IGS

NETWORK AND STATION REPORTS

GLOBAL, REGIONAL, AND LOCAL NETWORKS

Meeting the Challenges of 1999

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A major focus for the IGS network of precise GPS tracking stations in 1999 was the integrity of tracking station metadata, such as receivers and antennae installed over the history of the site, as recorded in the official IGS site logs. Necessary information such as standardized equipment naming conventions was updated at the Central Bureau with the help of a team including IGS Operational Data Centers and GPS equipment manufacturers. The system for detecting format errors and inconsistencies between site logs and data file headers was vastly improved and took on the automatic task of emailing site operators with any problems found. Furthermore, the format scanning software enabled a new system for the automatic email submission of logs, and a facility for operators to check site log format compliance on a test basis prior to submission. These tools, along with considerable operator effort, reduced the number of metadata discrepancies from well over 120 to 7 over the course of calendar 1999. The dedicated people comprising the IGS network component are to be commended for their part in this marked improvement, which enabled the first IGS SINEX combinations.

The year 1999 may be considered the "year of rollovers," perhaps especially for the GPS community, which experienced a GPS week 1000 rollover, a GPS week 1024 rollover, and of course preparations for the well-publicized Y2K rollover. In retrospect, these were readily handled in terms of the IGS network with software changes where necessary, and diligent attention by many IGS operators and analysts around the times of the rollovers. Rollover testing on the GPS satellites themselves resulted in undesirable effects in some IGS network receivers, and the IGS community quickly determined the extent and resolution by way of the IGSMail email list.

The approaching solar maximum presented another network technical difficulty which was addressed by several IGS components. The effect was first reported in late 1998 when sites with older TurboRogue receivers situated near the equator began to exhibit degraded tracking performance around local noon. Through 1999 as ionospheric activity continued to increase, this situation worsened to include mid-latitude sites. Communication and cooperation within the network and analysis components allowed evaluation of the extent of the problem and identification of equipment upgrades or software workarounds which would restore acceptable data acquisition.

Growth of the IGS Network

The IGS network of stations continued to grow both in number and in function through 1999. In total, 28 stations were added, including both new installations and previously existing sites which became IGS stations by submitting a site log to the IGS Central Bureau. The new group includes 11 southern hemisphere sites, and some which are favorably situated in regions where IGS coverage has been historically low. New sites are indicated on the map in Figure 1 in capital letters.

The following previously operating sites joined the IGS network in 1999 by submitting a site log to the IGS Central Bureau and sending data to an IGS Data Center:

ALIC	Alice Springs, Australia	
BJFS	Beijing, P.R.C.	
CEDU	Ceduna, Australia	
CHWK	Chilliwack, Canada	
DARW	Darwin, Australia	global
INEG	Aguascalientes, Mexico	
JAB1	Jabiru, Australia	
KARR	Karratha, Australia	
PIMO	Quezon City, Phillipines	global
RIOG	Rio Grande, Argentina	global
STR1	Canberra, Australia	
SYOG	East Ongle Island, Antarctica	
TID1	Canberra, Australia	
TOW2	Cape Ferguson, Australia	global
TUBI	Gebze, Turkey	

The following new stations also joined the IGS in 1999:

ARTU	Arti, Russian Federation	global
BILI	Bilibino, Russian Federation	
BUCU	Bucuresti, Romania	
CIC1	Ensenada, Mexico	Replacing CICE
CORD	Cordoba, Argentina	
DAEJ	Taejon, Korea	Replacing TAEJ
ISTA	Istanbul, Turkey	
JAMA	Kingston, Jamaica	
NRC2	Ottawa, Canada	
TRAB	Trabzon, Turkey	
UZHL	Uzhgorod, Ukraine	
YKRO	Yamoussoukro, Cote D'Ivoire	global
YSSK	Yuzhno-sakhalinsk, Russian Federation	

Here "global" denotes those new stations which enjoy sufficient worldwide popularity among Analysis Centers as of this writing to earn the IGS "Global" site label, which denotes sites regularly analyzed by at least one Analysis Centers, including at least one on a different continent. The set of IGS Global sites is shown in Figure 2 with the new sites labelled in capital letters.

The IGS hourly subnetwork, still voluntary in 1999, grew to nearly 50 sites, benefitting developments such as the new IGS Ultra-Rapid Orbit, as well as other near real-time applications, and readying the IGS for the upcoming low-latency needs of the Low-Earth Orbiter project.

Beyond the Successes of 1999

The advances in increasing and especially easily maintaining station metadata integrity not only aid IGS analysts and users, but also free the Central Bureau and Operational Data Centers to pursue other improvements in coming years. There is increasing interest in pinpointing patterns of usage of IGS station data; easy determination of which Working Groups and Pilot Projects make use of a particular site is a common request warranting attention from the network coordination element. Rapid advancements in applications requiring low-latency network operations will continue to demand insightful communication within the network in order to meet the need for collective network development and improvement.

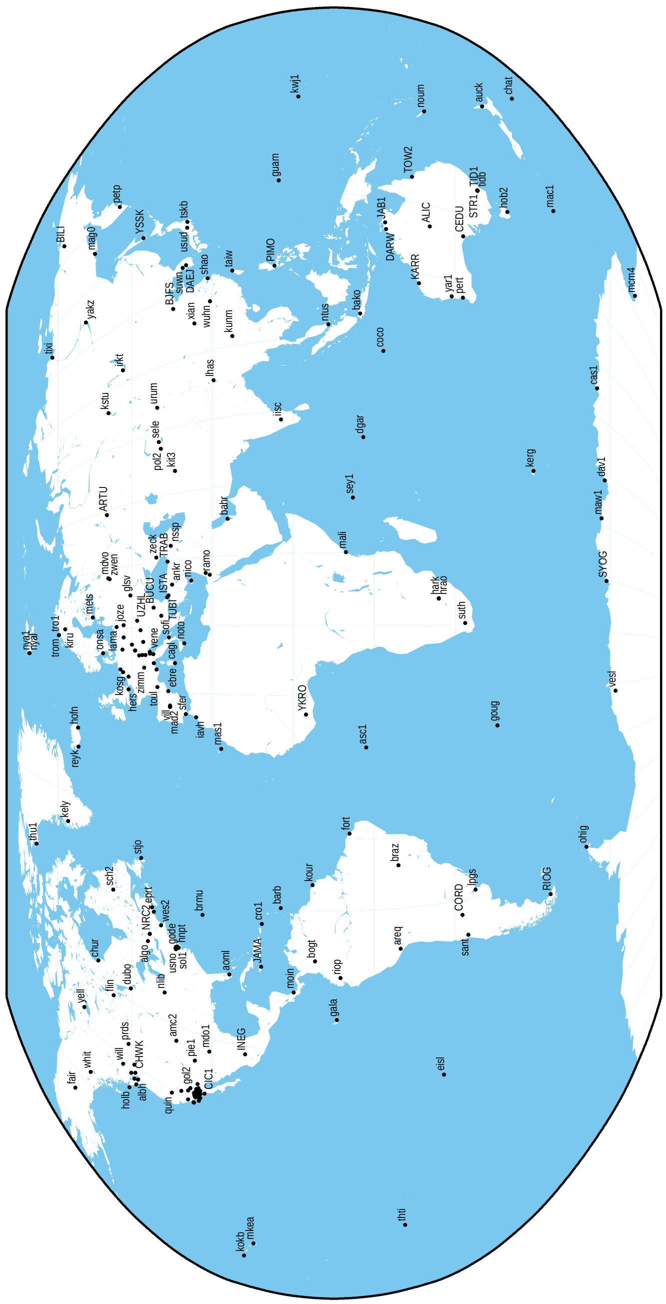


Figure 1. The IGS Tracking Network at the end of 1999. Stations new to the network in 1999 are labelled with capital letters.

Figure 2. IGS Global Stations at the end of 1999. Global Stations are routinely analyzed by at least three IGS Analysis Centers. Stations added in 1999 are labelled with capital letters.

The Australian Regional GPS Network
1999 Report

Jim Steed, Bob Twilley, Paul Digney
AUSLIG

Introduction

The Australian Regional GPS Network (ARGN) continued to operate successfully during 1999. As well as ensuring the continued operation of the sites, the systems were made more robust and users were kept informed of relevant changes through an E-mail list. The GPS week rollover and Y2k were managed successfully and receiver upgrades were introduced to cope with increasing ionospheric activity.

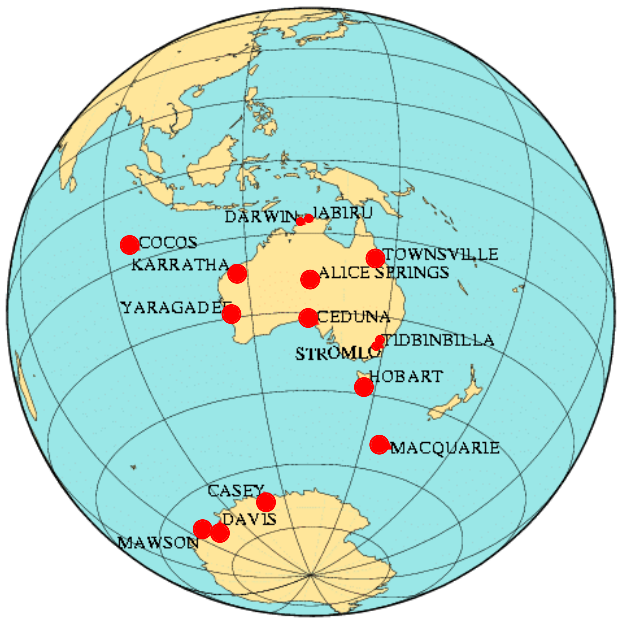


Figure 1. The Australian regional GPS Network

User Interface

Rinex data from all ARGN sites continues to be available from AUSLIG's WWW site (http://www.auslig.gov.au/geodesy/argn/argn.htm) and the same data is also available in Hatanaka format from the AUSLIG anonymous FTP site (ftp://ftp.auslig.gov.au/igs/).

