CDDIS Global Data Center Report

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1 Introduction

The Crustal Dynamics Data Information System (CDDIS) has supported the International GPS Service for Geodynamics (IGS) as a global data center since 1992. The CDDIS activities within the IGS during 1997 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 and Noll, 1997).

2 System Description

The CDDIS archive of IGS data and products are accessible worldwide by way of a password-protected user account. New users can contact the CDDIS staff to obtain the required username and password, as well as general instructions on the host computer, directory structure, and data availability.

2.1 Computer Architecture

During 1997, the CDDIS was operational on a dedicated Digital Equipment Corporation (DEC) VAX 4000 Model 200 running the VMS operating system. 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. The CDDIS is available to users globally through electronic networks using TCP/IP (Transmission Control Protocol/Internet Protocol) and DECnet (VAX/VMS networking protocol) and through dial-in service.

At this time, two magnetic disk drives, totaling 6.4 Gbytes in volume, are devoted to the storage of the daily GPS tracking data. A dual-drive, rewriteable optical disk system provides additional on-line disk storage for GPS data as well as the long-term archive medium for GPS data on the CDDIS. With the current nearly 120 station network, only three days of GPS tracking data can be stored on a single side of one of these platters. The older data continues to be stored on these optical disks and can easily be requested for mounting and downloading remotely by the user. Alternatively, if the request for older data is relatively small, data are downloaded to magnetic disk, providing temporary on-line access. A 4.3 Gbyte magnetic disk drive is devoted to the on-line storage of IGS products, special requests, and supporting information.

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. For the CDDIS, the following operational or regional data centers make data available to the CDDIS from selected receivers on a daily basis:

- Australian Survey and Land Information Group (AUSLIG) in Belconnen, Australia
- European Space Agency (ESA) in Darmstadt, Germany
- GeoforschungsZentrum (GFZ) in Potsdam, Germany
- Geographical Survey Institute (GSI) in Tsukuba, Japan
- NOAA's Geosciences Laboratory (GL/NOAA) Operational Data Center (GODC) in Rockville, Maryland
- Korean Astronomy Observatory in Taejeon, Korea
- Jet Propulsion Laboratory (JPL) in Pasadena, California
- National Geography Institute in Suwon-shi, Korea
- National Imagery and Mapping Agency (NIMA), formerly Defense Mapping Agency (DMA), in St. Louis, Missouri
- Natural Resources of Canada (NRCan) in Ottawa, Canada
- University NAVSTAR Consortium (UNAVCO) in Boulder, Colorado

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 a regional data center. Table 1 lists the data sources and their respective sites that were transferred daily to the CDDIS in 1997. Nearly 42K station days from 146 distinct GPS receivers were archived at the CDDIS during 1997; a complete list of all archived sites can be found on the web site (`http://cddisa.gsfc.nasa.gov/reports/gpsdata/cddis_summary.1997`).

Once they 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. Typically, the archiving routines on the CDDIS are executed several times a day for each source in order to coincide with their automated delivery processes and to ensure timely arrival in the CDDIS public disk areas. In general, the procedures for archiving the GPS tracking data are fully automated, requiring occasional monitoring only, for replacement data sets or re-execution because of system or network problems.

The CDDIS 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 (QC) program and are used for data inventory and quality reporting purposes. During 1997, the CDDIS archived data on a daily basis from an average of 115 stations; toward the end of the year, this number increased to nearly 125 stations. Under the current 125 station network configuration, about 100 days worth of GPS data are available on-line to users at one time. Each site produces approximately 0.8 Mbytes of data per day; thus, one day's worth of GPS tracking data, including the summary and meteorological data files, totals nearly 100 Mbytes. For 1997, the CDDIS GPS data archive totaled over 35 Gbytes in volume; this figure represents data from nearly 42K observation days. Of the 125 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.

During 1997, tests were conducted to incorporate a "compact RINEX" into the IGS data flow. This software, developed by Hatanaka Yuki (GSI) and Werner Gurtner (AIUB), when used with UNIX compression, reduces the size of the RINEX data by approximately a factor of eight (as compared to approximately 2.5 with using UNIX compression alone). Tests were performed at various data center levels within the IGS, with the intent to use files in this format as the in exchange between data centers and analysis centers. The CDDIS continues, however, to archive and make data available in the compressed RINEX format for the greater user community.

