IGS

DATA CENTER REPORTS

IGS

G L O B A L   C E N T E R S

CDDIS 2000 Global Data Center Report

Carey E. Noll

Terrestrial Information Systems Branch
NASA Goddard Space Flight Center, Code 922
Greenbelt, MD 20771

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).

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.

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 Thus far, GPS data from 1992 through 1999 have been archived to CD, at least one week per CD.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.

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.

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*.

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 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.

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.

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.

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.

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.

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.

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, which 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.

Other Activities

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

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*.

Future Plans

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.

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.

Contact Information

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

Ms. Carey E. Noll	Phone:	(301) 614-6542
Manager, CDDIS	Fax:	(301) 614-5970
Code 920.1	E-mail:	*noll@cddis.gsfc.nasa.gov*
NASA GSFC	WWW:	*http://cddisa.gsfc.nasa.gov/cddis_welcome.html*
Greenbelt, MD 20771		

Acknowledgments

The author would once again like to thank members of the CDDIS staff, Dr. Maurice Dube, Ms. Ruth Kennard, and Ms. Laurie Batchelor (from Raytheon Information Technology and Scientific Services, RITSS). Their continued professional and timely support of the CDDIS have made this system a success in the eyes of the international user community.

References

Estey, L. "TEQC Summary" in IGS Network Systems Workshop Proceedings. March 1999.

Noll, C. E. "CDDIS Global Data Center Report" in *IGS 1994 Annual Report*. September 1995.

Noll, C. E. "CDDIS Global Data Center Report" in *IGS 1995 Annual Report*. September 1996.

Noll, C. E. "CDDIS Global Data Center Report" in *IGS 1996 Annual Report*. November 1997.

Noll, C. E. "CDDIS Global Data Center Report" in *IGS 1997 Technical Report*. October 1998.

Noll, C. E. "CDDIS Global Data Center Report" in *IGS 1998 Technical Report*. November 1999.

Noll, C. E. "CDDIS Global Data Center Report" in *IGS 1999 Technical Report*. 2001.

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

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

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**
UFl	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

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)

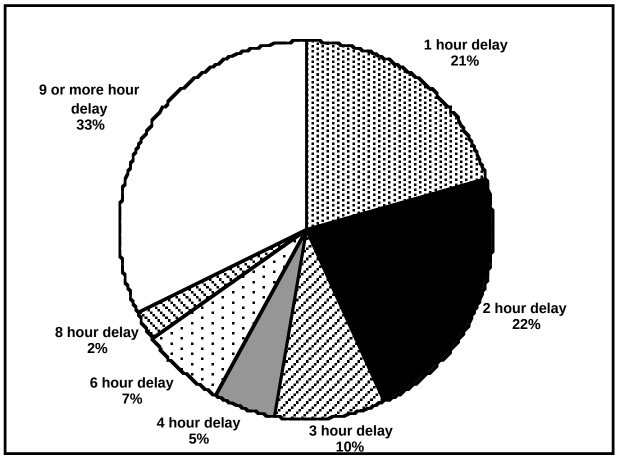

Figure 1: Average delay in delivery of GPS daily data files to the CDDIS in 2000

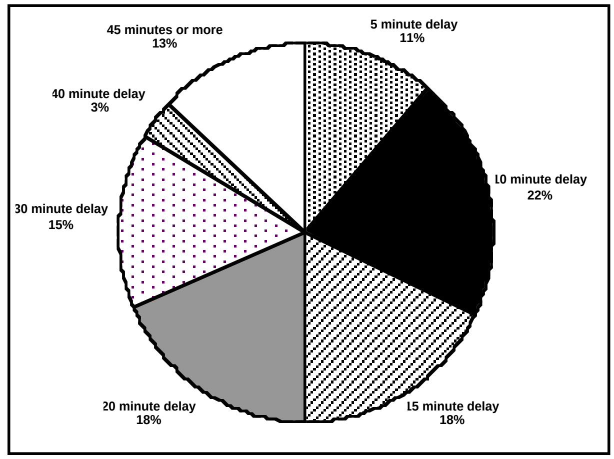

Figure 2: Average delay in delivery of GPS hourly data files to the CDDIS in 2000

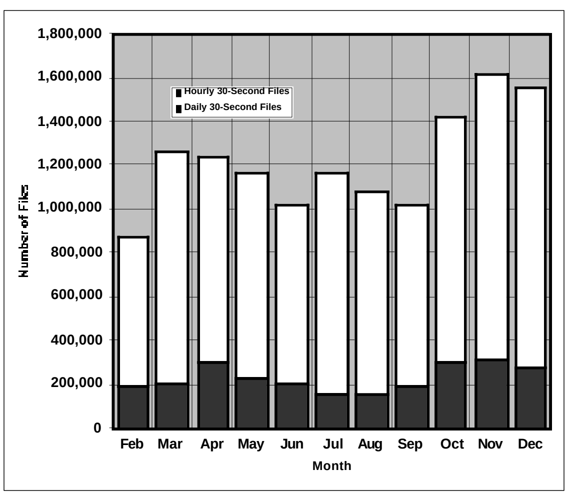

Figure 3: Number of GPS data files transferred from the CDDIS in 2000

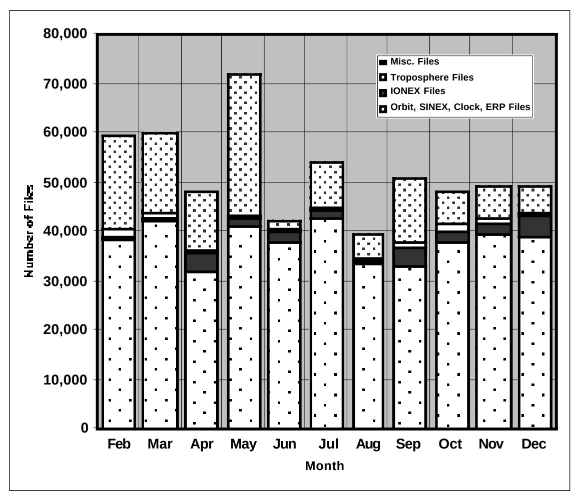

Figure 4: Number of GPS product files transferred from the CDDIS in 2000

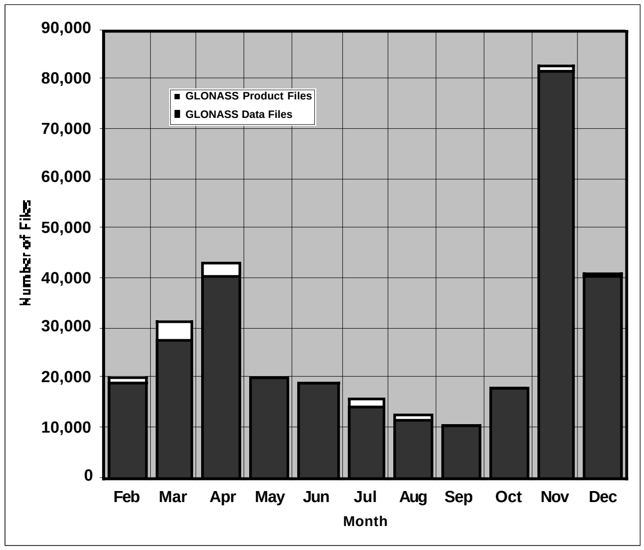

Figure 5: Number of GLONASS data and product files transferred from the CDDIS in 2000

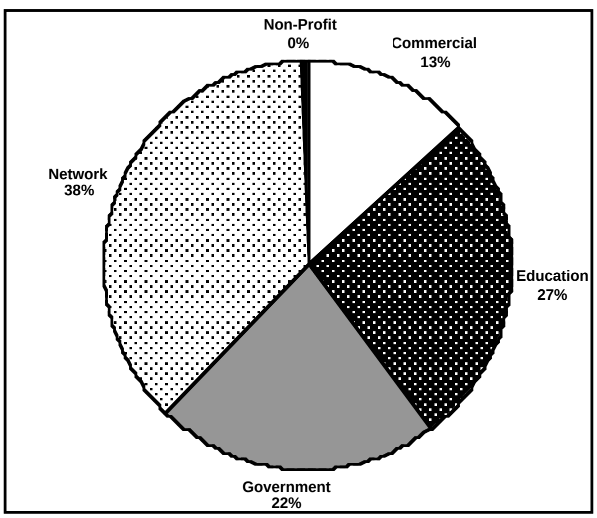

Figure 6: Distribution of IGS users of the CDDIS in 2000

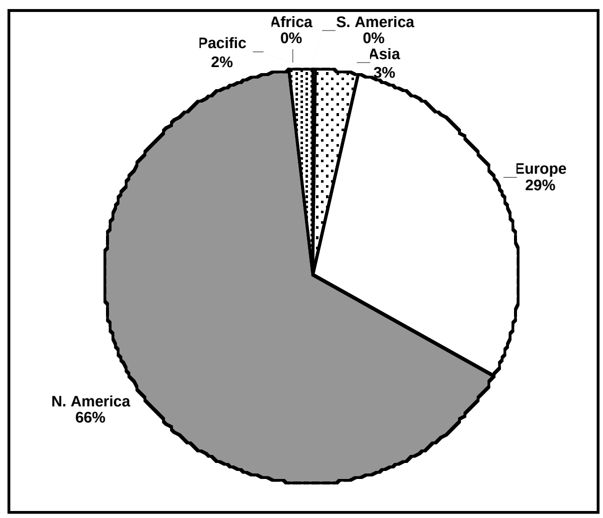

Figure 7: Geographic distribution of IGS users of the CDDIS in 2000

Scripps Orbit and Permanent Array Center (SOPAC) 2000 Report

Cecil H. and Ida M.
Green Institute of Geophysics and Planetary Physics
Scripps Institution of Oceanography
University of California, San Diego
La Jolla, CA 92037 USA
http://sopac.ucsd.edu; ftp://lox.ucsd.edu