In June 1999 a group E-mail system was introduced to keep ARGN users informed of any changes with the ARGN. Users can subscribe to the service to receive E-mail notifications and the archive of E-mails can be viewed on the web (http://www.auslig.gov.au/geodesy/argn/argnmail.htm). In most cases the information in these E-mails is repeated in IGS E-mail that continue to be distributed when necessary.

All relevant site changes are also documented in the site logs (http://www.auslig.gov.au/geodesy/argn/argnlogs.htm).

Before it is released, all ARGN data is quality checked using the UNAVCO TEQC software. Graphs for each site, indicating data availability, latency and quality are available on AUSLIG's WWW and are automatically updated daily. A summary of this information can be seen in the graphs in Annex A. In these graphs, the shaded vertical column indicates that data has been collected for that day and the joined black dots show the actual observations obtained each day as a percentage of the theoretical maximum.

RINEX translation software was updated on 10 August to ensure that the ARGN data conformed to the current file transfer standards. This version 2.5.2 of RGRINEXO had a significant impact on the translation of TurboRogue Ascii Conan data to RINEX, removing L2 observables if either P1=P2 or L2=L1. The removal of this bad data resulted in a decrease of about 10-15% in the collected data shown in Annex A (e.g. Alice Springs). This apparent data loss due to the low L2 signal to noise ratio of the cross-correlating TurboRogue receivers was later recovered when the receivers were upgraded to the TurboRogue ACT.

Site Updates

Firmware

In anticipation of Y2K and the GPS week rollover on 21-22 August, ARGN GPS (and Glonass) receivers were updated with the latest version of firmware. This preparation generally avoided problems with these events, although the Antarctic sites were not updated until access was available at the start of the southern summer. At these sites the backup receivers (Ashtech Z12 CGRS) were switched into operation until the TurboRogue firmware could be upgraded later in the year. This strategy worked satisfactorily at all sites except Casey, where the PC did not have the relevant software to download data from the Ashtech Z12 CGRS. Data from Casey became available again in early December, when the site was visited by AUSLIG staff with equipment and firmware upgrades. Table 1 shows the firmware version and date of implementation for each site.

Table 1: Firmware upgrades for GPS Week Rollover and Y2K

Site	Receiver	Date updated	New Firmware Version
Alice Springs	TurboRogue	31 July 1999	3.2.32.9
Macquarie	Ashtech	20 December 1999	CD00
Davis	TurboRogue	2 November 1999	3.2.32.9
Casey	TurboRogue	9 December 1999	3.2.33.9
Cocos	TurboRogue	18 August 1999	3.2.32.9
Hobart	TurboRogue	16 August 1999	3.2.32.9
Mawson	TurboRogue	22 October 1999	3.2.32.9
Ceduna	TurboRogue	4 August 1999	3.2.32.9
Darwin	TurboRogue	21 July 1999	3.2.32.9

Site	Receiver	Date updated	New Firmware Version
Jabiru	Ashtech	27 July 1999	CC00
Karratha	TurboRogue	3 July 1999	3.2.32.9
Stromlo	TurboRogue	23 August 1999	3.2.32.9
Tidbinbilla	TurboRogue	20 August 1999	3.2.32.9
Townsville	TurboRogue	11 August 1999	3.2.32.9
Yaragadee	TurboRogue	28 July 1999	3.2.32.9

Hardware

The graphs at Annex A show that in the later part of the year, at equatorial and high latitude sites, there was a decrease in data collected. This was apparently due to the effect of the increasing solar activity on the cross-correlating TurboRogue receivers resulting in low signal to noise on L2. To solve this problem a program to upgrade to the ACT technology was implemented. An immediate improvement in data was obtained when upgraded receivers were installed at the critical sites (e.g. see the improvement at Darwin on day 329, in Annex A). This upgrade program took some time and continues into 2000. To provide spare receivers for this upgrade program, the AUSLIG receivers at Tidbinbilla and Yaragadee were temporarily removed, leaving the JPL receivers operating on the same antenna. Upgraded receivers will be returned to these sites early in 2000.

Table 2: TurboRogue ACT GPS receivers installed

Site	Date Installed	Firmware Version
Cocos	12 December 1999	3.3.32.3
Darwin	25 November 1999	3.3.32.3
Hobart	30 November 1999	3.3.32.3
Stromlo	19 November 1999	3.3.32.3
Townsville	27 November 1999	3.3.32.3

In the leadup to the GPS week rollover and Y2K, backup Ashtech Z12 CGRS receivers were installed at Cocos, Hobart and Townsville. These receivers are connected with a splitter to the same antenna as the TurboRogue, ready for immediate changeover if required. In addition, all sites had a new GPS power controller installed to enable remote access to the GPS receivers' power.

At sites where network connection is not available and only telephone access is used (dialup), additional telephone/modem lines were installed to provide redundant communications.

Significant Events

Because of the remoteness of the generally unattended ARGN sites, communications are a continuing issue and account for most of the small outages seen in Annex A. However there were a few significant outages, other than those previously mentioned.

Casey

Inspection of the graph for Casey at Annex A shows a regular weekly dropout in the first part of the year. After some investigation this was traced to a problem with the on-site PC and was rectified.

Darwin

The Darwin site was again affected by lightning during the wet season (November-March) and required a complete overhaul, meaning that no data was available during the first half of the year. Improved lightning protection was installed and the site has successfully survived the first part of the current wet season.

Jabiru

The disconnection of the network at Jabiru meant that telephone dialup access has been used since 20 April 1999. The large block of missing data shown in Annex A is available in the on-site PC, but has not been retrieved due to the load on the phone access. It is not known as to whether the network connection will be re-established.

Cocos

A data gap of about fifty days early in 1999 at Cocos Island was due to receiver failure, combined with difficult access and communication. The receiver was subsequently replaced and operation continued largely uninterrupted for the rest of the year.

Davis

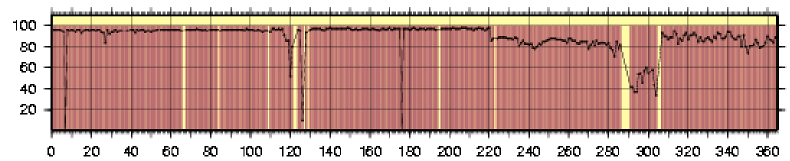
A deterioration in the data at Davis from about day 344 is thought to be due to a hardware malfunction and is expected to be fixed by the installation of a TurboRogue ACT that is to be sent on the first available ship in 2000.

Summary

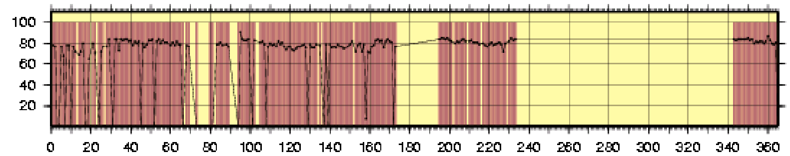
The remoteness of the ARGN sites and the uncertainties of the communications over extreme distances always provide a challenge. However - despite the triple threat of GPS rollover, Y2K and increasing ionospheric disturbance - the improved systems, quality checking and vigilance on the part of the project team ensured that the ARGN reliably provided quality data on AUSLIG’s web, within a few hours of the end of the observing day.