The majority of the data delivered to and archived in the CDDIS during 1997 was available to the user community within 24 hours after the observation day. As shown in Figure 1, over forty

percent of the data from all sites delivered to the CDDIS were available within six hours of the end of the observation day; over fifty percent were available within eight hours. 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.

The CDDIS staff often receives requests from users for the daily broadcast ephemeris file (denoted `BRDCddd0.yyN_Z`). To reduce the amount of time spent on these requests by the CDDIS staff, a new disk area has been established (`GPS3:[GPSDATA.BRDC.yyyy]`) to store the historic BRDC files.

Table 1: Sources of GPS data transferred to the CDDIS in 1997

Source	Sites								No. Sites
AUSLIG	*CAS1*	*COCO*	*DAV1*	*HOB2*	*MAC1*				**5**
NOAA/GL	*AOML*	*BARB*	*BRMU*	*FORT*	*HNPT*	*KELY*	*RCM6*	*SOL1*	**12**
	USNA	*USNO*	*WES2*	*WUHN*					
NRCan	*ALBH*	*ALGO*	*CHUR*	*DRAO*	*DUBO*	*FLIN*	*NRC1*	*PRDS*	**12**
	SCH2	*STJO*	*WHIT*	*YELL*					
ESA	*KIRU*	*KOUR*	*MALI*	*MAS1*	*PERT*	*VILL*			**6**
GFZ	*KIT3*	*KSTU*	*LPGS*	*OBER*	*POTS*	*ZWEN*			**6**
GSI	*TAIW*	*TSKB*							**2**
IGN	*ANKR*	*BOR1*	*BRUS*	*EBRE*	*GRAS*	*GRAZ*	*HARK*	*HART*	**32**
	HERS	*HOFN*	*IRKT*	*JOZE*	*KERG*	*(KIRU)*	*(KIT3)*	*KOSG*	**(39)**
	(KSTU)	*LHAS*	*(LPGS)*	*(MAS1)*	*MATE*	*MDVO*	*METS*	*NTUS*	
	NYAL	*OHIG*	*ONSA*	*PAMA*	*(POTS)*	*REYK*	*TAHI*	*TROM*	
	WETT	*WSRT*	*WTZR*	*ZECK*	*ZIMM*	*(ZWEN)*			
JPL	*AOA1*	*AREQ*	*ASC1*	*AUCK*	*AZU1*	*BOGT*	*BRAZ*	*CARR*	**60**
	CASA	*CAT1*	*CHAT*	*CICE*	*CIT1*	*CRO1*	*CSN1*	*DGAR*	
	EISL	*FAIR*	*GALA*	*GODE*	*GOL2*	*GOLD*	*GUAM*	*HARV*	
	HRAO	*IISC*	*JPLM*	*KOKB*	*KRAK*	*KWJ1*	*LBCH*	*MAD2*	
	MADR	*MCM4*	*MDO1*	*MKEA*	*MOIN*	*NLIB*	*OAT2*	*PIE1*	
	POL2	*PPYN*	*QUIN*	*SANT*	*SELE*	*SEY1*	*SHAO*	*SNI1*	
	SPK1	*THU1*	*TID2*	*TIDB*	*UCLP*	*USC1*	*USUD*	*WHC1*	
	WHI1	*WLSN*	*XIAN*	*YAR1*					
KAO	*TAEJ*								**1**
NGI	*SUWN*								**1**
NIMA	*BAHR*								**1**
SIO	*MAG0*	*MONP*	*PETR*	*PIN1*	*PVEP*	*SIO3*	*VNDP*	*YAKA*	**9**
	YAKZ								
UNAVCO	*POL2*								**1**
Totals:						**146 sites from 13 data centers**			

Note: Sites in () indicate backup delivery route
Sites in italics indicate sites new to the CDDIS in 1997

3.2 IGS Products

The seven IGS data analysis centers (ACs) retrieve the GPS tracking data daily from the global data centers to produce daily orbit products and weekly Earth rotation parameters (ERPs) and station position solutions; the nine 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 a central disk archive, and made available in ASCII format (generally uncompressed) on the CDDIS by automated routines that execute several times per day. The Analysis Coordinator for the IGS, located at NRCan, 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 to all IGS products generated since the start of the IGS Test Campaign in June 1992. As of 1996, access to the on-line archive of CDDIS products can also be performed through the World Wide Web (WWW) as well as through ftp.