Prepared by
Yehuda Bock, Director
Peng Fang, Rosanne Nikolaidis, Matthijs van Domselaar, Karen Watson (Analysis)
Brent Gilmore, Michael Scharber, Paul Jamason, David Malveaux (Archive)

Summary

The Scripps Institution of Oceanography's Orbit and Permanent Array Center (SOPAC) at the Cecil H. and Ida M. Green Institute of Geophysics and Planetary Physics (IGPP) has served as a Global Data Center and Global Analysis Center since the inception of the IGS in 1994. SOPAC is responsible for the collection, archiving, processing and publication of high-precision continuous GPS data to support the global GPS community. SOPAC's archive and analysis functions for the IGS overlap and complement other archiving and development activities at SIO for the Southern California Integrated GPS Network (SCIGN), NOAA/NOS' National Geodetic Survey, the California Spatial Reference Center (http://csrc.ucsd.edu), NOAA's Forecast Systems Laboratory (FSL), and UNAVCO, Inc.

Highlights of SOPAC activities through the end of 2001 of interest to the IGS, include:

- Complete redesign of the SOPAC Web Pages (http://sopac.ucsd.edu).
- Increase in the number of continuous GPS sites archived to just over 900.
- Maintenance of all historical (since 1990) and current data on-line, aided by converting from RINEX storage of UNIX-compressed files to Hatanaka compressed files.
- Complete redesign of the Site Information Manager (SIM).
- Increase in the number, scope, and utility of interactive user applications.
- Archive of one-hour global data files.
- Archive of all IGS orbital products including ultra-rapid orbits posted every 12 hours.
- Computation of real-time orbits based on hourly solutions of sliding 24-hour data window.

- Production of daily ITRF coordinates and SINEX solution files produced for over 600 sites, including all continuous GPS sites in Western North America (the "PBO" region).
- Production of decade-long consistent ITRF position time series, orbits, zenith delays, and EOP based on re-analysis of a large subset of global and regional data on SOPAC archive, starting in January, 1991.
- Development of GPS Seamless Archive (GSAC) for UNAVCO, Inc.
-

Data Archive

The SOPAC GPS archive currently has about 2.8 TB of on-line storage and includes current and historical data and data products since 1990. All operations are controlled by an Oracle 8.1 RDBMS (see Figure 1), supported by an equipment base significantly upgraded in 2000-2001 (Figure 2). See Appendix A for a complete list and locations of data and data products in the SIO archive. SOPAC continuously probes and collects RINEX data from more than 30 different global, regional and sub-regional GPS archives around the world. The automated processes which collect this data are continuously being upgraded and modified. The collection process compares the database description of the SIO archive to the remote archives, ftp's any needed files, quality checks the data, and makes them immediately available for on-line access. In addition, site log files are also compared and archived to provide current and historical listings of site equipment.

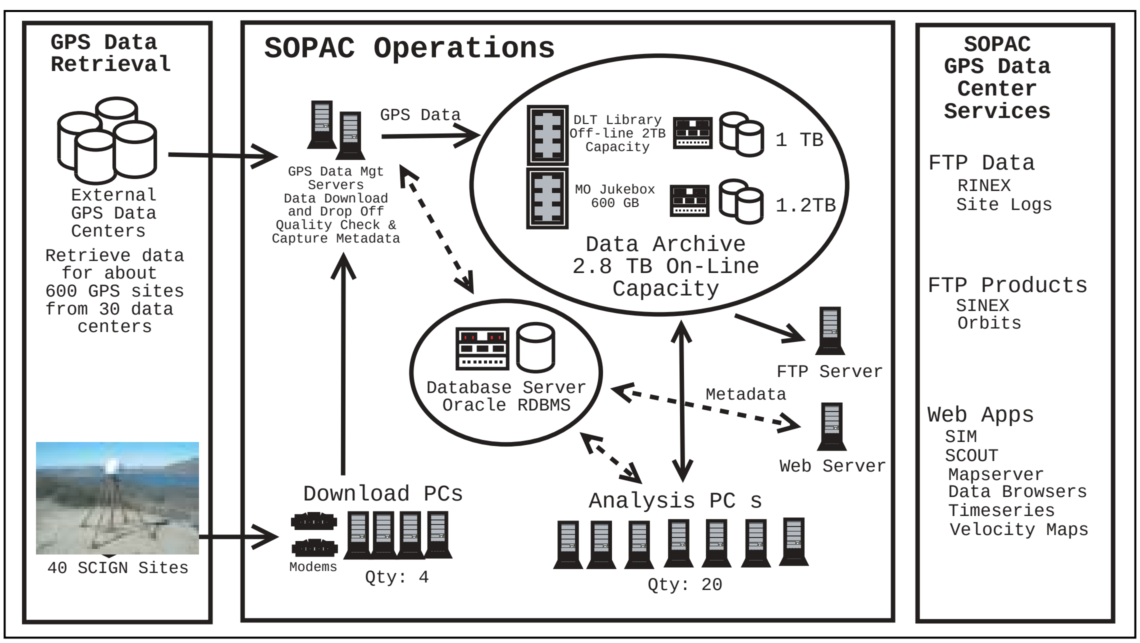

Figure 1. Schematic of SOPAC archive. See Figure 2 for a detailed hardware description.

SOPAC's publicly available data archive is accessible via anonymous ftp at the following URL: ftp://lox.ucsd.edu.

SOPAC makes every attempt to provide data that it collects or produces in a timely manner. All data on SOPAC's public archive may be obtained without restriction. An open data policy is intended to provide public users with the easiest means of collecting data from SOPAC on both a regular and irregular basis. Although private commercial use of such data is permitted, additional services and/or requests by private entities are given lowest priority. These policies are encouraged by SIO for other data centers wherever possible.

In addition to the regular nature of data collection and publication at SOPAC, older data and/or products are also added to the public archive, typically on an irregular basis. Various data formats are available from the SOPAC archive, such as ASCII and UNIX-compressed. In addition, formal requests for off-line data are handled by SOPAC and dealt with in a timely and appropriate manner.

In 2000 SOPAC saw its total archive size (first-copy data, excluding backups) actually decrease by nearly 400 hundred gigabytes thanks to the reclamation of over 500 gigabytes of space by the conversion of every RINEX file on SOPAC's archive from standard UNIX-compressed format to Hatanaka UNIX-compressed format. In addition to the obvious space savings are significantly reduced network usage and RINEX ftp transfer times for SOPAC's users. Accordingly, SOPAC's total archive usage decreased from around 1.4 terabytes in 1999 to roughly 1.0 terabyte by the end of 2000.

The steady increase in the number of permanent GPS sites archived at SOPAC since 1996 is shown in Figure 3, and by GPS network affiliation in Figure 4. By the end of 2000, SOPAC was collecting data from about 830 sites, by the end of 2001 that number had exceeded 900 sites.

The year 2000 was also a year where SOPAC saw continual growth in the number of file transfers by both public and private users, locally and from around the world (Figure 5). Nearing 5 million transfers for the year 2000 SOPAC continues to provide GPS data to an ever-growing constituency of GPS users the world over. By the end of 2001, the number of file transfers was almost 7 million. The most frequently downloaded GPS data at SOPAC were those affiliated with the IGS (Figure 6). By the end of 2001, we could identify more than 8000 unique ftp clients (Figure 7). The number of unique clients domains (e.g., ".gov", ".edu", ".com") leveled off in 2000-2001 to over 70 (Figure 8).

SCIGN, the Southern California Integrated GPS Network (http://www.scign.org), also grew substantially in 2000. SOPAC is the primary data archive for the SCIGN network. By the end of 2000 the SOPAC had at least one day of data from 229 different SCIGN sites. That number has climbed to over 250 by the end of year 2001 making SCIGN the largest RINEX data constituent at SOPAC, in terms of the number of total sites archived (Figure 4). Among file transfers from SOPAC, the SCIGN network was the second most popular network downloaded (Figure 6).