ARGN Data Availability and quantity, 1999

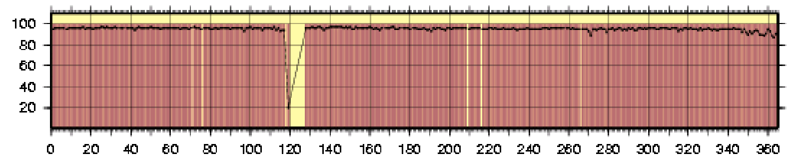
Annex A



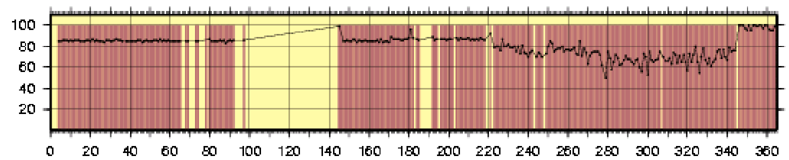
Alice Springs



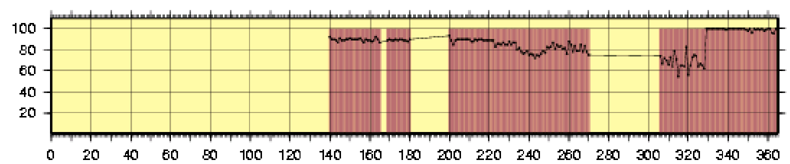
Casey



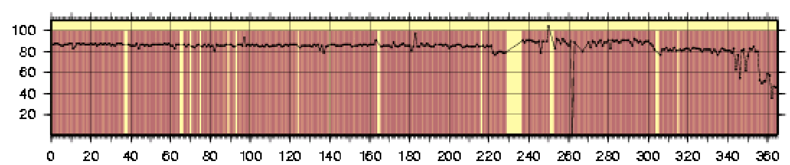
Ceduna



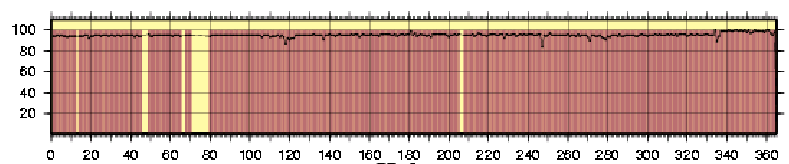
Cocos



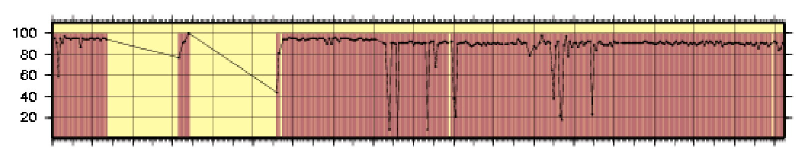
Darwin



Davis

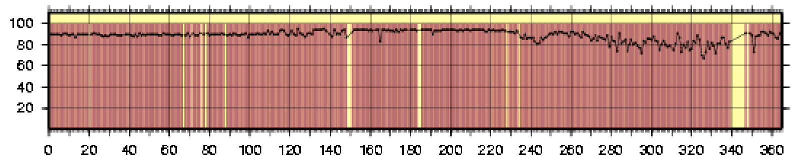


Hobart

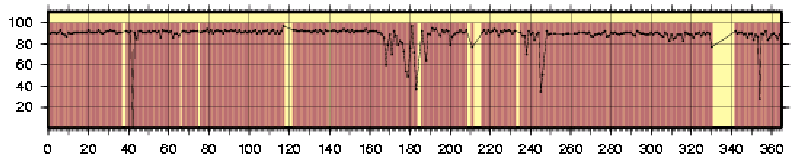


Jabiru

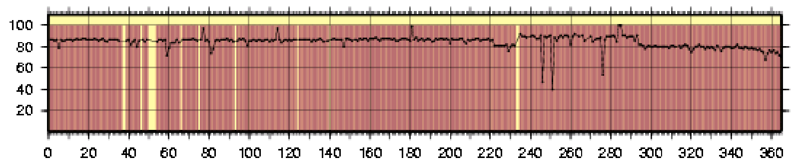
Annex A (cont'd)



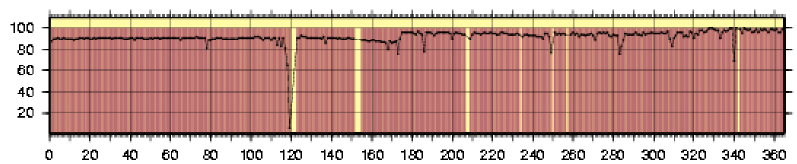
Karratha



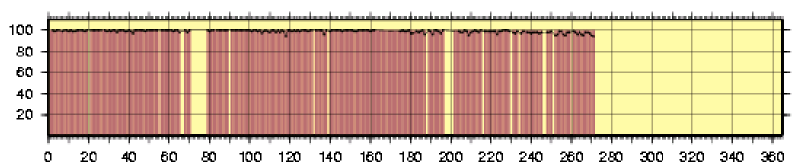
Macquarie



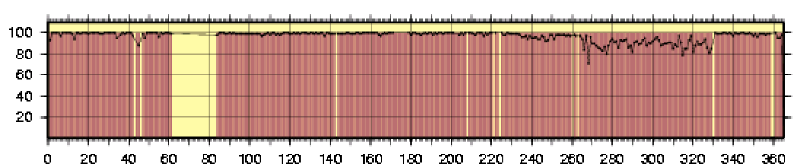
Mawson



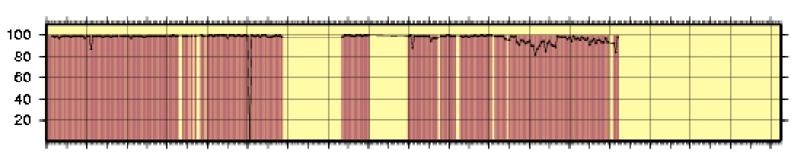
Stromlo



Tidbinbilla



Townsville



Yaragadee

The GPS Receiver Network of ESOC: Maspalomas, Kourou, Kiruna, Perth, Villafranca and Malindi

C. Garcia, J.M. Dow, J. Feltens, I. Romero

ESA/European Space Operations Centre.
Darmstadt, Germany.

Overall Hardware Configuration

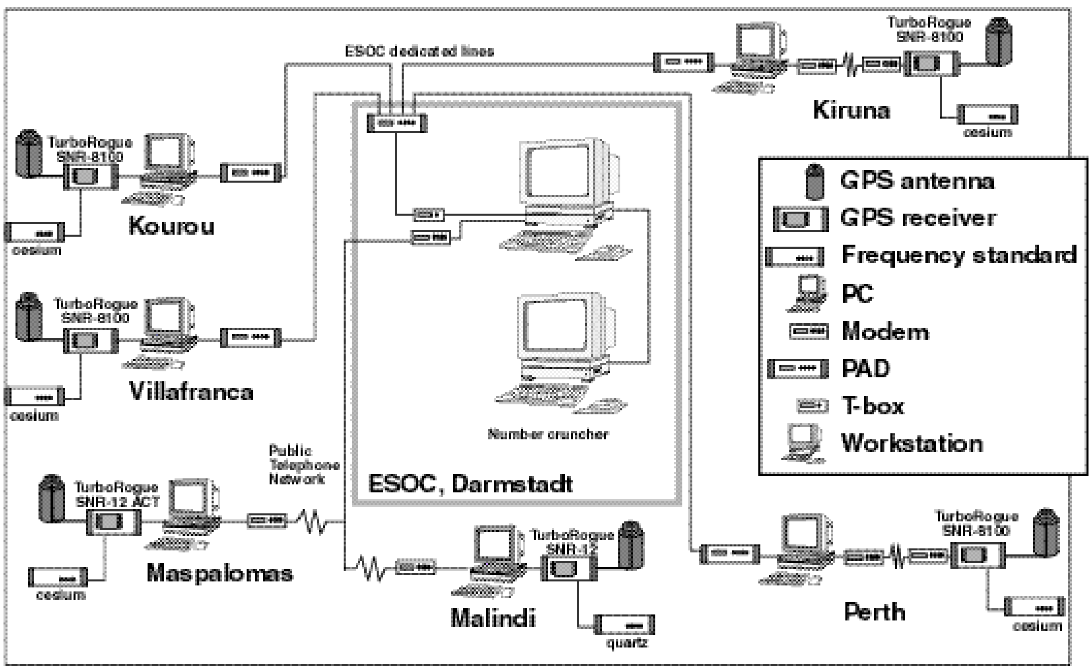


Figure 1 shows the configuration of the ESA stations by the end of 1999.

Receiver Performance

Two major events are remarkable in 1999 regarding the IGS network. The GPS roll-over in August and the Y2K compatibility.

The firmware of our TurboRogue receivers was upgraded to release 3.2.32.9 during the first months of the year and both roll-over and Y2K did not represent a problem.

The software of our remote computers was patched to overcome some problems with non Y2K compliant operative system and applications. A solution to avoid the difficult replacement in remote locations was possible.

As it was reported in the IGS Network Systems Workshop, held in Annapolis 2-5 November 1998, the TurboRogues located at equatorial stations show many limitations in the cross correlation mode tracking during the solar maximum. The only solution is a replacement by new receivers.

Maspalomas was upgraded to a AOA SNR-12 ACT on August 14th. The performance of the receiver during the high ionospheric activity periods was greatly improved.

The new receiver required several modifications to the software of the remote computer in order to be download it in the way recommended by IGS. All observables had to be downloaded to be able to reconstitute the cross correlation observables and process the data along with the cross correlation receivers which were by then the main part of the IGS network.

An effort was undertaken to evaluate new types of receivers to diversify and upgrade our network. The Ashtech Z-XII and the Z-FX were considered as well as the Javad Legacy. We will also continue to upgrade our existing AOA TurboRogue receivers to ACT during the year 2000.

One-Hour Downloads.

One-hour data of Kiruna, Kourou, Perth and Villafranca are available since September 1998. These stations have permanent leased data links to ESOC. The data flow has been continuos with only one hour latency during 1999.

The hourly data is currently included in the ESA Rapid solution, if available, and mainly as the basis for the new Ultra Rapid products, developed towards the end of the year.

Solar Eclipse Campaign

A solar eclipse took place in Central Europe on the 11th August 1999. A campaign was organized by the IGS Ionosphere Group. Our European stations, Maspalomas and Villafranca collected data with a higher sampling rate than normal for this purpose (3 sec.)

References

GPS-TDAF Stations Configuration Manual. Version 1.4, October 1999.

The GPS receiver Network of ESOC: Maspalomas, Kourou, Kiruna, Perth, Villafranca and Malindi. C. Garcia-Martinez, J.M. Dow, T. Martin-Mur, J. Feltens, P. Bernedo. 1998 Technical Reports. IGS Central Bureau.

ESA/ESOC IGS Analysis Centre Poster Summary. C. Garcia-Martinez, J.M. Dow, T. Martin-Mur, J. Feltens, P. Bernedo. 1998 IGS Network Systems Workshop.

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Technical Improvements of the IGS Stations Monitored by GFZ

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Introduction

An improving of the data quality and the data availability at the GPS Analysis Centres in time are permanent tasks for monitoring the IGS network. According to these requirements the IGS stations monitored by GFZ have been improved by the following features:

1. All receivers ROGUE SNR-8000 have been replaced by the upgraded AOA SNR 8000 ACT receivers.
2. The file size has been set to hourly data files and the data are transferred to the IGS data centres in hourly intervals.
3. The file transfer from the IGS site to ODC Potsdam has been improved by installing of a radio modem link and better telelephone modem and Internet connections.