During 1996, Regional Network Associate Analysis Centers (RNAACs) began the generation and submission of station position solutions for regional networks in Software INdependent EXchange (SINEX) format. The three Global Network AACs (GNAACs) continued their comparison of these files during 1997 and submitted the resulting SINEX files to the CDDIS. The GNAACs accessed the SINEX files from the IGS ACs and RNAACs and produced comparison and combined, polyhedron station position solutions.

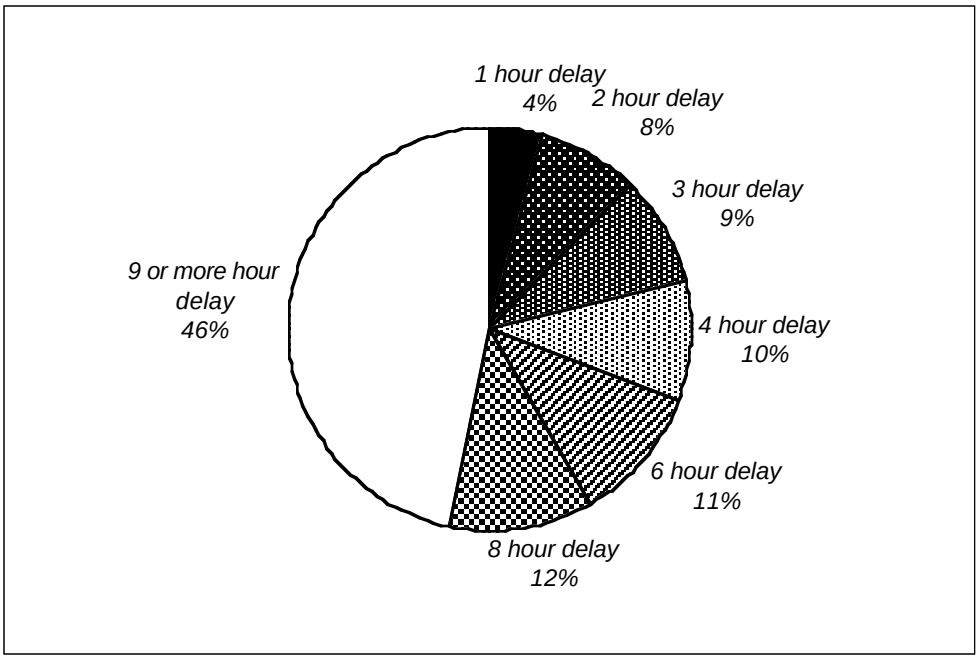

Figure 1: Median delay in GPS data delivery (all sites) to the CDDIS in 1997

The derived products from the IGS ACs are typically delivered to the CDDIS within seven days of the end of the observation week; delivery times for AAC products vary, but average 25 days for regional solutions. Figure 4 presents the median delay during 1997, in days and by source, of AC and AAC products delivered to the CDDIS. The statistics were computed based upon the arrival date of the solution summary file for the week. The time delay of the IGS products and the combined SINEX solutions are dependent upon the timeliness of the individual IGS analysis centers; on average, the combined orbit is generated within one to two days of receipt of data from all analysis centers and is typically available to the user community within ten days.

The rapid orbit and ERP products generated by the IGS Analysis Coordinator were also made available to the IGS global data centers starting in June 1996. These products are produced daily, within 24 hours UTC; automated procedures at the CDDIS download these files from NRCan in a timely fashion. Starting in early 1997, the IGS Analysis Center Coordinator began generating predicted orbit, clock, and Earth rotation parameter combinations based upon the individual ACs' predicted solutions. These solutions, designated IGP, are available within 0.5 hours of the beginning of the observation day.