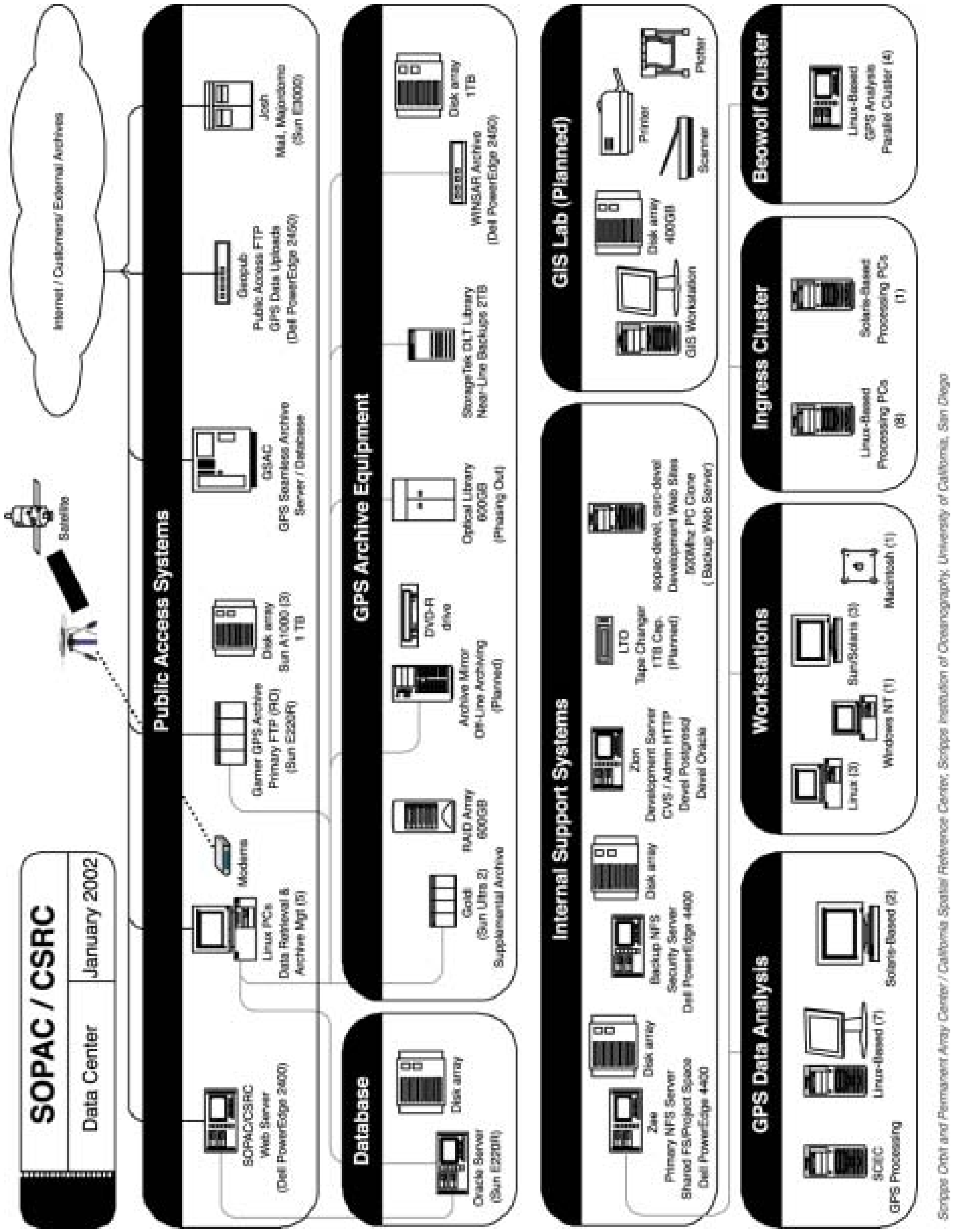

Figure 2. Schematic of SOPAC/CSRC hardware components.

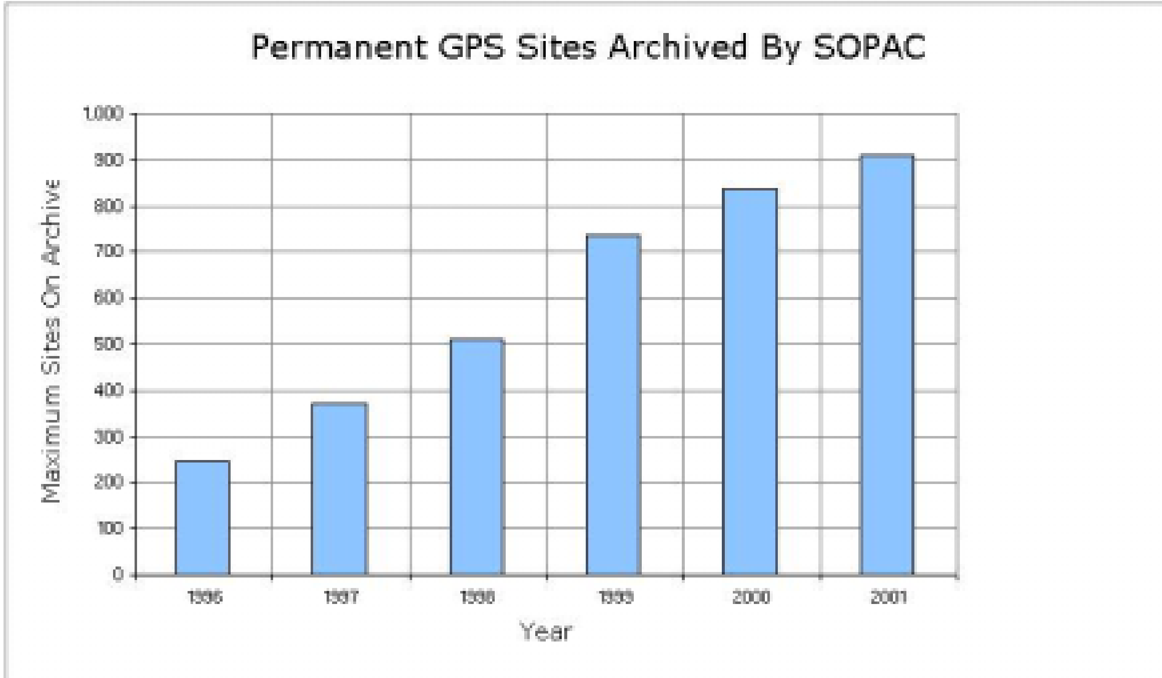

Figure 3. Number of continuous GPS sites archived at SOPAC between 1996-2001.

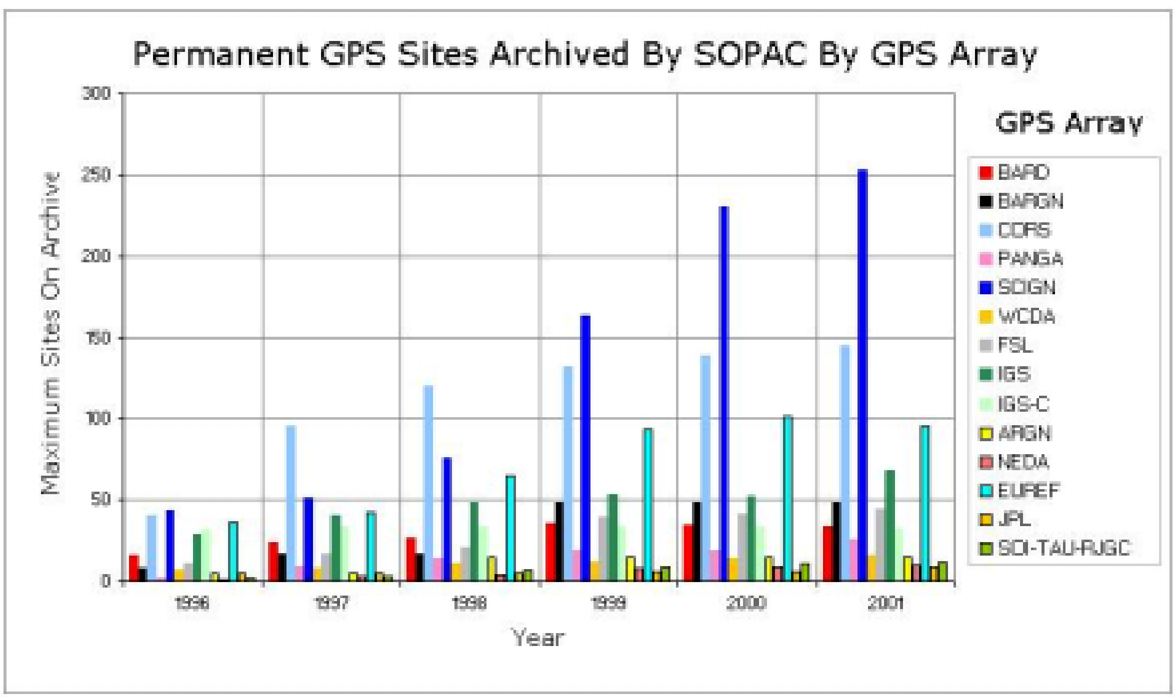

Figure 4. Number of continuous GPS sites archived at SOPAC between 1996-2001 by GPS array for 14 different arrays. "IGS-C" include core sites (that define the global reference frame) and "IGS" contain other IGS sites.