Data Transfer Routes

Depending on the infrastructure at the GPS site different communication links are used for the data transfer. Fig 1 shows the data transfer routes for the IGS sites. Beside the direct Internet and telephone modem link to an Internet Service Provider special applications of radio modem links and Inmarsat-A are in use.

Radio Link

In areas with bad or no telephone connection to the station radio modem links can operate. Two different applications are in use.

- Direct data transfer between the station computer and a computer at a location with Internet connection. The frequency range of the radio modem (Type WIMAN) is 2.4 to 2.48 GHz, and the modems operate up to a distance of 60 km. 115.2 Kb/s is the maximum transfer speed.
- Wireless Internet connection to an Internet Service Provider via ORINOCO Fixed Wireless PC Card. It can provide 2 Mb/s IEEE 802.11b high rate compliant wireless connectivity.

Inmarsat-A

For long distances a satellite-based file transfer is the only way to obtain data in near real-time. As soon as the logging computer gets a new set of data the file is transferred to a second local computer (part of the Inmarsat Mobile Station), who’s only task is to establish the link to the Inmarsat satellite. Using the high-speed data channel of Inmarsat-

A (transfer rate up to 64 Kb/s) the file is sent to the base-station in Norway and via ISDN to a listener-computer (part of the Sky Link Base Station) at GFZ. The file is then moved forward to ODC (Operational Data Centre) Potsdam via FTP.

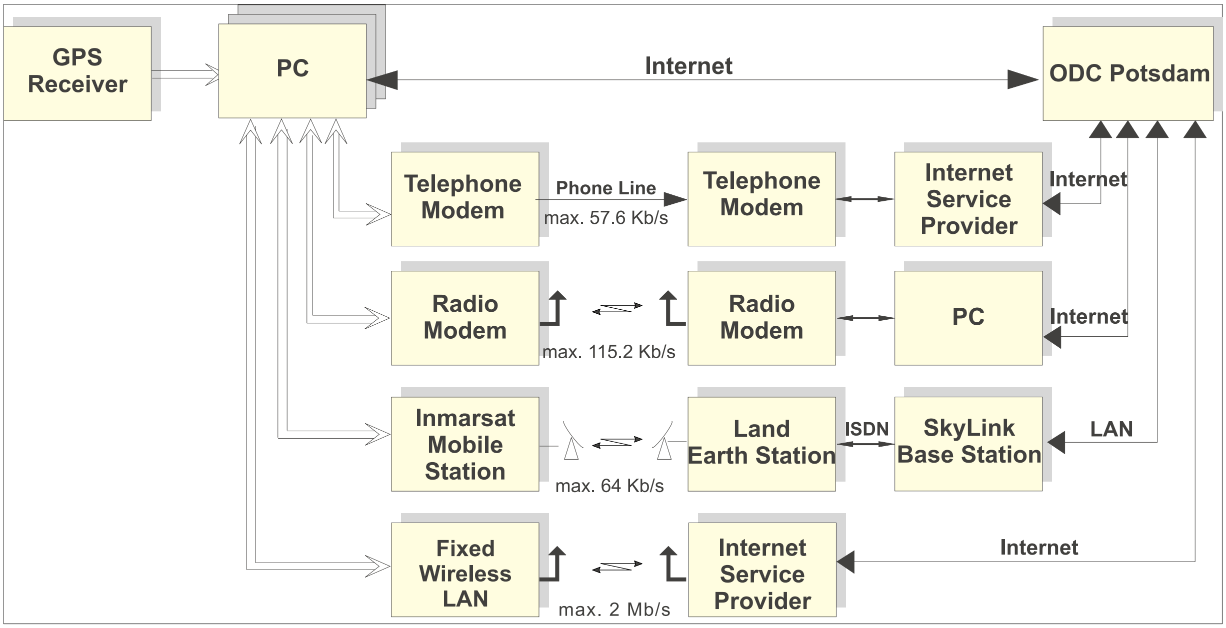

Figure 1. Data transfer routes of IGS stations.

The present configurations of the stations (hardware, software, file transfer and latency) are summarised in Table 1. The station KIT3 has been prepared for modem and Internet connection. Unfortunately the new phone line to the KIT3 station could not be installed. Therefore in the near future an Inmarsat-A system will be installed.

New Station

The station UNSA got the IGS status in March 2000. It is located at the University of Salta in Argentina. Based on an Ashtech Z12 receiver the station operates automatically and delivers hourly data files.

NASA-Sponsored GPS Global Network Activities

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University NAVSTAR Consortium, Boulder, CO, USA

R Khachikyan
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Activities in 1999

NASA continues to sponsor the maintenance, upgrade, and expansion of a significant fraction of the global GPS network.

Seven new sites were established in 1999 including CIC1 (a momument relocation from CICE), PIMO, CORD, and YKRO. ARTU, YSSK, and BILI were installed in collaboration with IRIS and RDAAC.

The TurboRogue L2 tracking issue continues to be a problem. Receiver upgrade or replacement still appears to be the best solution, although several sites (USUD and PIMO) are running at 1s, essentially providing a "workaround" to the tracking problem as well as yielding high rate data in support of real-time applications and Low Earth Orbiter (LEO) missions.

During the year, TurboRogue receivers were replaced with ACT-type receivers at sites ASC1, CRO1, DGAR, HARV, KWJ1, and SANT.

Approximately 60 receivers were upgraded with Y2K and GPS week rollover compliant firmware.

Computer replacements were installed at 26 locations to enable useof a common linux-based offload platform.

A VSAT installation was utilized for improved communications at Galapagos and is planned for the Uganda site.

Site reconnaissance was performed for new sites in Uganda andBrazil which are planned to be installed during 2000.

FAIR, GODE, and KOKB were established as initial LEO support sites in 1999, and operate with ACT-type receivers at 1s samplerate. Nearly 20 sites are now operated at 1s with a mix of AOA and Ashtech receiver types.

NRCan – GSC
Western Canada Deformation Array GPS Network
1999 Report

Michael Schmidt, Herb Dragert
Geological Survey of Canada
Natural Resources Canada

Introduction

The Western Canada Deformation Array (WCDA) is the western component of the Canadian Active Control Network. As of the end of 1999 the WCDA consisted of 12 stations, 11 of which contribute data to the IGS. The 12th station (PGC5) is considered a test site and is therefore not posted to the IGS. New receiver technology and data flow were implemented at some sites and all receivers had firmware upgrades to handle the GPS week rollover and Y2K events. Two sites, DUBO and FLIN, are supported under a joint GSC – NASA/JPL research agreement.

Figure 1. WCDA GPS Network

Data Retrieval, Validation and Distribution

Data retrieval is handled by an automated process on a UNIX platform. This process, *'rogueget'*, is scheduled hourly for those sites that contribute 1-hour files to the IGS. Other sites are scheduled for data retrieval and validation every four hours. At the termination of each 24-hour period all partial files are merged to form 24-hour files.

All data is validated as it is retrieved and again after the creation of the 24 hour files. The validation process uses three separate programs: GIMP, GPSPACE (both GSD/NRCan) and TEQC (UNAVCO). GIMP provides arc-by-arc statistics including number of observations, data gaps and cycle slips, ionospheric parametres and multipath parametres.

The daily totals and averages of these parametres are appended to monthly summary files used for generating validation plots. ASCII summary files are generated with a detailed output for each 24-hour data file. The data check keys on the number of observations, data gaps and cycle slips. The remaining parametres are used to monitor ionospheric disturbances and site multipath characteristics. GPSPACE uses either broadcast orbits or 'SP3' format orbits to calculate single point position, clock offset and clock drift. The output from GPSPACE includes arc by arc statistics (start / end time, No. of observations, range residuals), daily totals and averages of these parametres as well as detailed ASCII summary files. The data check keys on the number of observations and computation epochs, the daily position offsets and for sites with external clocks, the clock offset and drift.

The results from the automated GIMP and GPSPACE validation, run after each offload, are logged in a daily log file – tolerances for the automated check are specified in a separate input file. Email warning messages are broadcast to staff tasked to oversee the daily operations.

TEQC was implemented in 1999 and all data are processed by TEQC upon download and after merging of partial files. Summary statistics are appended in an annual summary file used for plotting. Summary files are generated and posted with the data. The transition to use TEQC for RINEX'ing all data was started in 1999.

The receiver binary native format is converted to RINEX and compressed using the Hatanaka and UNIX compression schemes prior to distribution. All meta data for the RINEX header is generated on the fly from a time stamped input file to ensure correct meta data in the RINEX file headers. The compressed files are posted on a local FTP server and pushed to CDDIS immediately after automated data retrieval and validation is complete. The compressed RINEX data files as well as the IGS site logs are available via the web at:

http://www.pgc.nrcan.gc.ca/geodyn

and via anonymous FTP from sikanni.pgc.nrcan.gc.ca.

Site Upgrades

Site upgrades include receiver, receiver firmware, antenna and dome changes. In-line RF surge arrestors have been installed at those sites considered most at risk. It is planned to equip all WCDA sites with lightning protection. A program to replace all EMRA domes with SCIS domes commenced in 1999.

Receiver Upgrades

Two stations were upgraded to the AOA BenchMark ACT technology. All other sites continue to operate with the Rogue SNR-8000 GPS receivers.