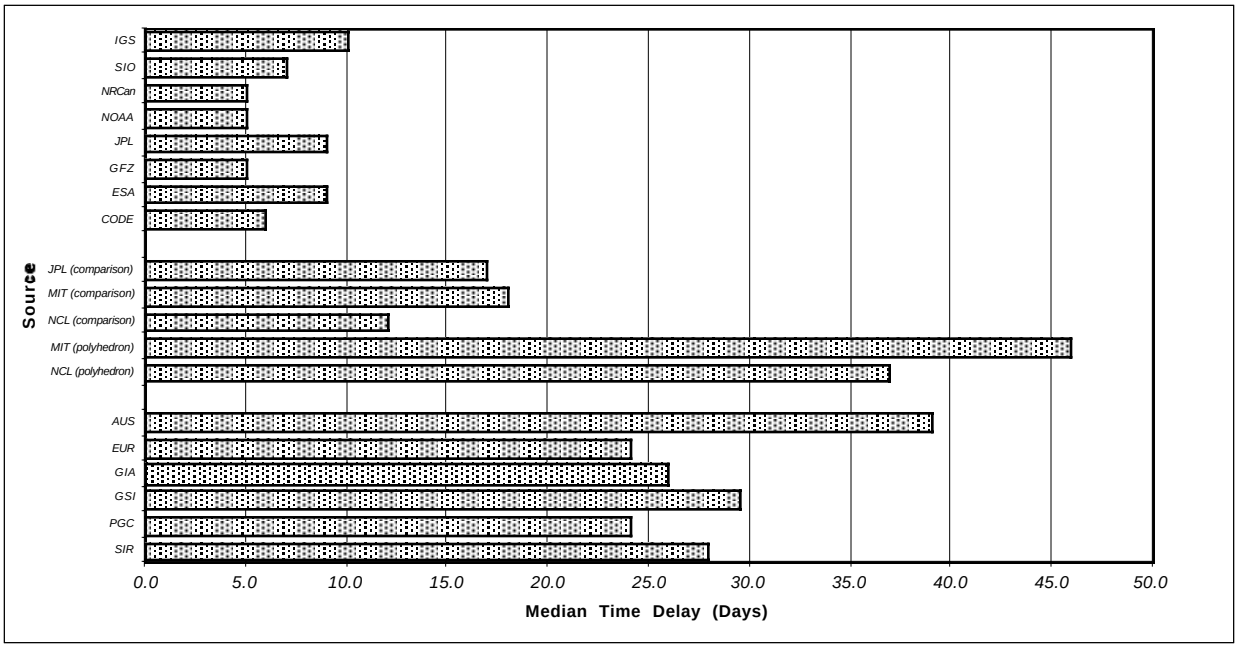

Figure 2: Median delay in GPS product delivery to the CDDIS (by source) in 1997

3.3 Meteorological Data

The CDDIS currently receives meteorological data from approximately twenty sites. In 1997, additional IGS sites began providing meteorological data from collocated sensors; these stations are: Albert Head, Ottawa, Priddis, St. John's, and Yellowknife Canada, Colorado Springs CO, McDonald TX, USNO Washington D.C., Zimmerwald Switzerland, and Zwenigorod Russia. 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.

3.4 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 downloading a single file. Furthermore, monthly summaries of the data quality for the IGS sites are also generated. Both the daily and monthly status files are available through the WWW at URL `http://cddisa.gsfc.nasa.gov/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 now accessible through the WWW at URL `http://cddisa.gsfc.nasa.gov/gpsdata/gpsdata_list.html`. The CDDIS also maintains an archive of and indices to IGS Mail, Report, and Network messages.

