IGS
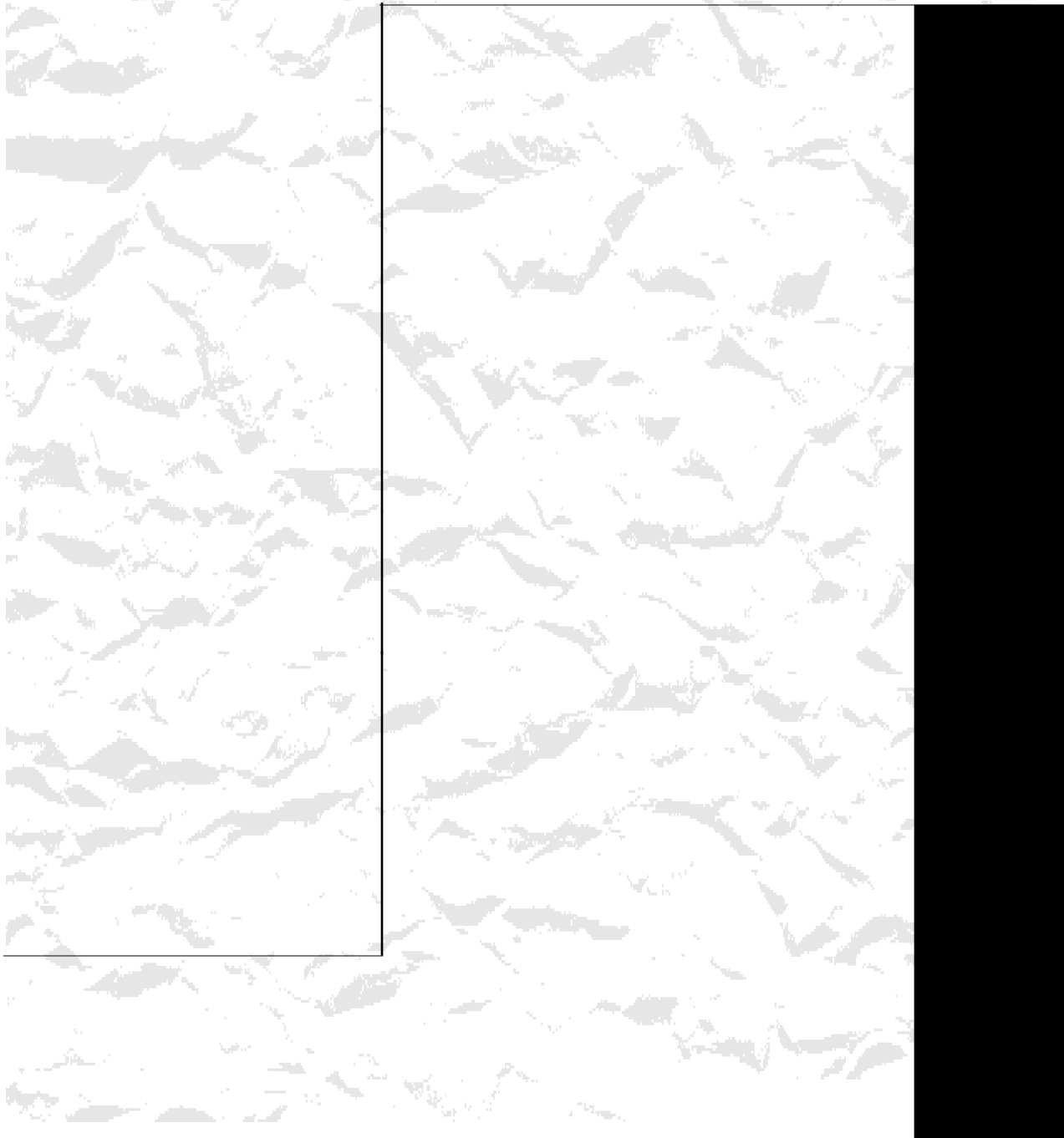
NETWORK AND STATION

REPORTS

IGS

GLOBAL, REGIONAL, AN

LOCAL NETWORK

Report from the IGS Network Coordinator

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The IGS global network of precise GPS tracking stations is critically depended upon by every other component of the IGS. A review of IGS Mails summarizing Governing Board meetings in late 1997 and 1998 shows that the Board and 1997 IGS Retreat attendees recognized that "the global IGS Network should be enhanced in the overall sense," and recommended that a Network Coordinator be appointed. By September 28, 1998, the IGS Central Bureau had created and filled a Deputy Director position which also carries the Network Coordination duty.