Table 1: AOA BENCHMARK ACT GPS receiver installation - as of Dec. 31, 1999

Site	Date Installed	Firmware Version
HOLB	May 19, 1999	3.3.32.2
DRAO	October 8, 1999	3.3.32.2

Firmware Upgrades

In order to prepare for both the GPS Week Rollover and Y2K all sites were upgraded prior to rollover resulting in no operational difficulties during either of these two events. Minor issues did crop up in downstream processes and were dealt with promptly to ensure robust data flow. Table 2 lists the receiver type with date of most recent firmware upgrade prior to December 31, 1999. The table does not reflect any changes made subsequent to January 1, 2000.

Table 2: Receiver Firmware: Date of Upgrade and Version Number - as of December 31, 1999

Site	Receiver Type	Date Installed	Firmware Version
ALBH	Rogue SNR-8000	August 8, 1999	3.2.32.9N
CHWK	Rogue SNR-8000	May 31, 1999	3.2.32.8
DRAO	AOA BENCHMARK ACT	October 8, 1999	3.3.32.3
DUBO	Rogue SNR-8000	May 26, 1999	3.2.33.8
FLIN	Rogue SNR-8000	May 26, 1999	3.2.32.8
HOLB	AOA SNR-8000 ACT	May 19, 1999	3.3.32.2
NANO	Rogue SNR-8000	May 13, 1999	3.2.32.8
UCLU	Rogue SNR-8000	June 1, 1999	3.2.32.8
WHIT	Rogue SNR-8000	July 30, 1999	3.2.32.8
WILL	Rogue SNR-8000	June 3, 1999	3.2.32.8
WSLR	Rogue SNR-8000	June 4, 1999	3.2.32.8

Antenna / Dome Upgrades

All WCDA sites are equipped with AOAD/M_T antennas. Several models of this antenna are available as indicated by the different part numbers used by the manufacturer. Serial numbers are re-used for the different models. Therefore in order to uniquely identify the antennas used in the WCDA a two-digit year, reflecting the year of purchase, has been inserted in front of the manufacturer's serial number for all GSC antennas. This avoids duplication of serial numbers given that older antennas have been upgraded. It also uniquely identifies the antenna when only the IGS antenna code and serial number are used in RINEX / SINEX file headers. It should be noted that IGS site logs for all WCDA sites include the antenna part number in the comments field.

The newer antennas provide better tracking characteristics. Table 3 summarizes the antenna upgrades made at WCDA sites in 1999.

Table 3: Antenna Type, Part Number and Upgrades - as of December 31, 1999

Site	Antenna Type	Antenna Part Number	Antenna Changes
ALBH	AOAD/M_T	7490582-1	
CHWK	AOAD/M_T	7490582-2	
DRAO	AOAD/M_T	7490582-1	
DUBO	AOAD/M_T	7490582-2	upgraded from 7490400-2 Aug. 18/99
FLIN	AOAD/M_T	7490400-2	
HOLB	AOAD/M_T	7490582-2	upgraded from 7490582-1 Jan. 6/99
NANO	AOAD/M_T	7490582-2	upgraded from 7490400-1 Aug. 6/99
UCLU	AOAD/M_T	7490400-4	
WHIT	AOAD/M_T	7490582-B	
WILL	AOAD/M_T	7490582-1	
WSLR	AOAD/M_T	7490582-2	

Most WCDA sites have domes placed over top of the AOAD/M_T antenna. Table 4 summarizes the dome types and changes made in 1999.

Table 4: Antenna Dome Status as of December 31, 1999

Site	Dome Type + RF screen	Changes
ALBH	EMRA + RF screen	
CHWK	SCIS	UNAV Dome replaced by SCIS Dome Aug. 5/99
DRAO	RF screen (no dome)	
DUBO	SCIS + RF screen	EMRA Dome replaced by SCIS Dome Oct. 4/99
FLIN	SCIS + RF screen	EMRA Dome replaced by SCIS Dome Sep. 21/99
HOLB	EMRA + RF screen	
NANO	EMRA + RF screen	
UCLU	EMRA + RF screen	
WHIT	RF screen (no dome)	
WILL	EMRA + RF screen	
WSLR	SCIS	

External Frequency (Clock) Status

Five WCDA sites are equipped with external 5MHz frequency standards. Some changes to these clocks were made in 1999 and are summarized in Table 5.

Table 5: External Frequency (clock) Status as of December 31, 1999

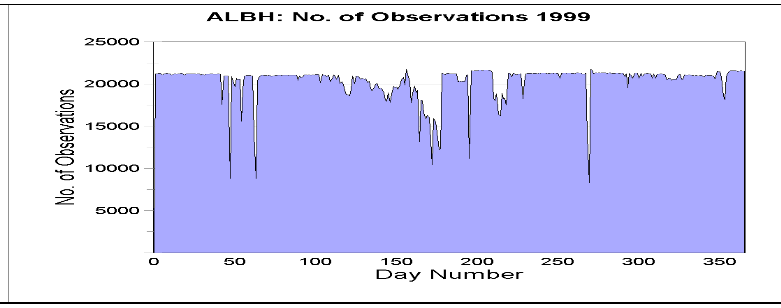
Site	Clock Type	Changes
ALBH	Rubidium	Cesium Jan. 1- Sep. 29/99 Clock Steering Sep. 29 – Dec 13/99 Rubidium Dec. 13/99
CHWK	clock steering	
DRAO	Hydrogen Maser	
DUBO	clock steering	
FLIN	clock steering	
HOLB	Rubidium	New Rubidium May 19/99
NANO	Rubidium	
UCLU	clock steering	Rubidium Jan. 1 – Mar. 27/99 Clock Steering effective Mar. 29/99
WHIT	clock steering	
WILL	Rubidium	
WSLR	clock steering	

Data Discontinuities

Two sites, DUBO and HOLB, experienced extensive outages due to equipment failure and or damage. The lengths of the outages were due to lack of replacement equipment combined with site access problems due to remoteness of sites and / or weather. More subtle problems were also encountered including gradual external clock failures and receiver failures. While all sites are equipped with either UPS or battery backup, several extended power outages were experienced. In all of these cases local grid power failed due to extreme weather conditions. One data outage (NANO) was caused by a massive lightning strike in the area surrounding the GPS installation.

The following tables summarize the data collection status of each site as indicated by the total number of daily observations. The absolute numbers will vary from site to site based on the elevation cut-off used combined with site masking as well as the number of channels in the GPS receiver, (see for example the increase at DRAO due in part to a change from 8 channel to 12 channel receiver).

ALBH
- power outages D062, 268, 352;
- D164-177 receiver tracking problem;
- D210-218 clock (Cesium) problem;



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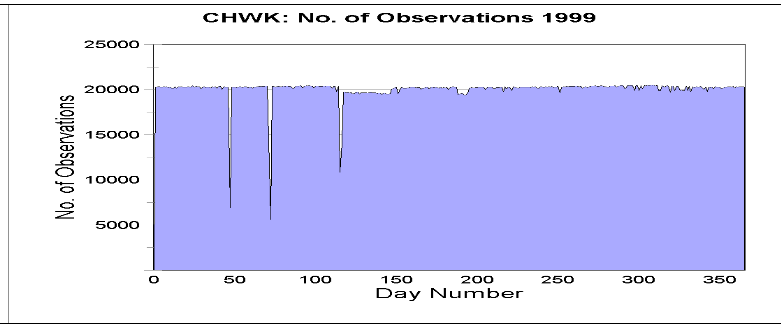
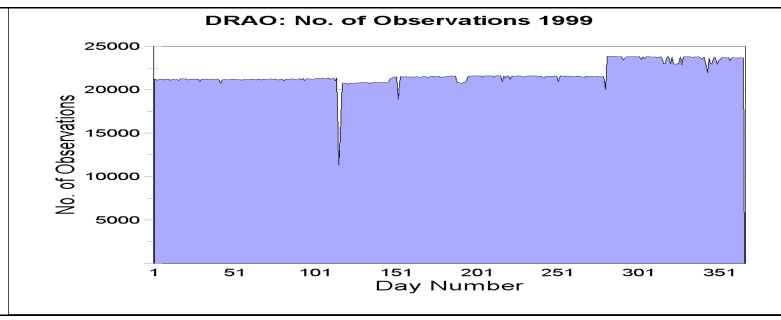
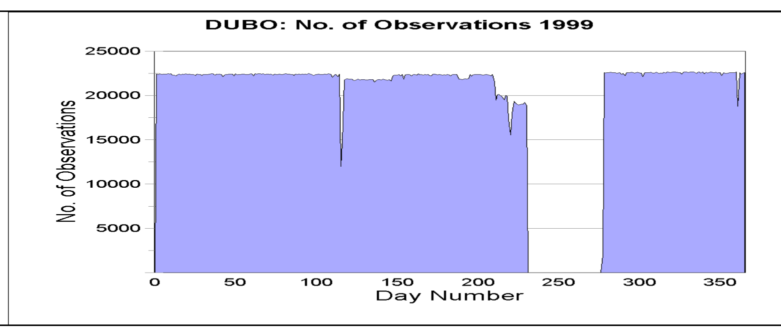
CHWK
- D047, 071, 115: receiver problem (terminated tracking during offload resulting in loss of data);



DRAO
- D115/116 data loss due to receiver flashcard problem;
- Increase in number of observations D281 due to change in receiver from an 8-channel SNR-8000 to a 12 channel AOA BENCHMARK;