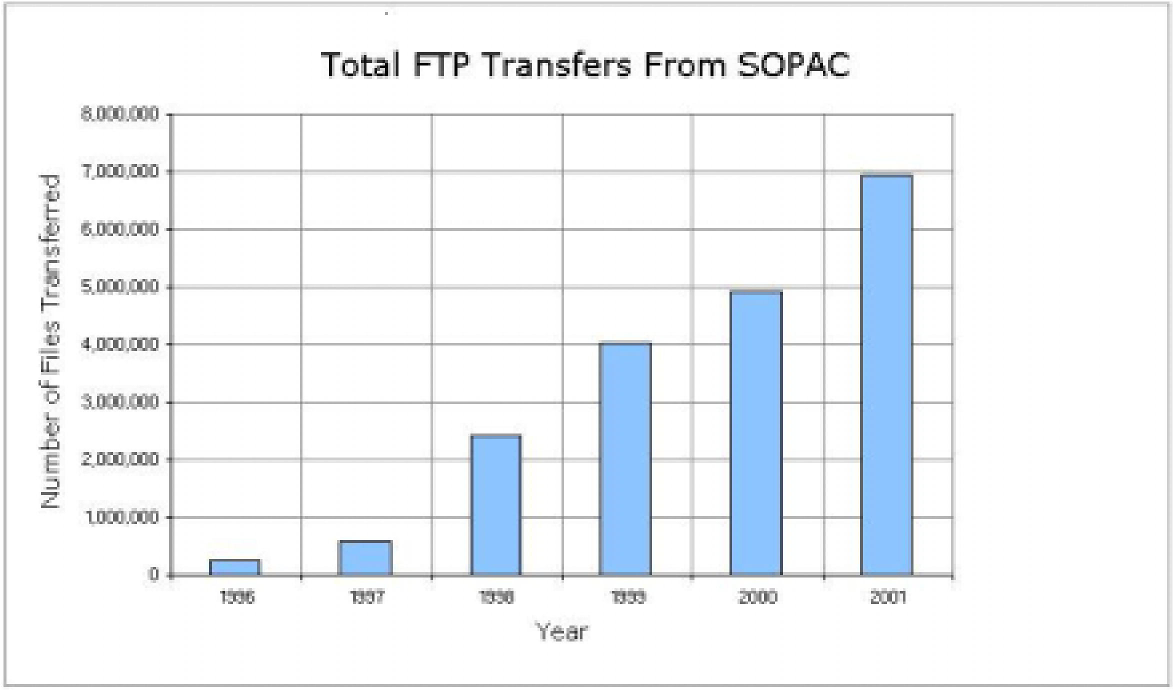

Figure 5. Number of files transferred from SOPAC via ftp://lox.ucsd.edu between 1996-2001.

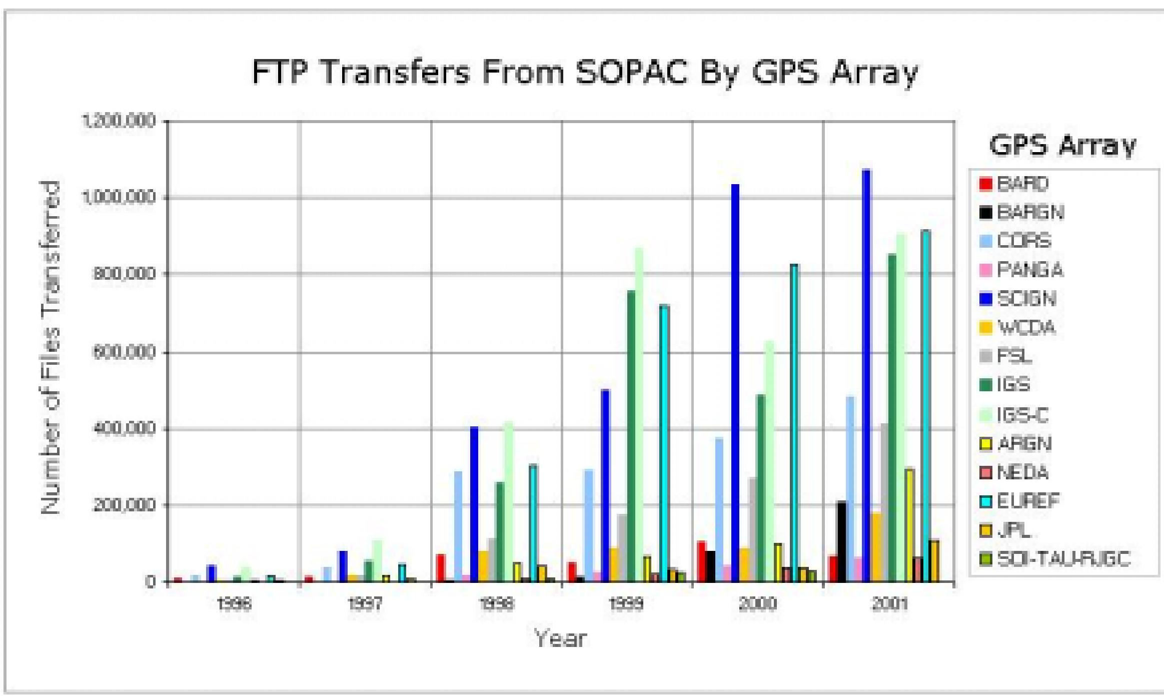

Figure 6. Number of files transferred from SOPAC via ftp://lox.ucsd.edu between 1996-2001 for 14 different GPS arrays.

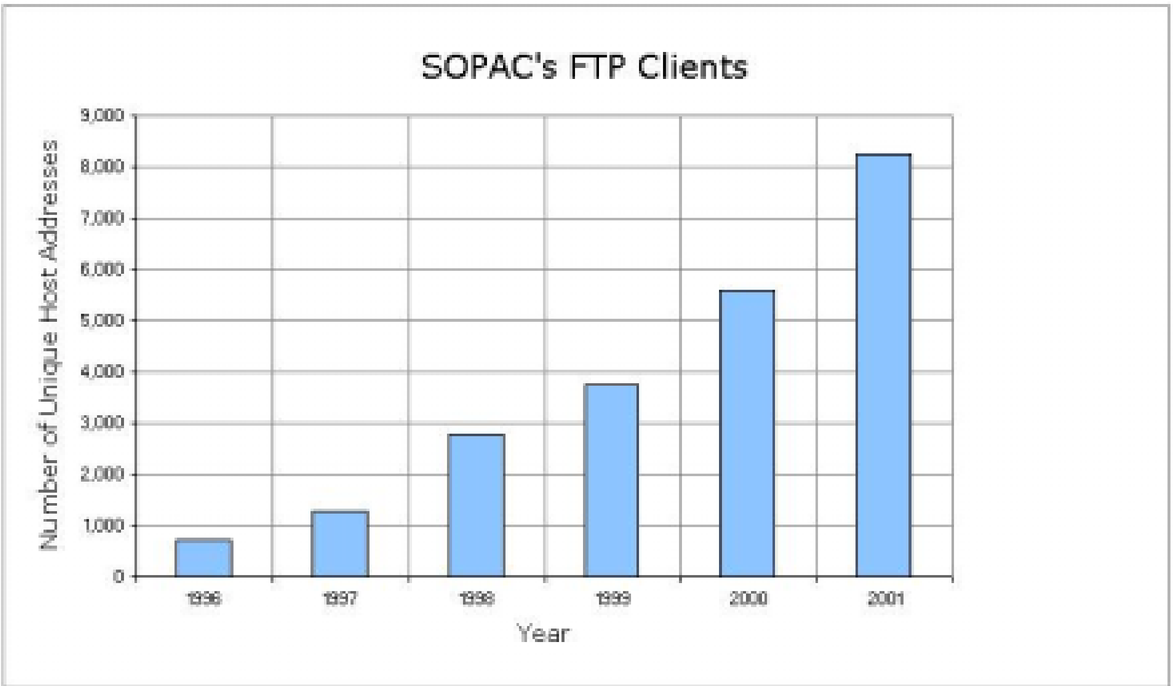

Figure 7. Number of unique ftp clients transferring data from SOPAC in the years 1996-2001. An ftp client is counted as a unique address for a user of the SOPAC archive. We have made an effort to ensure that ftp users provide a legitimate username.

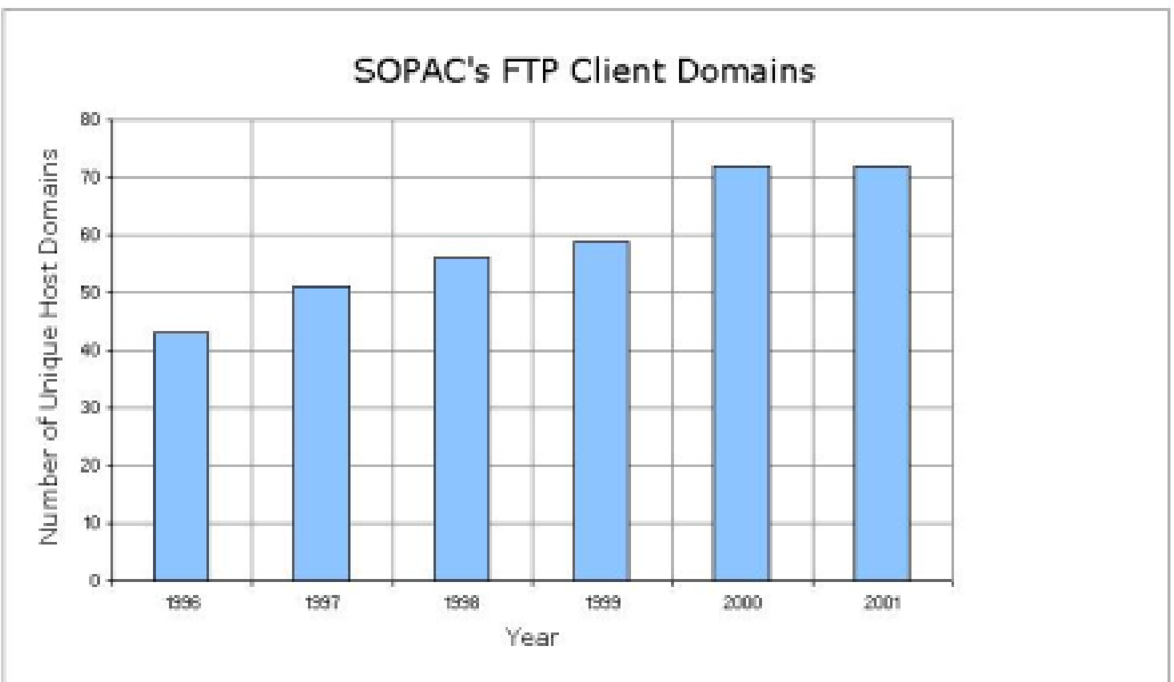

Figure 8. Number of unique ftp client domains (e.g., ".gov", ".edu", ".com") obtaining data from SOPAC in the years 1996-2001.