4 System Usage

Figures 3 through 5 summarize the monthly usage of the CDDIS for the deposit and retrieval of GPS data during 1997. These figures were produced daily by automated routines that peruse the

log files created by each network access of the CDDIS. Figure 3 illustrates the amount of data retrieved by the user community during 1997. Over one million files were transferred in 1997, totaling approximately 360 Gbytes in volume. Averaging these figures, users transferred 90K files per month, totaling nearly 30 Gbytes in size. The chart in Figure 4 details the total number of host accesses per month with the number of distinct (i.e., unique) hosts per month shown as an overlay. Here, a host access is defined as an initiation of an ftp session; this session may transfer a single file, or many files. Figure 5 illustrates the profile of users accessing the system during 1997; these figures represent the number of distinct hosts in a particular country or organization. Nearly two-thirds of the users of GPS data available from the CDDIS come from U.S. government agencies, universities, or corporations.

The figures referenced above present statistics for routine access of the on-line CDDIS GPS data archives. However, a significant amount of staff time is expended on fielding inquiries about the IGS and the CDDIS data archives as well as identifying and making data available from the off-line archives. Table 2 summarizes the type and amount of special requests directed to the CDDIS staff during 1997. 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, or for larger requests, mount the optical disks in a scheduled fashion, coordinating with the user as data are downloaded.

Table 2: Summary of special requests for GPS data and information in 1997

Type of Request	Totals
General IGS/CDDIS information	*~215 requests (phone, fax, e-mail)*
Off-line GPS data	*~130 requests (phone, fax, e-mail)*
Amount of off-line data requested	*~40,650 station days*[†]
Volume of off-line data requested	*~35 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 Publications

The CDDIS staff attended several conferences during 1997 and presented papers on or conducted demos of their activities within the IGS, including:

- "Flow of GPS Data and Products for the IGS" (Carey E. Noll) was presented at the Workshop on Methods for Monitoring Sea Level in March 1997
- "GIS and GPS Applications at the National Aeronautics and Space Administration" (Lola Olsen and Carey E. Noll) was presented at the Georesearch GPS/GIS '97 conference in May 1997

Hypertext versions of this and other publications can be accessed through the CDDIS on-line documentation page on the WWW at URL `http://cddisa.gsfc.nasa.gov/documents.html`.

6 Future Plans

6.1 Computer System Enhancements

Procurement of a replacement hardware platform for the CDDIS VAX system was undertaken in early 1997. This system will be a DEC AlphaServer 4000 running the UNIX operating system; the system will have over 120 Gbytes of on-line magnetic disk storage. A significant amount of the CDDIS staff time was spent during 1997 developing data processing and archiving routines for this new system. The staff hopes to have all GPS data activities transferred to the UNIX platform by mid-1998; the host name for this computer is `cddisa.gsfc.nasa.gov`. The CDDIS anonymous