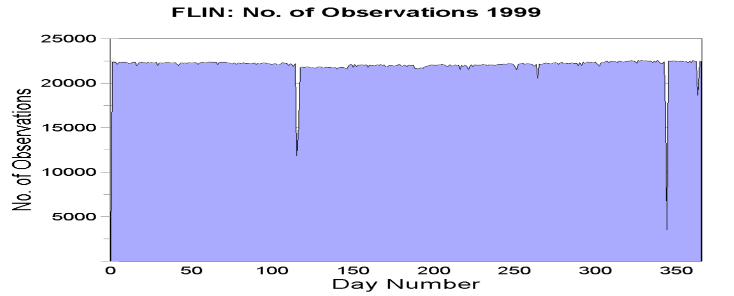


DUBO
- D115/116 data loss due to receiver flashcard problem;
- D219-230 poor tracking due to damage to cable and receiver;
- D231 — 276 no equipment available; site repaired D277;
- D368 - 4 hour data gap due to data offload problem;



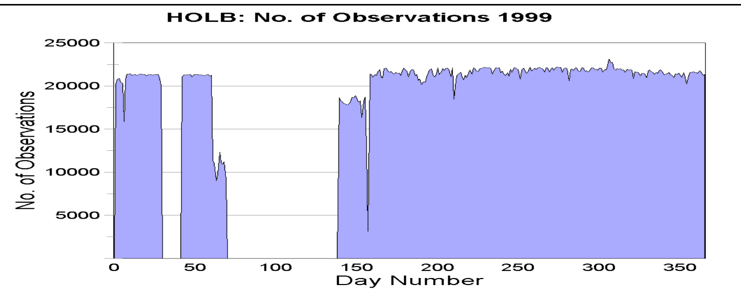
FLIN

- D115/116 data loss due to receiver flashcard problem;
- D363 - 4 hour data gap due to data offload problem;
- otherwise no significant disruption in tracking;



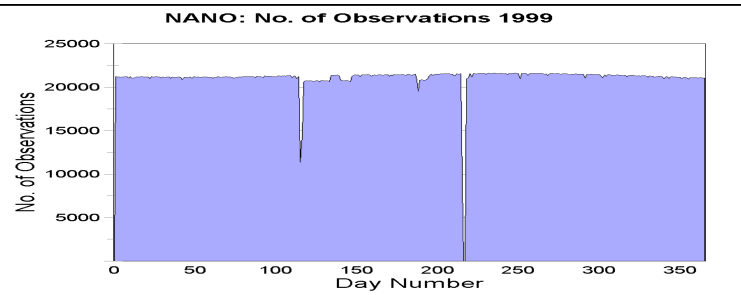
HOLB

- D006 receiver change;
- D030-041, D070-138 no data due to site instrumentation problems;
- D139-157 elevation mask at 10 degrees;
- D158 changed to 5 degree elevation cut-off;



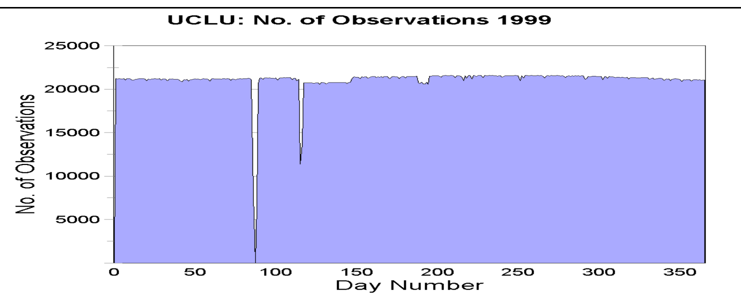
NANO

- D115/116 data loss due to receiver flashcard problem;
- D216-218 data loss due to lightning strike;
- otherwise no significant disruption in tracking;



UCLU

- D115/116 data loss due to receiver flashcard problem;
- D086-087 data loss due to failure of external Rubidium clock;
- otherwise no significant disruption in tracking;



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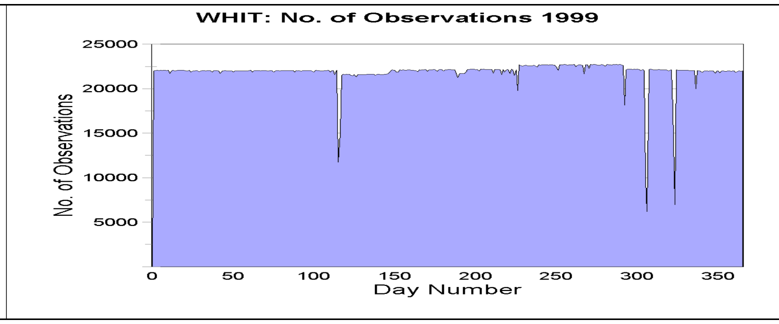
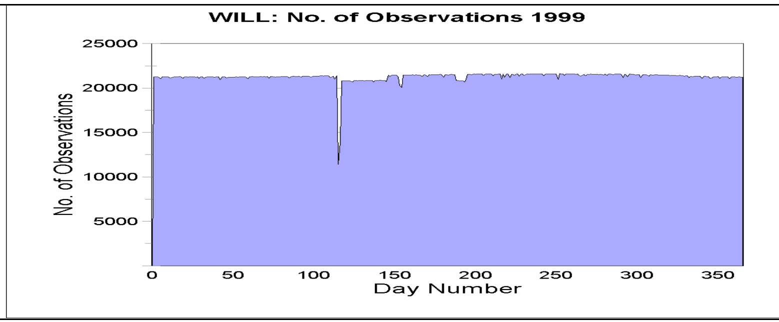
WHIT

- D115/116 data loss due to receiver flashcard problem;
- D306—307, 322-323 partial data loss due to power outage;
- otherwise no significant disruption in tracking;



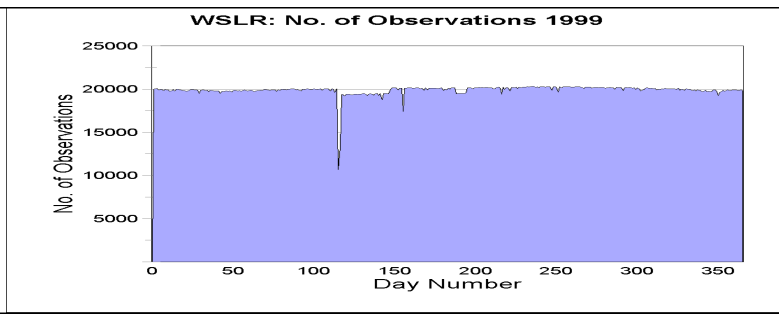
WILL

- D115/116 data loss due to receiver flashcard problem;
- otherwise no significant disruption in tracking;



WSLR

- D115/116 data loss due to receiver flashcard problem;
- otherwise no significant disruption in tracking;



Summary

The WCDA continues to provide robust data for both in-house and international scientific applications. Some of the shortcomings, for example the lack of back up instrumentation, are being addressed. Further robustness is expected by improving backup infrastructure such as UPS and batteries. The introduction of lightning protection will hopefully minimize damage due to lightning strikes. Standardization on one type of dome should also provide consistent phase centre offsets between each site in the network. Improvements in the data validation are an ongoing priority as is the emphasis on correct meta data in RINEX file headers, the latter supported through the use of chronological, time stamped meta data input files used in the generation of the RINEX files.

Operation and Densification of Continuous GPS Stations in Russia

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Densification of IGS Network in Russia

RDAAC and LDEO installed three new IGS stations which filled in large gaps in the global IGS polyhedron in tectonically important regions of Eurasia (Table 1, Figure 1):

Table 1: New IGS stations of RDAAC/LDEO

Station	City/ Village	Coordinates			Tectonic Location	Start of Operation
		Lat N	Lon E	Elevation	.	
YSSK	Yuzhno-Sakhalinsk	47.030	142.717	91.289	Sakhalin Seismic Belt. Eurasia / North America plate boundary.	28-JUL-99
ARTU	Arti	56.430	58.560	247.511	Suture dividing Europe and Asia. Eurasia plate.	07-AUG-99
BILI	Bilibino	68.076	166.438	456.238	Chukotka Foldbelt. North America plate.	04-SEP-99

New IGS stations make the IGS polyhedron over Eurasia significantly more uniform by filling in gaps in regions between Europe and Asia (ARTI), in the Arctic (BILI), and in the Far East to the north of Japan (YSSK).

The data quality can be judged from inspection of one-way phase residuals plotted for all stations with respect to satellite orbits (Figure 2). RMS residuals are quite small , on the level of some millimeters which is characteristic of best IGS stations. They show progressive increase with the decrease in stations latitude, from ± 7 mm for arctic stations towards 10-12 mm for stations in midlatitudes.