Immediately it was clear that the need for network coordination was both real and challenging. On the one hand, analysts had issues, which were from their perspectives quite long-standing, such as inconsistencies in site parameters between those reported in stations' daily data file headers and those found in IGS logs of station configuration. Meanwhile, site operators produced requests for clarification of the guidelines under which their stations should be operated. Both items were exacerbated by the quick movement of the IGS into a wide array of multipurpose projects, increasing the complexity of site instrumentation and operation. It was apparent that these suggested a singular need for careful consideration of the network as a whole in view of analysis requirements as well as practical implementation matters.

The Network Workshop held in November, 1998 was a productive gathering of participants representing all components of the IGS to discuss Network needs and functions. Recommendations and action items (available at the Central Bureau Information System, http://igscb.jpl.nasa.gov) which became early priorities for the Network Coordination task include:

- Functional classification of sites into application networks and generation of instrumentation and operation guidelines appropriate to the various applications.
- Moderation of a dialogue regarding station naming guidelines, and the broader issue of the relationship of regional or alternate sites to the IGS Network.
- Quality control of information contained in site logs and data headers.
- Improvement of communication and sense of community in the Network component.

Activities to these ends by the end of 1998 included:

- Identification of the necessity of updating the IGS list of antenna and receiver naming conventions to accommodate equipment newer than the existing list.

- Improvement of existing code identifying site log/RINEX header inconsistencies, and two rounds of email to Operational Data Centers requesting correction. Good response eliminated most inconsistencies not due to use of equipment too new for the approved list.
- Procurement of a new computer to act as the CBIS, which will allow more interactive functions and better communication to all IGS components.
- Preliminary formulation of recommendations for the relationship of regional arrays and alternate sites at established locations to the IGS.

The IGS tracking network itself continued to expand in 1998. The following previously operating stations joined the IGS network by submitting a site log to the IGS Central Bureau and flowing data to an IGS Data Center:

BZRG	Bolzano, Italy	
MAW1	Mawson, Antarctica	
NANO	Nanoose, Canada	
NOUM	Noumea, New Caledonia	
NSSP	Yerevan, Armenia	
RIOP	Riobamba, Ecuador	
SUTH	Sutherland, South Africa	
UCLU	Ucluelet, Canada	
VENE	Venzia, Italy	
VESL	Vesleskarvet, Antarctica	
WIDC	Sky Valley, USA	replacing WIDE

The following new stations also joined the IGS in 1998:

AMC2	Colorado Springs, USA	replacing AMCT
BAKO	Bakosurtanal, Indonesia	
BARH	Bar Harbor, USA	
EPRT	Eastport, USA	
GENO	Genova, Italy	
GLSV	Kiev, Ukraine	
GOUG	Gough Island, South Atlantic	
IAVH	Rabat, Morocco	
KUNM	Kunming, China	
PETP	Petropavlosk, Russian Federation	replacing PETR
RAMO	Mitzpe Ramon, Israel	
SCIP	San Clemente Island, USA	
THTI	Tahiti, Pacific	replacing TAHI
TIXI	Tixi, Russian Federation	
URUM	Urumqi, China	

The sites which joined the IGS network in 1998 are indicated on the adjoining map in capital letters. Some of these significantly improve the global coverage of the IGS network, which numbered 201 stations at the end of 1998. Only a few years ago,

northeast Asia represented a large void in the IGS coverage; this region has improved greatly in recent memory.

As with other components of the IGS, the success of the IGS network is a reflection of the dedication of the agencies who install and operate the stations. Although new stations are highlighted in this report, operators of long-standing IGS stations are also to be commended for their continued efforts. The Central Bureau Network Coordination effort seeks to provide tools and performance feedback which enable operators to effectively contribute to the quality of the highly important network component.