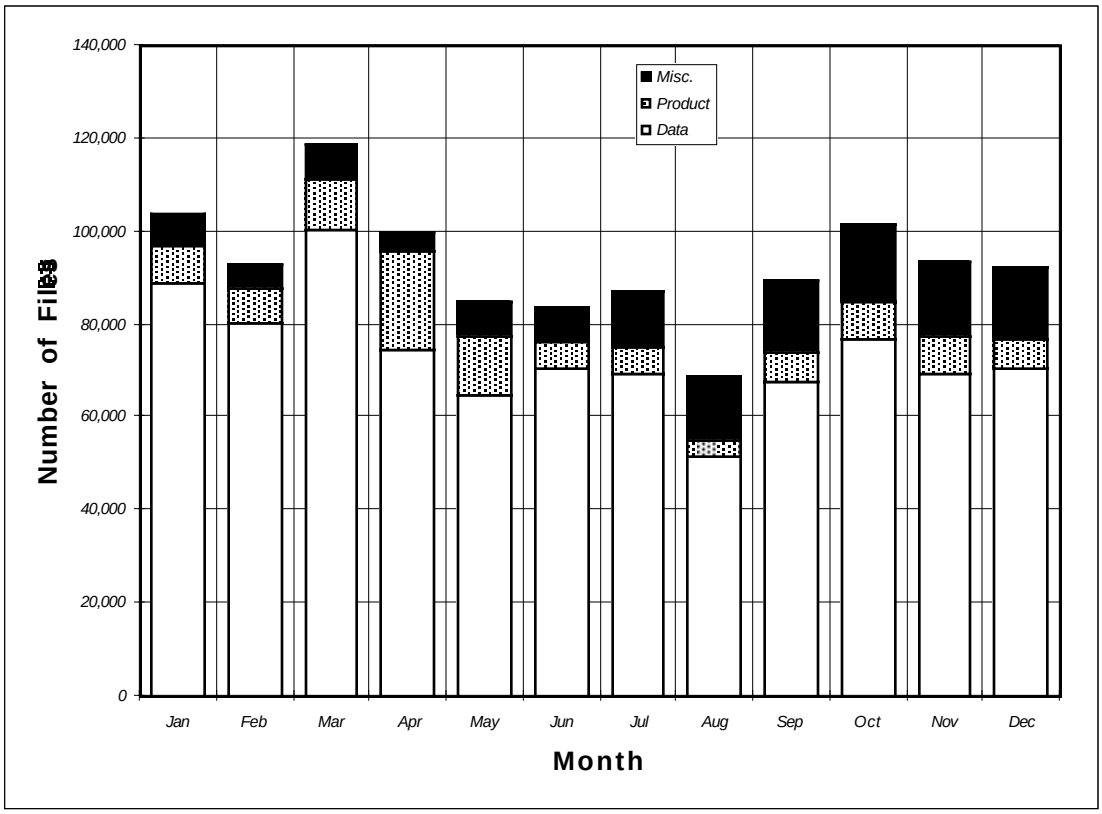

Figure 3: Number of GPS related files transferred to/from the CDDIS in 1997

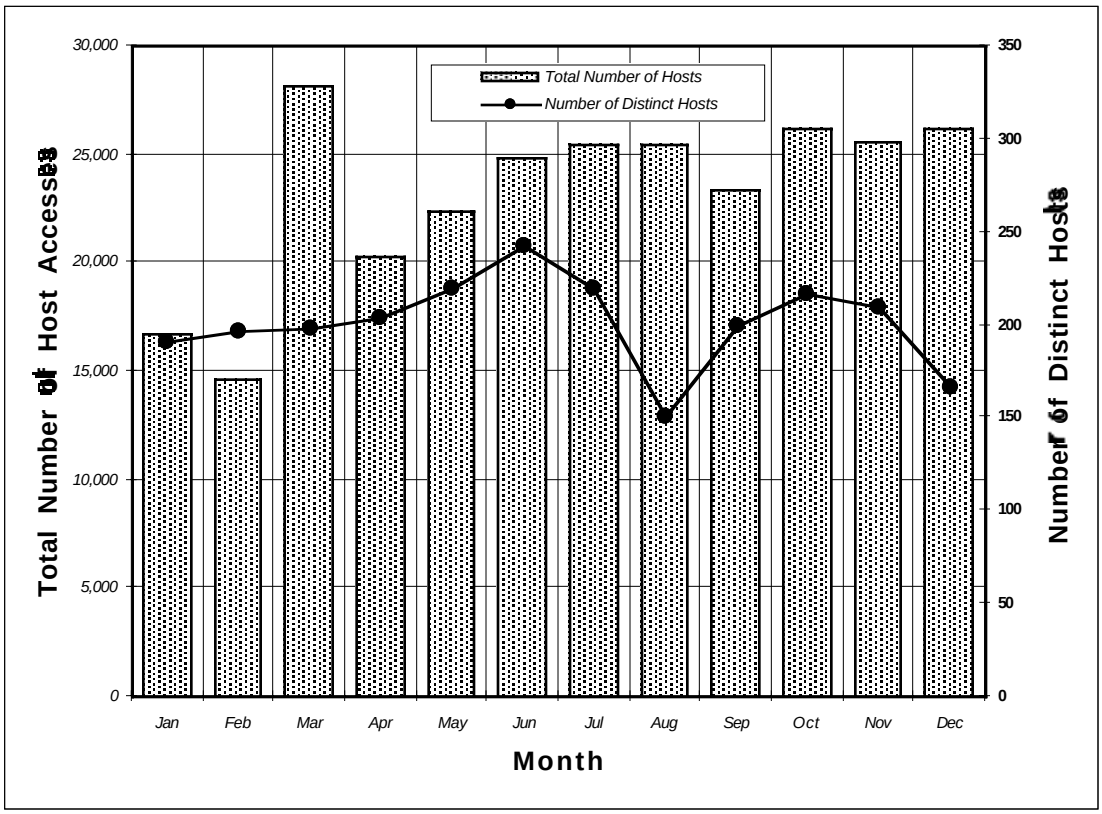

Figure 4: Number of hosts accessing GPS data and products on the CDDIS in 1997