Local computers connected with GPS receivers ARTU and YSSK are plugged into Internet as hosts. The data are retrieved from them daily to the central computer of RDAAC in Moscow. However at YSSK the computer is connected with the receiver via

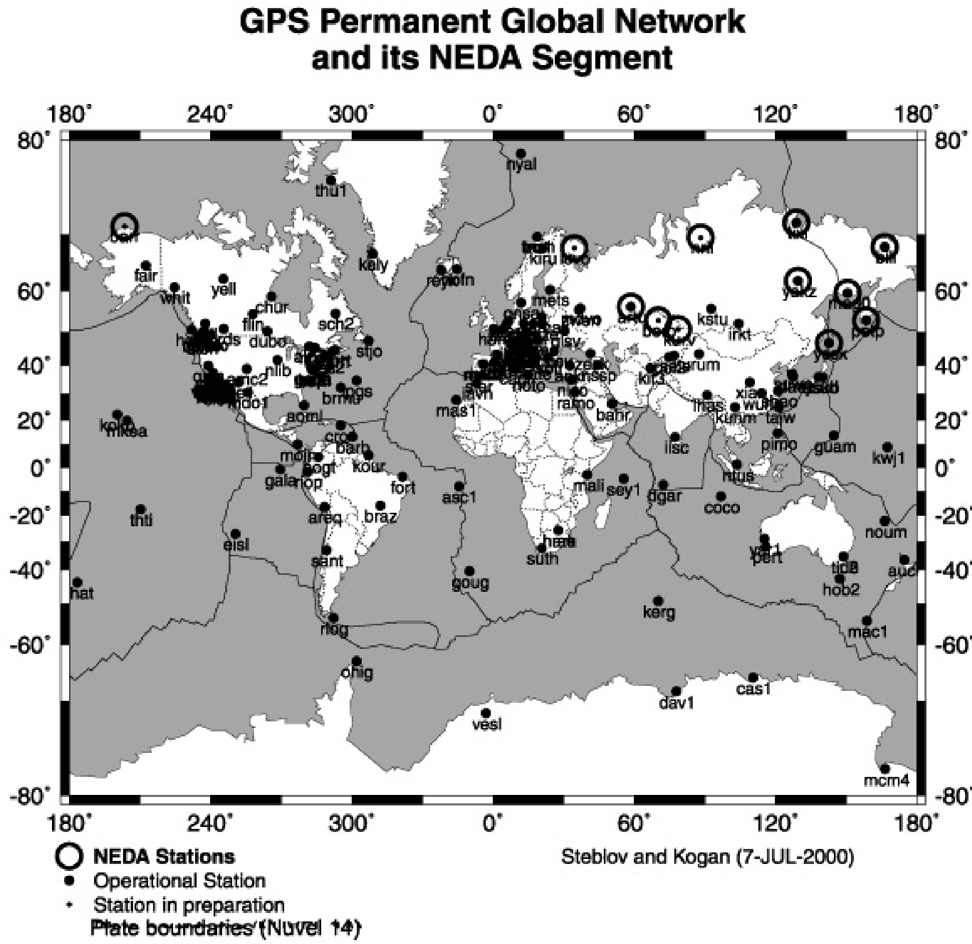

Figure 1. IGS Global Network and its enhancement in Russia by RDAAC

the dialed telephone channel by use of modems. This happened because the best place for the GPS antenna was the Institute of Marine Geology and Geophysics while the Internet facility was available at the GSN Seismic Station 12 km away. We installed the Ashcan utility for the communication between the receiver and computer.

There is no yet Internet facility at station BILI. We installed a direct computer-to-computer link BILI-MAG0 (1000 km) via the dialed telephone line. The data downloaded by the computer from the GPS receiver at BIL are transferred to the computer at MAG0 under the Z modem protocol. The data collected at both sites are then retrieved via Internet by the Central computer in Moscow. This communication will hold on until the Internet is set up at Bilibino, hopefully this year.

We set up auxiliary GPS stations in the neighborhood of each new IGS station for two reasons: to ensure the continuity of monitoring the station motion in case the main mark is damaged; to assess local crustal motions by repeated observations at auxiliary stations. Observations at such sites were performed as soon as the permanent station started collecting data.

The data from three new stations are collected without interruption since installation. YSSK and ARTU are filed officially by JPL as incorporated in the global network. Documentation on BILI will be passed over to JPL in the next few days.

With installation of ARTU, YSSK, and BILI, we monitor totally seven IGS stations in Russia, over whole northern Eurasia. This makes 2/3 of all IGS stations in Russia.

It should be noted that BILI is located in the barely accessible, unpopulated remote region of Chukotka with temperatures to -62°C in January. Our GPS station is located next to the nuclear power plant. We intend to monitor the ground stability in the neighborhood of the nuclear reactor by using BILI as the reference station.

Support of Stable Operation of Existing IGS Stations

We continued to supervise, improve and stabilize the GPS data collection at existing IGS GPS stations: YAKZ, MAG0, PETP, all since 1997, and TIXI since 1998 (Figure 1 and Table 2).

Table 2: IGS Stations in Russia supervised by RDAAC since 1997-1998

Station	City/ Village	Coordinates			Tectonic Location	Start of Operation
		Lat N	Lon E	Elev.		
YAKZ	Yakutsk	62.031	129.681	100.064	Siberian Platform. Eurasia plate.	12-NOV-97
MAG0	Magadan	59.576	150.770	361.927	Okhotsk volcanic belt. North America plate.	12-NOV-97
PETP	Petropavlovsk	53.067	158.607	211.034	Kamchatka volcanic belt. North America – Pacific plate boundary.	14-NOV-97
TIXI	Tixi	71.634	128.866	46.985	Verkhoyansk fold-and-thrust belt, Eurasia - North America plate boundary	08-OCT-98

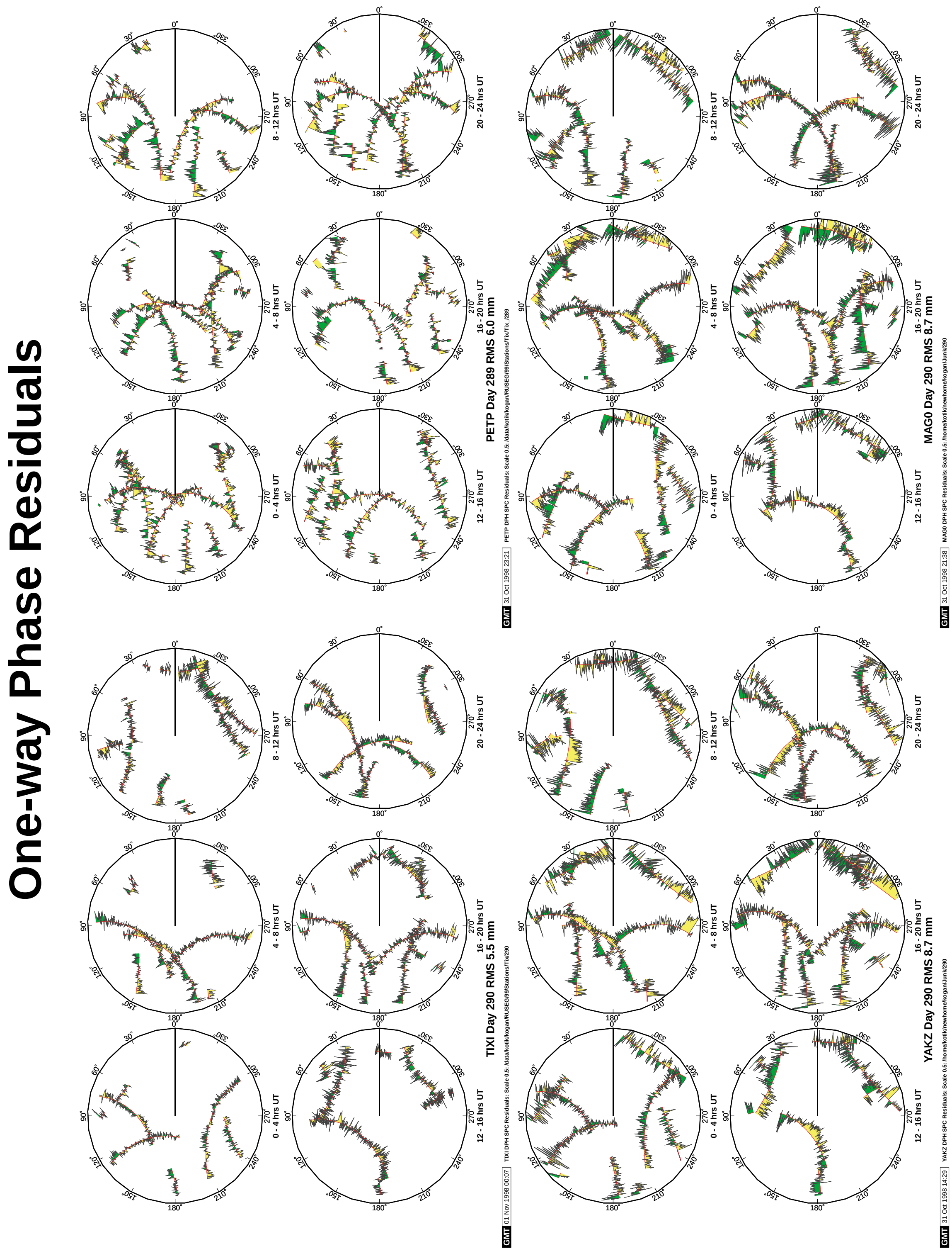

Figure 2. One-way phase residuals and RMS at IGS stations of RDAAC

Significant changes were performed at all four sites:

1. ***Receiver changes***. TurboRogue SNR8000 receivers were replaced with the Ashtech Z-12 CGRS models at TIXI and PETP. The TurboRogue was removed from YAKZ where it worked together the Z-12 connected to a single antenna via the splitter. There were various motivations for such changes. At TIXI and YAKZ, the local FCC administration required TurboRogues to be removed since this model was never certified by the Russian Federal Committee of Standards. We also thought that there was no need for continued receiver redundancy at YAKZ. At PETP, the TurboRogue experienced severe loss of lock on channel L2, more than could be expected at that latitude. The problem disappeared completely since the replacement.

2. ***Software upgrade***. We upgraded all local computers used for the data download from Win311 to Win95, which allowed faster and more stable downloads from GPS receivers and faster data retrieval via Internet. The Ashtech download utility **cgremote** was replaced by the **ashcan** developped at SIO Global Data Center which is more stable, more fast, and firmware independent.

3. ***Firmware upgrade***. To avoid problems with the W1K and y2K, we upgraded all GPS receivers to firmware CC00 or CD00 in time, before W1K rollover in August '99.