From the standpoint of a user constituency SOPAC, U.S. educational institutions accounting for the largest use of the archive with nearly 2 million file transfers alone. U.S. government and German domains were the second and third largest user groups of SOPAC's archive in 2000.

RINEX observation format GPS data files continue to be far and above the most frequently accessed data at SOPAC, accounting for over 90% of the total file transfers in 2000. As such, there is a high correlation between the number of permanent GPS sites archived on a daily basis at SOPAC and both the total size of the SOPAC archive and the number of file transfers from SOPAC. We expect this trend to continue to rise in the future and are taking appropriate steps to ensure SOPAC can maintain its high level of service to the global GPS community.

Information Management

SOPAC is dedicated to providing the GPS community with useful and timely information describing GPS data. In this effort SOPAC utilizes a relational database to track information about data, creates web-based software to assist with user entry and retrieval of site information (e.g., Figure 9), and maintains ftp statistics about the data's access by the GPS community.

Over the past few years, SOPAC has integrated an Oracle Relational Database Management System into its archiving operations. This has enabled us to increase the efficiency of both local and remote GPS data downloading, and improve the accuracy of GPS site metadata stored at SIO.

Front- and back-end database applications continue to be a top priority for SOPAC's archive management team each year. The "archive browsers" on SOPAC's web page feed directly off of our relational database server, providing a centralized and integral information source for numerous web-related utilities and services.

The SIO database catalogs and organizes SIO data holdings, and the tools used to obtain these data. Revised remote collection software then utilizes this information to determine which remote archive files are needed.

SOPAC continues to improve its management of GPS site-related information. The Site Information Manager (SIM) is a web-based application that allows users access to site information contained in the SOPAC database (http://sopac.ucsd.edu/scripts/SIMpl_launch.cgi). It provides secured users with a single mechanism of updating site information, which is then propagated to several applications. Alternatively, users may manually generate products such as site logs from the SIM. The SIM has relevant help sections with URL links to helpful resources, and limits equipment types to those recognized by the IGS.

Several of SOPAC's automated database applications make direct use of site information managed via the SIM. These include:

- Submission of SCIGN site logs to the IGS Central Bureau.
- GPS site log parsing into the database.
- SCIGN site log creation and updating.
- SCIGN mail generation.
- Updating of site equipment local download software to allow correct equipment types to be entered into RINEX headers.
- Automated station.info (GAMIT configuration file) creation.
- Automated SINEX creation.

FTP access statistics for the SIO archive are updated semi-hourly in the database. The number of transfers from the archive may be queried based on GPS site name, array, several temporal parameters, and by remote host types. This allows for a timely, detailed description of the data archive's usage, and creates a usage profile which enables SIO to better deliver its products to the GPS community (see http://sopac.ucsd.edu/cgi-bin/dbFtpStats.cgi).

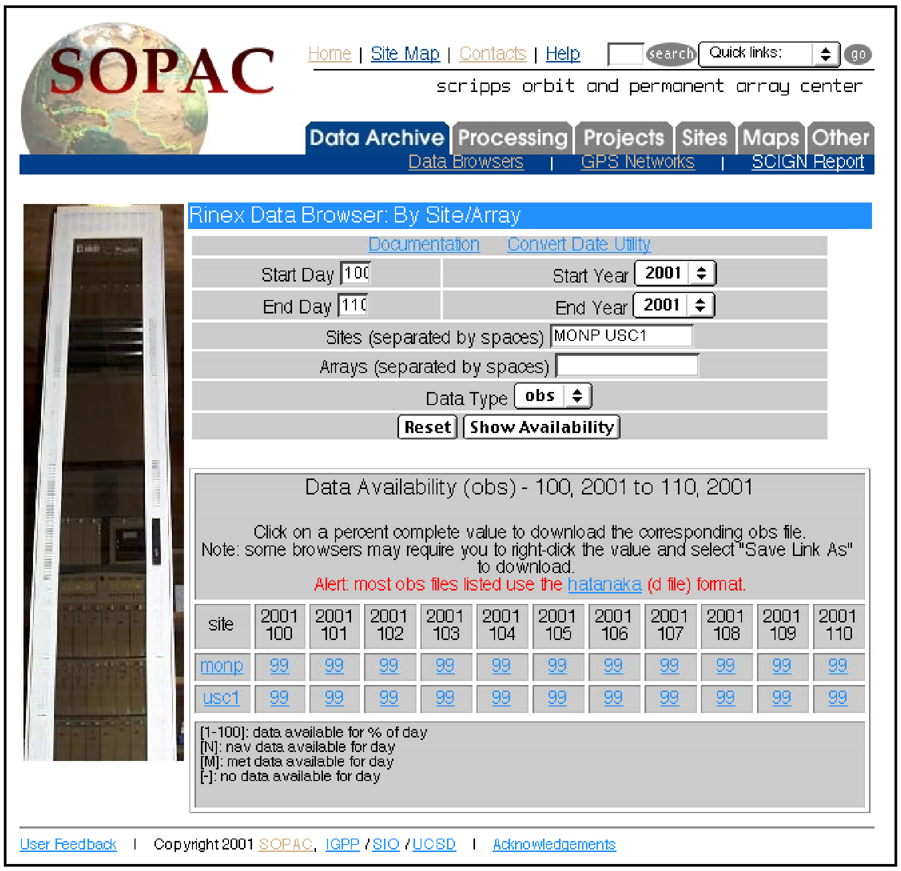

Figure 9. An example of a SOPAC user application. This application allows the user to browse the data archive for RINEX data availability. All interactive tools are interfaced to SOPAC's Oracle 8.1 RDBMS.

Analysis

In 2000-2001 SOPAC initiated computation of real-time orbits based on hourly solutions of a sliding 24-hour data window, primarily to support short-term weather forecasting for NOAA. Production of daily ITRF coordinates and SINEX solution files exceeded 600 sites, including all continuous GPS sites in Western North America (the "PBO" region). SOPAC completed production of an 11-year consistent ITRF position time series, orbits, zenith delays, and EOP based on re-analysis of a large subset of global and regional data on SOPAC archive, starting in January, 1991 (e.g., Figure 10). See Appendices A and B for a summary of analysis products and their locations in the SOPAC archive.