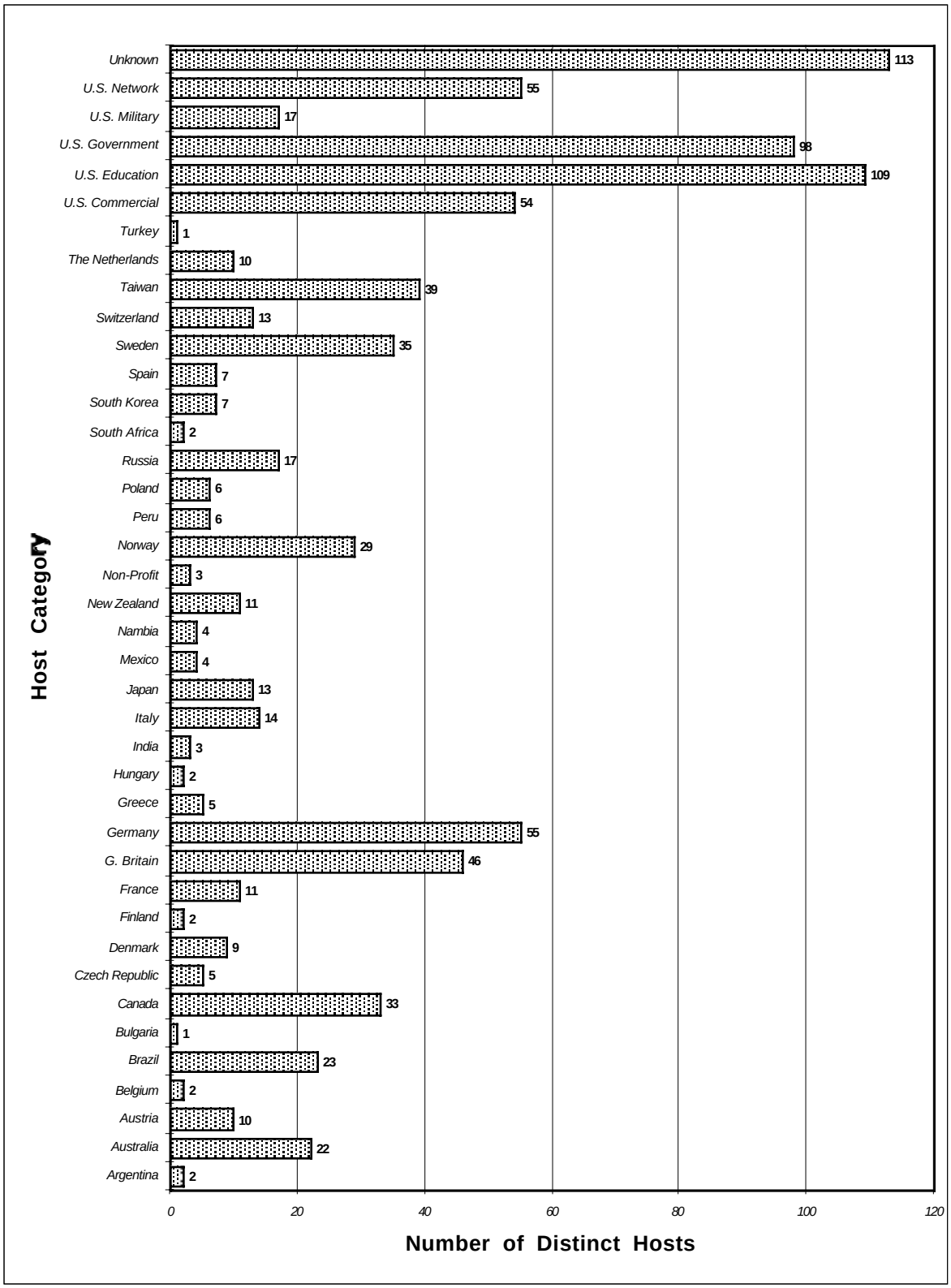

Figure 5: Distribution of IGS users of the CDDIS in 1997

ftp and WWW sites, however, will be operational on the UNIX platform in early 1998 (in fact, all URLs in this document reflect the web site on the new CDDIS computer).