4. ***Power backup upgrade***. To overcome power outages occurring at MAG0 and at PETP, we developed and installed state-of-the-art power backup systems at both sites. The uninterrupted data collection and retrieval is now guaranteed for 5-6 days since the break of the power supply.

5. ***Installation of Meteorological Systems MET3***. We have seven MET3 systems, two of which were installed at MAG0 and at PET. The meteo data (temperature, pressure, and relative humidity) are sampled every 5 min and stored by the Ashtech Z-12 receiver together with the GPS data. Remaining systems will be installed at other GPS stations during this autumn.

6. ***Upgrade of Antenna Cables***. We intend to replace 30-m coaxial cables with Andrews low-loss cables to improve the signal-to-noise ratio. This work will be first done in Yakutsk (YAKZ) in October 1999.

Overall Network Performance

Completeness

Since the improvements and enhancements outlined in the previous paragraph, the data in terms of rinex files are retrieved by the central computer of RDAAC (Moscow) from computers at stations, and further retrieved from Moscow by global data centers daily, without gaps.

Latency

Latency is defined as the time interval since UTC midnight till the moment when the data become available at global data centers. The latency for rinex files from RDAAC stations is typically less than 2 hours which allows to include these stations for computations of rapid and predicted satellite orbits (Table 3).

Table 3: Latency of data from IGS stations of RDAAC compared with all other IGS stations in Russia for 8-SEP-1999 (Holdings of SIO Global Center)

RDAAC IGS Stations

```
-r--r--r--   1 618      geo       864327 Sep  8 02:54 artu2500.99o.Z

-r--r--r--   1 618      geo       901423 Sep  8 03:38 mag02500.99o.Z
-r--r--r--   1 618      geo       818577 Sep  8 05:33 petp2500.99o.Z
-r--r--r--   1 618      geo       941913 Sep  8 07:32 tixi2500.99o.Z
-r--r--r--   1 618      geo       902075 Sep  8 02:54 yakz2500.99o.Z
-r--r--r--   1 618      geo       814036 Sep  8 14:42 yssk2500.99o.Z
```

All other IGS stations in Russia

```
-r--r--r--   1 618      geo       616893 Sep  8 11:43 irkt2500.99o.Z

-r--r--r--   1 618      geo       678216 Sep  8 11:43 mdvo2500.99o.Z

-r--r--r--   1 618      geo       598691 Sep  9 19:50 zeck2500.99o.Z
DOES NOT FUNCTION                                     kstu2500.99o.Z
DOES NOT FUNCTION                                     zwen2500.99o.Z
```

Quality

The high quality of observations at RDAAC IGS stations is demonstrated by the fact that four stations functioning since 1997-1998 (YAKZ, MAG0, PETP and TIXI) were classified by IGS as global stations and were included in the ITRF97 Geodetic System. Earlier we commented on the small values of one-way phase residuals at all seven stations (Figure 2).

Geometry of the Polyhedron

IGS stations run by RDAAC fill in one of largest gaps in the global IGS polyhedron (Figure 1). They make the IGS coverage of northern Eurasia uniform to a reasonable approximation. Most of our stations are located at remote regions of eastern Siberia, Arctic, and Far East, with severe weather conditions. We make preparations for further densification of the network by planning new IGS stations at Norilsk (station NRIL, Arctic Siberia, north of Siberian platform) and at Blagoveschensk (station BLAG, Far East, Mongol-Okhotsk foldbelt, Russian-Chinese border). See Figure 1.

IGS

INDIVIDUAL STATIONS

The BOR1 IGS Station

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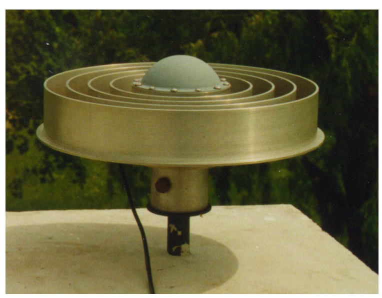
Antenna Change at BOR1

In early 1998, we observed disturbances in the Turbo Rogue receiver at the BOR1 (12205M002) IGS station, generated by two external radio sources: working at frequencies 1300MHz and 900MHz.

Due to lower quality of the observations obtained from BOR1 GPS receiver, we decided to replace old Dorne Margolin T antenna with the new one with RFI Low Noise modifications (founded by Polkomtel S.A.). This was done on May 31, 1999 at 19:00 UT (DOY 151 – see IGS Message 2284).

Because the antenna is mounted on the centering device (see picture below), we do not expect any shifts in horizontal position (antenna height was changed from 0.0624m to 0.0621m for the new). For certainty, we measured an eccentricity from EUREF 0216 marker – BORO (12205M001).



This vector was observed several times, starting in 1992, and we know that values of eccentricities are accurate to within about 1mm.

Duration of observations was 12 days:

- 152 – 157 with two Dorne Margolin T antennas,
- 165 – 170 with Dorne Margolin T – Trimble Compact L1/L2 GND (TR GEOD L1/L2 GP) pair,

After computation, we found small differences from previous solutions. We decided to perform the following:

1. Make additional observations for this vector with Dorne Margolin T antennas
2. from 31-10-1999 to 13-11-1999 (DOY 304 – 317),
3. from 29-11-1999 to 06-12-1999 (DOY 333 – 340),

4. recompute all old observations in Bernese GPS Software ver. 4.2 to avoid software effects in values of the eccentricities.

Table 1. Values of the geodetic components for the vector BOR1 – BORO

	ΔB	ΔL	Δh	Length	period	Receivers
Old Antenna	+0º00´03.037098"	–0º00´05.064533"	+7.5355	134.4981	15 days'92	T–T
	03.037118"	05.064545"	+7.5294	134.4984	5 days'93	R–R
	03.037131"	05.064523"	+7.5308	134.4984	11 days'95	R–R
	03.037125"	05.064541"	+7.5328	134.4987	3 days'97	R–R
	03.037160"	05.064498"	+7.5360	134.4990	46 days'97	R–T
	03.037103"	05.064526"	+7.5376	134.4983	9 days'97	R–T
	03.037134"	05.064585"	+7.5339	134.4995	20 days'98	R–R
Av.	**+0º00´03.037124"**	**–0º00´05.064536"**	**+7.5337**	**134.4986**		
New antenna	+0º00´03.037107	–0º00´05.064345"	+7.5298	134.4955	6 days'99	R–R
	03.037140	05.064452"	+7.5291	134.4976	6 days'99	R–T
	03.037138	05.064306"	+7.5289	134.4956	13 days'99	R–R
	03.037094	05.064313"	+7.5290	134.4947	11 days'99	R–R
Av.	**+0º00´03.037120**	**–0º00´05.064354"**	**+7.5292**	**134.4959**		

T – Trimble 4000 with TRM14532.00 or TRM22020.00+GP (from 1994) antenna
R – Turbo Rogue SNR8000 with AOAD/M_T antenna

Conclusion

We get significant "movement" in longitude and height components after the changing of the antenna on BOR1 stations.

Because the horizontal position is constrained by the centering device, these effects are probably caused by another definition of the phase center in the Dorne Margolin T new antenna. In the future, we will try to make some additional measurements and analyse these effects.

Status of the IGS Stations Operated by the Main Astronomical Observatory

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General Information

In 1999 the Main Astronomical Observatory (MAO) of the National Academy of Sciences of Ukraine operated two stations contributing data to the IGS: GLSV (Golosiiv, Kiev) and UZHL (Uzhgorod).

The GPS station GLSV operates since December 16, 1997. It is located at MAO in the southern part of the city of Kiev. The antenna is placed at the top of steel pillar mounted on the roof of the Observatory office. During the Solar eclipse (August 11, 1999) observations at GLSV were performed with 3 sec interval.

The new station UZHL is situated at the Space Research Laboratory of Uzhgorod University. Like at GLSV the antenna is placed at the top of steel pillar mounted on the roof of the Laboratory office. Observations were started on February 5, 1999. Unfortunately, there were some gaps in observations at UZHL due to power failure.

Both stations work in a fully automatic mode. Raw data from the receivers are daily downloaded to on–site computers, transformed to the Compact RINEX Format, and sent to the Regional Data Center in BKG (Frankfurt am Main, Germany). Raw data from the station UZHL are also sent to the MAO archive.

GPS Stations Configuration

Station name:	Golosiiv, Kiev	Uzhgorod
4-char ID:	GLSV	UZHL
DOMES Number:	12356M001	12301M001
Receiver type:	Trimble 4000SSI	Trimble 4000SSI
Firmware version:	7.15 (till 24–JUN–1999)	7.15 (till 16–JUN–1999)
	7.29 (since 24–JUN–1999)	7.29 (since 16–JUN–1999)
Antenna type:	TRM29659.00	TRM29659.00
Antenna height:	0.000 m	0.000 m
Antenna reference point:	ARP	ARP
Clock:	Internal	Internal

Approximate coordinates (WGS–84):		
Latitude:	50.3642 N	48.6320 N
Longitude:	30.4967 E	22.2976 E
Height:	226.8 m	232.0 m
On-site PC:	Pentium (Linux)	Pentium (Linux)
Collocation:	SLR 1824 Kiev	—

Future Plan

Since October 13, 1999 MAO has started permanent observations at station Evpatoria (proposed 4–char ID: EVPA). This station is located in a few meters from the SLR station 1867 Evpatoria (DOMES No. 12344S001). We hope that the Evpatoria station will be included in the IGS network after on–site PC will be connected to the Internet.

In 2000 MAO is going to establish a new station in Kharkiv (East Ukraine).