS-PP committee issued a Call for Participation in early 2000. Later that year, the steering committee, in conjunction with representatives of various IGS components, developed recommendations for incorporating the

flow of GLONASS data and the generation of official products into the existing IGS infrastructure. Plans are to complete this transition in mid-2001.

In 2000, the CDDIS proposed to serve as a data center supporting the IGS Pilot Project for Low Earth Orbiting (LEO) Missions. The GPS products required by these missions require one second GPS data on an hourly basis. The CDDIS will begin the archive and distribution of one-second data, stored in files containing fifteen minutes of data, from a network of thirty to forty sites during the mid-2001 timeframe. The CDDIS will also become involved in the archive of space-borne GPS receiver data. A pilot program for the use of this flight data will begin operation in 2001.

8 Contact Information

To obtain more information about the CDDIS IGS archive of data and products, contact:

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NASA GSFC	WWW:	*http://cddisa.gsfc.nasa.gov/cddis_welcome.html*
Greenbelt, MD 20771		

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10 References

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