GPS TRACKING NETWORK

International GPS Service
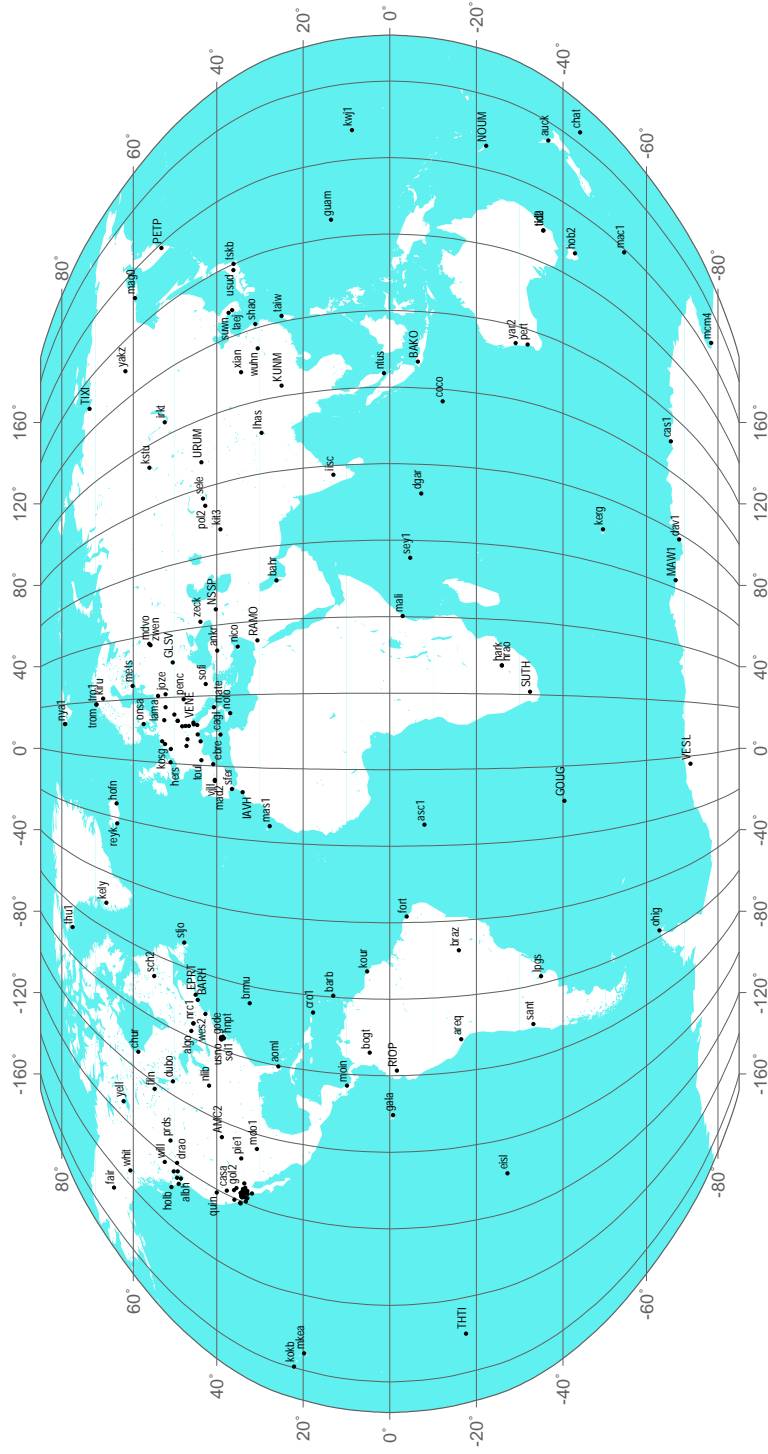
1998

The Australian Regional GPS Network
1998 Report

Jim Steed, Bob Twilley, Paul Digney
AUSLIG

Introduction

Since 1994, AUSLIG has gradually established across Australia and its offshore territories (including Antarctica) an array of fifteen permanent GPS sites, known as the Australian Regional GPS Network (ARGN). Each site consists of a geologically stable mark and a redundant system to collect geodetic quality GPS data that is automatically retrieved from AUSLIG's office in Canberra, Australia. Although all fifteen sites meet the IGS standards for monumentation, documentation and data, only seven of the sites are official IGS sites (Casey, Davis, Macquarie Island, Cocos Island, Hobart, Tidbinbilla and Yaragadee). This paper reports on the ARGN for the period 1 January – 31 December 1998, with particular focus on the seven IGS stations.