An area of ongoing concern to the CDDIS staff is the ability to respond to special requests for older, off-line GPS data. Currently, this is a time-consuming activity for the staff since all older data are stored on optical disks in VAX VMS file format and the CDDIS VAX system is equipped with only two optical disk drives. The future CDDIS AlphaServer system under UNIX will not be equipped with these magneto-optical drives; therefore, a new medium for long-term storage of the historic GPS archive must be identified. The CDDIS staff has decided to utilize CD-ROMs for this archive. A CD recordable system and 600 platter jukebox were purchased during 1997. The CD recordable system consists of a Macintosh computer and a CD-ROM tower with the capability of recording up to five copies of a CD. The existing GPS archive on magneto-optical disks (in VAX/VMS format) will be migrated to CD-ROM during 1998. The data will most likely be written to CD-ROM by GPS week.

6.2 Changes in the Data Archive

The CDDIS data and product archive directories will be consolidated in mid-1998 once the system is operational on the new UNIX computer. This change will simplify data access for the user community since all data will be under one directory path.

Tests are underway in mid-1998 to provide hourly data to the IGS user community. During the tests, hourly data will be transmitted to CDDIS from JPL for several NASA sites. The hourly data will be archived to a public disk area on CDDIS in a timely fashion and retained there for three days. After three days, the hourly data will be deleted; the daily file, transmitted through normal channels with typically a one to two hour delay, will have been received and archived already and thus the hourly data are of little use.

In early 1998, a Call for Participation in the International GLONASS EXperiment (IGEX-98) was issued. IGEX-98 is sponsored by several organizations, including the IGS, and requests participation by stations, data centers, and analysis centers. The CDDIS responded to this call and hopes to make GLONASS data available to the IGS user community. The CDDIS plans to establish on-line directories for these data and to incorporate GLONASS data in normal data processing procedures.

6.3 Changes in the Product Archive

Starting in early 1998, the IGS Analysis Center Coordinator began generating predicted orbit, clock, and Earth rotation parameter combinations based upon the individual ACs' predicted solutions. These solutions, designated IGP, will be available within 0.5 hours of the beginning of the observation day. The IGS global data centers, including the CDDIS, will make these products available as soon as possible each day to ensure the timely utility to the user community.

Also early in 1998, the IGS Analysis Center Coordinator began generating accumulated IGR and IGS ERP files on a daily and weekly basis; these data are used with either the final or the rapid orbits. These files will be produced at the same time as the IGS rapid and final products are generated and downloaded by the IGS Global Data Centers. The files are designated IGS95P02.ERP (to be used with the IGS final orbits) and IGS96P02.ERP (to be used with IGS rapid orbits).

The CDDIS began generating "short-SINEX" files, designated with an .SSC extension in early 1998. These files contain the site information from the SINEX file but no matrices. The files are stored in the weekly IGS product subdirectories.

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 100 IGS sites. These troposphere products will be available at all IGS Global Data Centers, including the CDDIS starting in early 1998.

As of June 1, 1998, several IGS Analysis Centers will be 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 will also be available from the IGS Global Data Centers. At the CDDIS, the IONEX files will be located in subdirectories of the main product area, rather than under the weekly subdirectory structure, since the files are produced daily.

7 Contact Information

To obtain more information about the CDDIS or a username and password to access the IGS archive of data and products, contact:

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Phone: (301) 286-9283
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E-mail: `noll@cddis.gsfc.nasa.gov` or `CDDIS::NOLL`
WWW: `http://cddisa.gsfc.nasa.gov/cddis_welcome.html`

8 Acknowledgments

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