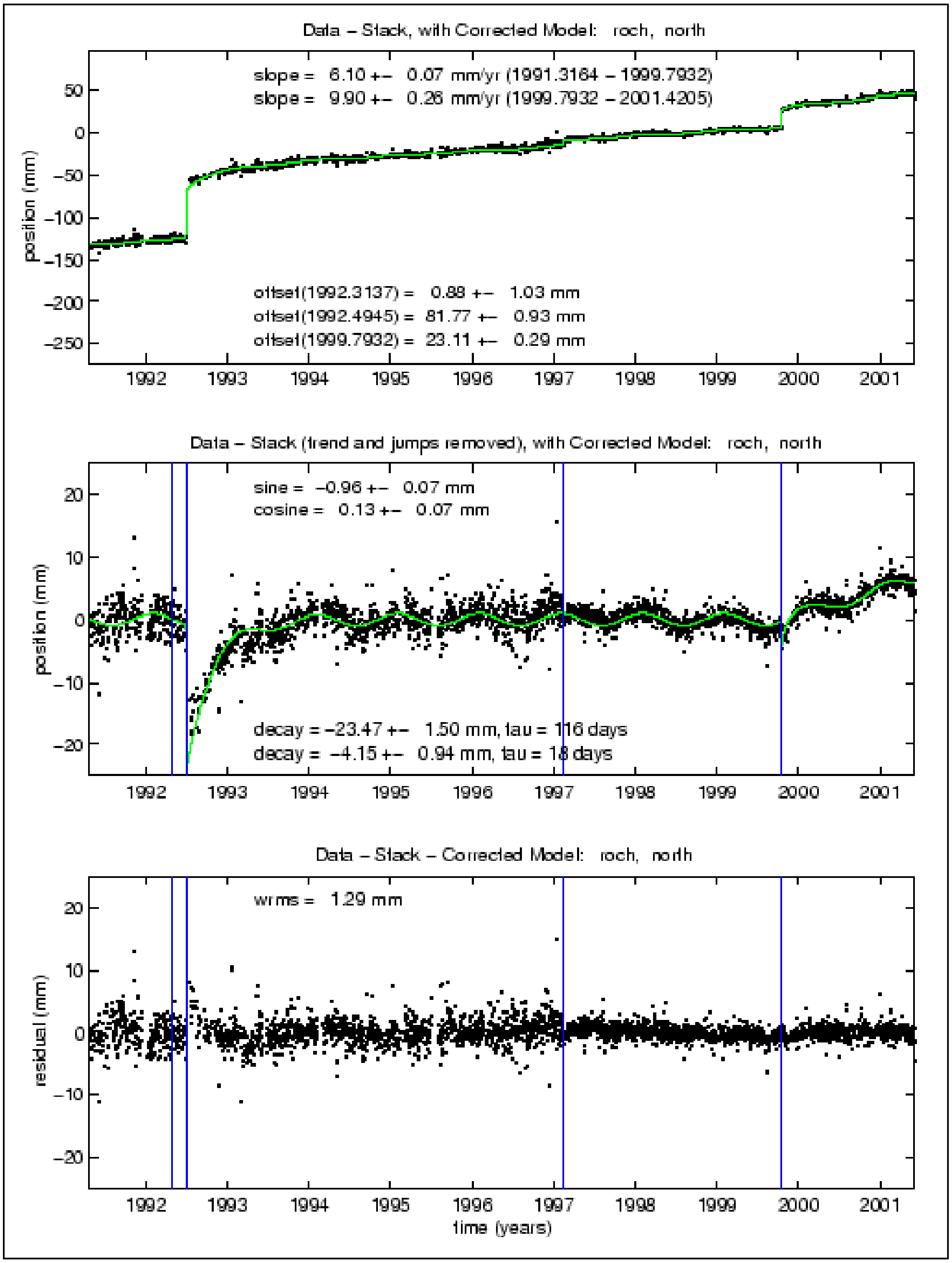

Figure 10. Typical coordinate time series of analyzed by SOPAC. The time series shows the north position component of the SCIGN site at Pinemeadows (ROCH). The time series is modeled by a linear trend, three coseismic offsets (Joshua Tree, Landers, Hector Mine), two postseismic decay (Landers and Hector Mine), an annual term, and one equipment-change offset (early 1997). The weighted rms is only 1.3 mm but exhibits some non-linear behavior.

Appendix A. Directory structure and directory information for SOPAC archive (ftp://lox.ucsd.edu)

```
------------------------------------------------------------------------------
                          DIRECTORY STRUCTURE
------------------------------------------------------------------------------
Directory             Filenames                Description
------------------------------------------------------------------------------

rinex/YYYY/DDD        ssssDDD0.YYd.Z           Hatanaka compressed RINEX obs
                                                     files for stations 'ssss',
                                               day 'DDD', year 'YY'

                      ssssDDD0.YYo.Z           UNIX-compressed RINEX obs
                                               (last 60 days only)

                      autoDDD0.YYn.Z           RINEX navigation files
                                               concatenated from all stations
                                               day 'DDD', year 'YY'

nav/YYYY/DDD          ssssDDD0.YYn.Z           RINEX nav files
                                               for stations 'ssss',
                                               day 'DDD', year 'YY'

                      autoDDD0.YYn.Z           RINEX navigation files
                                               concatenated from all stations,
                                               day 'DDD', year 'YY'

met/YYYY/DDD          ssssDDD0.YYm.Z           RINEX met files
                                               for station 'ssss',
                                               day 'DDD', year 'YY'

raw/YYYY/DDD          ssssDDDS.YYr.Z           ROGUE raw obs files
                                               for station 'ssss',
                                               day 'DDD', year 'YY', sess 'S'

                      ssssDDDY.rSS             Trimble raw obs file
                                               for station 'ssss',
                                               day 'DDD', year 'Y', sess 'SS'

                      rssssSYY.DDD             Ashtech raw obs files
                                               for station 'ssss',
                                               day 'DDD', year 'YY', sess 'S'

products/WWWW         igsWWWWD.sp3.Z           IGS Final Orbits
                                               for GPS week 'WWWW' and
                                               day 'D' in SP3 format,
                                               D=0,..,6

                      igrWWWWD.sp3.Z           IGS Rapid Orbits
                                               for GPS week 'WWWW' and
                                               day 'D' in SP3 format,
                                               D=0,..,6

                      iguWWWWD_HH.sp3.Z        IGS Ultra-Rapid Orbits
                                               for GPS week 'WWWW'
                                               day 'D' hour 'HH' in SP3 format,
                                               (H=00 or H=12)

                      iguWWWW7_HH.erp.Z        IGS Ultra-Rapid Earth Rotation
                                               Parameter file
                                               for GPS week 'WWWW', hour 'HH'
                                               (H=00 or H=12)
```

iguWWWW7_HH.sum.Z	IGS Ultra rapid summary file produced by center 'ccc' for GPS week 'WWWW', hour 'HH' (H=00 or H=12)
cccWWWWD.sp3.Z	Orbits produced by center 'ccc' for GPS week 'WWWW' and day 'D' in SP3 format, D=0,..,6
cccWWWW7.erp.Z	Earth Rotation Parameter file produced by center 'ccc' for GPS week 'WWWW'
cccWWWW7.sum.Z	Data Analysis Summary file produced by center 'ccc' for GPS week 'WWWW'
cccWWWW7.clk.Z	Combined Clock Estimates file for satellite and station clocks produced by center 'ccc' for GPS week 'WWWW'
cccWWWW7.cls.Z	Summary of Clock Combination file produced by center 'ccc' for GPS week 'WWWW'
jplWWWWD.yaw.Z	JPL Satellite Yaw File for GPS week 'WWWW', day 'D' D=0,..,6
sirWWWWD.sp3.Z	SIO (SOPAC) Rapid Orbits for GPS week 'WWWW' and day 'D' in SP3 format, D=0,..,6
siuWWWWD_HH.sp3.Z	SIO (SOPAC) Ultra-Rapid Orbits for GPS week 'WWWW' and day 'D' in SP3 format, D=0,..,6 Updated every 12 hrs (24 hours actual + 24 hour predicted)
sihWWWWD.sp3.Z	SIO (SOPAC) Hourly Orbits for GPS week 'WWWW' and day 'D' in SP3 format, D=0,..,6 Updated hourly (24 hours actual + 12 hour predicted)
sioigsWWWW7.snx.Z	Station Solution SINEX file for global sites produced by SIO for GPS week 'WWWW'
siopboWWWW7.snx.Z	Station Solution SINEX files for "PBO" sites in Western NA produced by SIO for GPS week 'WWWW' PBO: Plate Boundary Observatory

```
                      gpggaY.DDD.Z            Satellite initial conditions
                                              file (GAMIT/GLOBK users)
                                              generated from final analysis
                                              year 'Y', day 'DDD'

                      gpggaY.DDD.rap.Z        Satellite initial conditions
                                              file (GAMIT/GLOBK users)
                                                    generated from rapid analysis
                                              year 'Y', day 'DDD'

                      gpggaY.last.Z           Most recent satellite initial
                                              conditions file
                                              (GAMIT/GLOBK users)
                                                    Generated from SIO hourly
                                              solutions ('sih')
                                              year 'Y'
                                              Updated hourly

-------------------------------------------------------------------------------
               MISCELLANEOUS DIRECTORY INFORMATION
-------------------------------------------------------------------------------
Directory             Description
-------------------------------------------------------------------------------

GSAC                  SOPAC GPS Seamless Archive (UNAVCO GSAC) holdings

docs                  GPS sitelogs and SOPAC data reports (SCIGN, all sites)

misc                  Miscellaneous data and products

nrtdata               Hourly GPS RINEX data files

software              Publicly-available software

troposphere           IGS combinations of tropospheric estimates

For GAMIT/GLOBK users:

processing            GAMIT/GLOBK related tables

global                GAMIT solution files for daily SOPAC global analyses

regional              GAMIT solution files for daily SOPAC regional analyses

hfiles                Global and regional GAMIT/GLOBK h-file solutions

combinations          SOPAC's weekly GLOBK solutions

gfiles                Orbits in the GAMIT g-file format

-------------------------------------------------------------------------------
```

Appendix B. SIO orbital products

```
-----------------------------------------------------------------------------
Software Used      | GAMIT v. 10.05, GLOBK v. 5.05,   developed at MIT/SIO
-----------------------------------------------------------------------------
Final Products     | siowwwwn.sp3    GPS ephemeris files in 7 daily
generated for      |                 files at 15 min intervals in SP3 format,
GPS week 'wwww'    |                 including accuracy codes computed from
day of week 'n'    |                 overlapping analysis wrt previous day.
(n=0,1,...,6)      | siowwww7.erp    ERP (pole, UT1-UTC) weekly solution
                   | siowwww7.sum    Summary of weekly solution combining both
                   |                 IGS global and regional solutions.
                   | siowwww7.snx    Weekly coordinates in SINEX format
                   | siowwwwn.tro    Daily files of 1-h troposphere delay
                   |                 estimates in SINEX format (based
                   |                 on 1-day solutions).
Rapid Products     | sirwwwwn.sp3    Daily orbits for current-1 day. ~8 hour
                   |                 delay.
                   | sirwwwwn.erp    Daily EOP for current-1 day. ~8 hour
                   |                 delay.
Ultra Rapid        | siuwwwwn.sp3    Daily orbits for 24h(post)+24h(predicted).
Products           |                 3 hour delay (twice daily).
                   | siuwwwwn.erp    Daily EOP for 4day(post)+3day(predicted).
                   |                 3 hour delay. (twice daily)
Hourly             | sihwwwwn.sp3    Hourly orbits for 24h(post)+12h(predicted).
Products           |                 1 hour delay (24 times daily).
```

IGS

REGIONAL/OPERATIONAL CENTERS

BKG Regional IGS Data Center Report 2000

Heinz Habrich, Kurt Herzberger

Federal Agency for Cartography and Geodesy
D-60598 Frankfurt at Main, Germany

Introduction

The Federal Agency for Cartography and Geodesy (BKG) operates the Regional IGS Data Center for Europe since the beginning of the IGS Test Campaign in June 21, 1992. GPS tracking data from permanent GPS sites in Europe are obtained from Operational Data Centers (ODC's), Local Data Centers (LDC's), or directly from the stations. Also tracking data from stations outside of Europe are transferred to BKG, if these stations are operated by an European institution. The received data are uploaded to the Global Data Center (GDC) at the Institut Géographique National (IGN) in Paris, and are also made available to other users. The IGS products as computed by the IGS Analysis Centers are downloaded from the GDC's to BKG in order to provide these information to European users.

GPS observation data from the permanent GPS network of the European Reference Frame (EUREF) and mixed GPS/GLONASS observation files from the International GLONASS Experiment 1998 (IGEX) are also available. The continuation of the IGEX campaign is now proposed to become an IGS pilot service for a period of four years (2000-2003) named International GLONASS Service – pilot project (IGLOS-PP). A subset of the IGS , EUREF, and IGEX stations deliver hourly observation files to BKG additionally to the daily files.

Computer Architecture

The data center runs on an HP-workstation under HP-UX. This workstation is connected to the Internet with a maximum transfer rate of 2 MB/s and a disk capacity of about 100 GB. The directory structure (see Figure 1) shows three project related directories (IGS, EUREF, and IGEX). The various projects show analogous directory structures. The data are accessible through both, ftp and http. The RINEX observation files of the stations are now online available for 3 years. During 2000 a new http-server (http://igs.ifag.de) had been installed, and the html pages had been newly created. They correspond now very well to the disk structure, to make the use of ftp and http as similarly as possible.

Hourly Observation Files

The hourly RINEX observation files may be used for near real time applications and could replace the daily files if all hourly files of one day are concatenated to one file successively. As soon as the daily observation files are available at the data center the hourly observation files are no longer of interest. Therefore, the hourly files are deleted after 7 days in the "nrt" subdirectory. For test purposes, BKG compares the

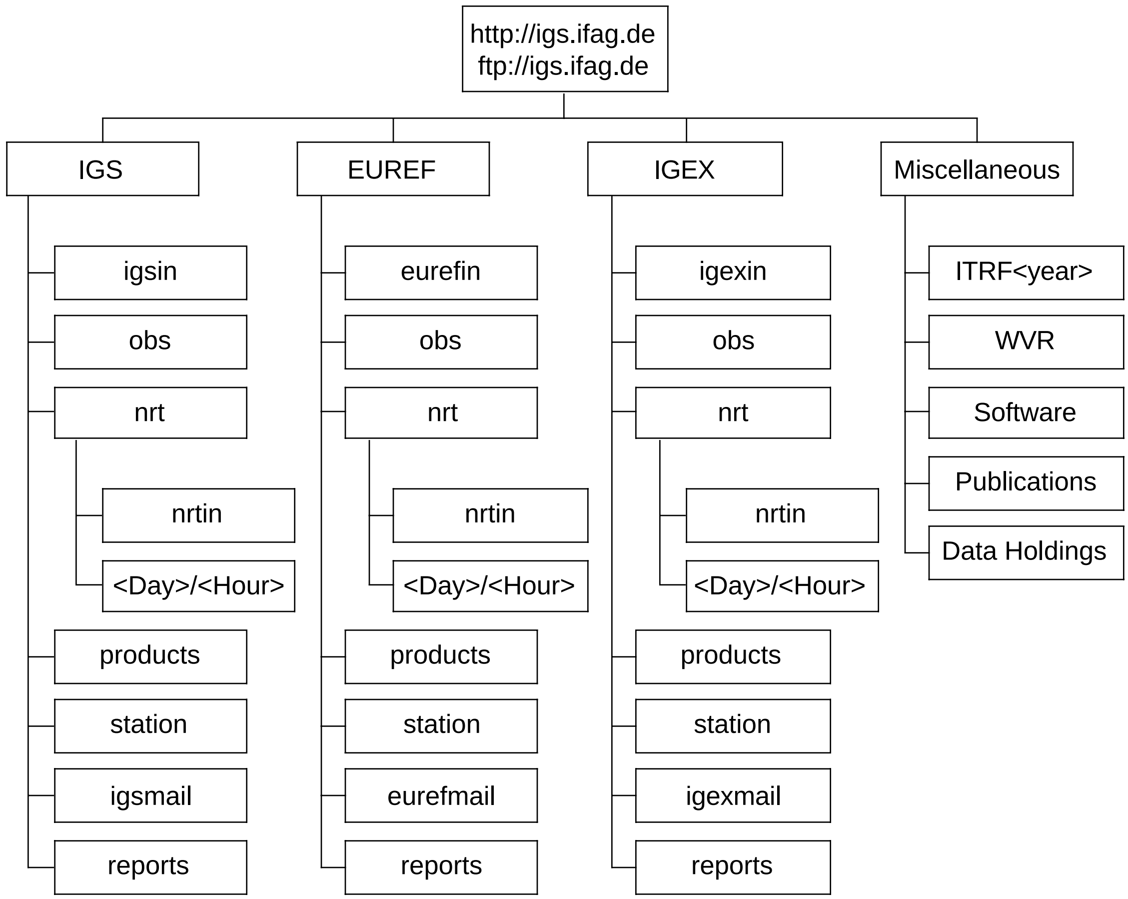

Figure 1: Access and Structure of the BKG Data Center

concatenated hourly files with the daily observation files, which are submitted by each station at the end of a day, using the program RNXDIF (Habrich H., 2001). Detected differences are saved into summary files for each station and publicly available. This long term study may be contribute to decide, that the daily observation files should no longer be submitted additionally.

Figure 2 shows the latency of hourly RINEX observation files for GPS week 1115. About 40 % of the hourly IGS observation files had been available at BKG at 8 minutes after the full hour, and only 1 % show a latency of more than 30 minutes. The files of the EUREF and IGEX projects show a latency of 8, i.e., 10 minutes for the majority of the sites.

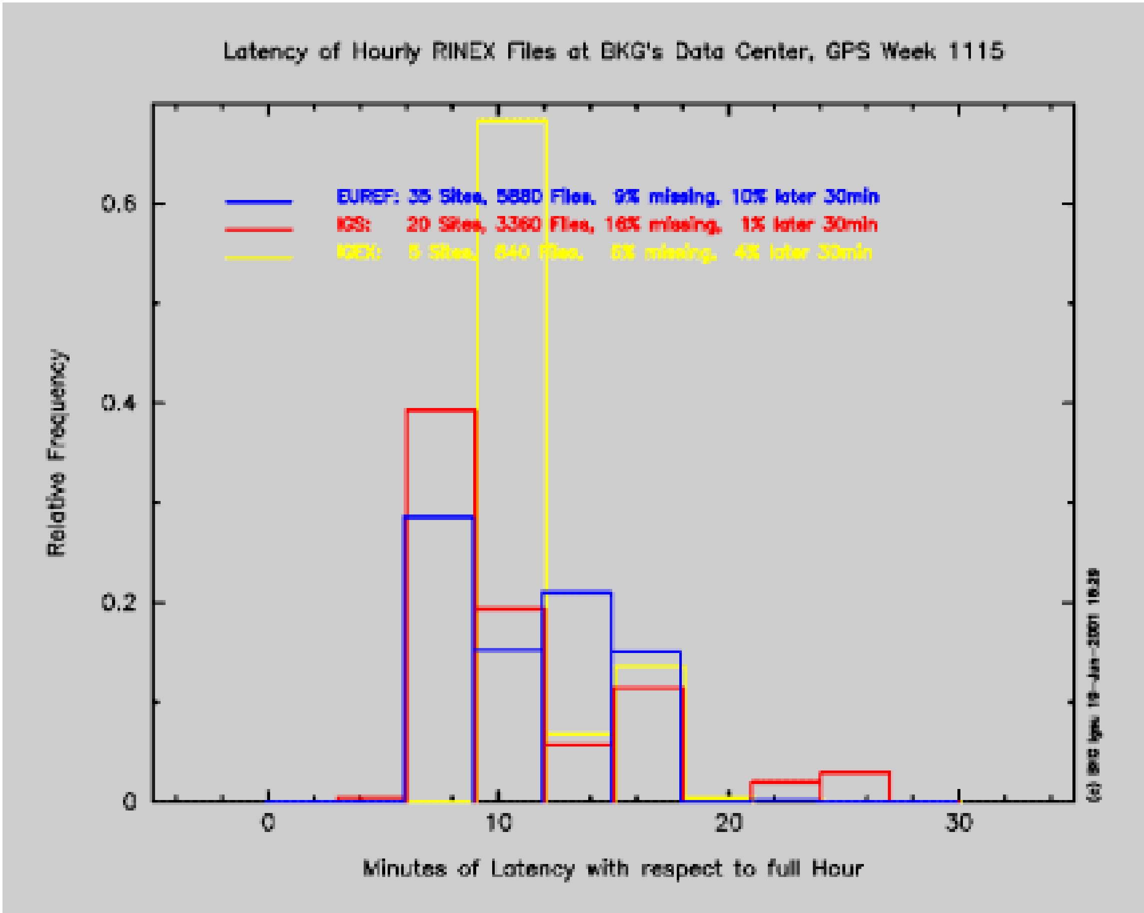

Figure 2: Latency of Hourly RINEX Files for GPS Week 1115

User Activity And Future Plans

The total number of stations (i.e. of receivers) of BKG's data center has increased to 160. Approximately 100 distinct users contact the data center and perform some 10,000 file transfers every day. In order the make the success to the data center more comfortable, it is planed to extend the html pages with dynamic links and the possibility of user queries.

References

Habrich H. (2001): *Concatenation of Hourly RINEX Files*, Physics and Chemistry of the Earth, Vol. 26, No. 6-8,pp, 561-567, 2001, Elsevier Science Limited, Oxford, England.

Hartebeesthoek Radio Astronomy Observatory (HartRAO)

Ludwig Combrinck

Abstract

This report gives an overview of our IGS activities during the year 2000. A brief description of our involvement with other space geodesy techniques is given.

Geodesy at HartRAO

HartRAO is located north of Johannesburg, South Africa, in a valley of the foothills of the Wit-waters mountain range (see Table 1). HartRAO uses a 26 metre equatorially mounted Cassegrain radio telescope built by Blaw Knox in 1961 (Figure 1). The telescope was part of the NASA deep space tracking network until 1975 when the facility was converted to an astronomical observatory. The radio telescope is collocated with an IGS GPS station HRAO and an SLR station MOBLAS6. HartRAO is the IGS regional data centre for Africa.

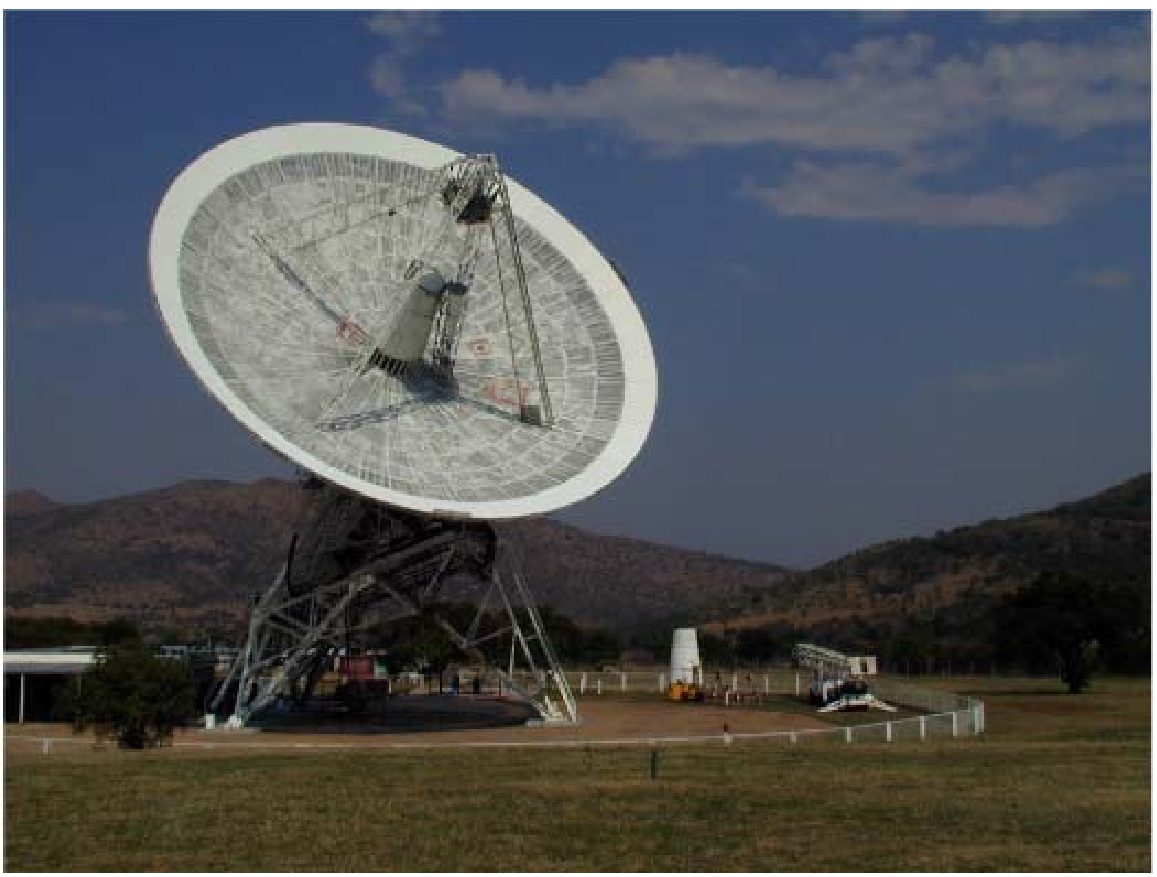

Figure 1. The 26 metre radio telescope. Solid panels have been fitted on the outer ring as part of a surface upgrade. All panels will eventually be replaced with non-perforated, higher tolerance panels. Typical rms accuracy of these panels is 170 microns.

Table 1. Location and addresses of HartRAO.

Latitude	25.889- S
Longitude	27.686- E

Hartebeesthoek Radio Astronomy Observatory
Geodesy Programme
PO BOX 443
Krugersdorp, 1740, SOUTH AFRICA
http://www.hartrao.ac.za/geodesy/geodesy index.html

IGS Activities

HartRAO supported an IGS tutorial presented by Ruth Neilan (IGSCB), Angelyn Moore (IGSCB) and Jan Kouba (NRC) on the 3rd of April 2000. The tutorial was well attended by delegates from local universities, the Weather Bureau, local surveying companies and the Council for Geosciences. After the necessary equipment procurement, HartRAO will be able to operate as a mirror site for the IGSCB, which will facilitate the use of all its products by local users. The IGS tutorial was greatly appreciated and we wish to thank the IGSCB for visiting South Africa.

The author attended the Second Network workshop of the IGS in Oslo, Norway, during July 2000. A position paper was presented at the conference (Combrinck & Chin 2001). The author acted as one of the guest editors for the conference proceedings. The kindness of Hans-Peter Plag, Oddgeir Kristiansen and Gunnar Elgered led to very interesting and worthwhile visits to Statens kartverk (Norwegian Mapping Authority) and the Onsala Space Observatory. A special effort by Jan Johansson and his wife must be mentioned as this led to a day of sailing.

Regional Data Centre

Rinex data for 16 IGS stations and one regional station (NAMI, see Figure 2) were archived. The IGS station SUTH (Figure 3), located at Sutherland suffered data outage due to a nonfunctional receiver at the end of December 2000, but was restored to working order soon afterwards. An additional 20 GB hard disk was procured for GEOID, the data centre server, to cope with the increasing amount of data. Due to the exposure the IGS achieved during the year 2000, rinex data and IGS product retrievals have increased with regular access by local users and neighbouring countries.

Figure 2. The NAMI GPS antenna monumentation located in Windhoek, Namibia. The antenna needed to be elevated to alleviate the possible adverse effect of multi-pathing from a nearby corrugated iron roof. The pole is thick-walled and stayed for rigidity. NAMI is a regional station at the moment, but it is hoped that an equipment upgrade can bring it to IGS status. (Donors?)

Figure 3. The SUTH IGS GPS antenna monumentation. The antenna is situated on a hill overlooking the barren semi-desert of the Karoo.

Current Activities

We are continuing our footprint survey, which has as its main purpose the determination of eccentricities between the GPS, VLBI and SLR reference points as well as the maintenance of a control network to enable stability monitoring of the site on a local scale. The current eccentricities between VLBI and SLR (Table 2) were determined using GPS (Combrinck & Merry 1997) and the SLR to GPS eccentricities values are from 1998 footprint results. We are processing HRAO ina17 station regional (IGS) network and envisage processing the SLR (MOBLAS 6) data for eccentricity determinations. This will strengthen collocation and with accurate eccentricities should tie the independent ITRF coordinates to a high degree of accuracy.

Table 2. Table of eccentricities, VLBI telescope to SLR and GPS (HRAO) reference points.

Reference	Coordinate	Δ	σ (mm)
SLR	X	41.680	15.8
SLR	Y	-66.564	7.5
SLR	Z	-8.131	3.9
HRAO	X	90.236	15.8
HRAO	Y	-132.190	7.5
HRAO	Z	-34.704	3.9

Future Plans

In order to bring geodesy closer to home and the African continent, the Geodesy Programme is in the process of establishing a Geodetic Institute for Africa. The purpose of this Institute at HartRAO will be to establish strategic alliances and collaborative projects with other African countries. These projects will be tied in a unifying structure which will advance and support Africa's role in geodesy. It will support and promote the activities of the IVS, ISLRS and IGS. It will also support the objectives of the African Reference Frame (AFREF).

With the addition of the MOBLAS-6 SLR unit, several new staff members were recruited as part of the SLR project. Plans are in progress to expand GPS activities and to develop an active research component as an IGS Associate Analysis Centre. We are in the process to equip Zambia, Malawi, Mocambique, Madagascar, Botswana, Namibia and Zimbabwe with IGS stations. Members of the IGS who upgrade stations and have redundant equipment available should please contact the author.

References

[1] Combrinck W.L. and Merry, C.L. Very long baseline interferometry antenna axis offset and intersection determination using GPS. JGR, Vol.102, NO.B11, pp 24,741-24,743, 1997.

[2] Combrinck W.L and Chin, M. IGS Stations: Station and Regional Issues. Phys. Chem. Earth (A), Vol. 26, N0.6-8, pp. 539-544, 2001.