Figure 1: The Australian Regional GPS Network

ARGN Management

Mr. John Manning is the Manager of AUSLIG's Geodesy program that has two areas: the Space Analysis Centre headed by Dr Ramesh Govind and the Geodetic Information Centre headed by Mr Jim Steed. Until December 1998, the Project Manager for the ARGN, which falls within the Geodetic Information Centre, was Mr Martin Hendy.

However, since December 1998 Mr Bob Twilley has been acting in this position and has responsibility for the ARGN, with the assistance of Mr Paul Digney.

The ARGN System

The ARGN sites were specifically selected and established to ensure that the data would be suitable for geodetic processing. Each site is on geologically stable ground; has a generally clear 360° horizon above 15° elevation; is free of significant signal interference and multipath reflection; has 240 volt power and Internet or telephone available and is in a secure, government-owned property. The marks generally consist of reinforced concrete pillars securely anchored to bedrock, with three deep-driven reference marks nearby, to allow monitoring of any possible local movement.

Particularly because of their remote and often unattended locations, the ARGN sites were designed to be reliable through the use of redundant equipment and to operate automatically through specifically designed hardware and software. Wherever possible the remote sites are connected to the Internet, but where this is not possible a normal telephone line and modem connection is used.

A Personal Computer (PC) using the Linux operating system is used at the remote sites to control the local operations and store the data locally. Specific processes have been developed to download the raw data from the GPS receiver so it can then be automatically transmitted to AUSLIG's Canberra office. To minimise the chance of telephone drop-out at sites relying entirely on telephone access, the data is transmitted every _ hour, as fifteen-minute data files.

Sites with only telephone access have two independent lines and modems, one of which is connected to a multiplexer and the other directly to the PC. Data is transferred from the PC on the line to the multiplexer and the other line allows remote access to the system and acts as a spare. Both modems are connected to a power timer that resets them every day. The Internet sites may be accessed by Telnet sessions. The 8-port multiplexer allows ARGN personnel to remotely access and control many functions of the PC, GPS receiver and Power Controller, allowing problems to be remotely diagnosed and frequently solved.

A GPS power controller (GPC) was specifically designed for ARGN site operation. It provides uninterrupted +12volt or +24volt DC power for two GPS receivers and if required, two Rubidium frequency standard units, from either a 240volt mains supply or a +24volt battery supply. The unit is also connected to a battery charger which maintains external DC batteries, which provide backup power to the GPS receiver for at least of 150 hours. The GPC monitors the GPS receiver's functions by an internal microprocessor, which transmits the receiver's status through a serial port. The GPC is also connected via serial port to the PC and to a modem via the multiplexer. An uninterruptible power supply (UPS) provides 240 volts AC power to the remote system, giving a power backup of up to 4 hours. The UPS can be monitored via a serial connection to the PC.

Remote sites linked by telephone are automatically dialled from the Canberra Office every hour and the 15-minute data files are transferred to a Personal Computer that also runs the Linux operating system. The files are then automatically moved to a Unix workstation for later processing. Data from sites linked to the Internet is also transferred as 15-minute files. At the end of each day (2400 hours UT) all 15-minute data files are concatenated into single 24-hour files, converted to Rinex format and copied to AUSLIG's FTP server. Both the raw and Rinex data files are also written to CD for long term archive.

Since March 1998, the ARGN Rinex data has been available in a separate directory in the Hatanaka format required by IGS. In June 1998 all ARGN Rinex data was made available on AUSLIG's annonymous FTP site and was linked to AUSLIG's WWW site (www.auslig.gov.au/geodesy/argn/argn.htm).

ARGN IGS Sites

Casey (1998)

Domes No.	66011M001
4 Character ID	CAS1
Mark description:	Stainless steel antenna plate attached directly to rock
Receiver:	TurboRogue SNR-8100 (Ashtech Z12 as backup)
Receiver Firmware:	3.2.33.1
Antenna:	Dorne Margolin T
Radome:	Acrylic hemispherical
Communications	Internet
Significant occurrences during 1998:	On 8 January 1998 the external Rubidium was removed. The receiver operated for the rest of 1998 on its internal oscillator.

Davis (1998)

Domes No.	66010M001
4 Character ID	DAV1
Mark description:	Stainless steel antenna plate attached to rock
Receiver:	TurboRogue SNR-8100 (Ashtech Z12 as backup)
Receiver Firmware:	3.2.33.1
Antenna:	Dorne Margolin T
Radome:	Acrylic hemispherical
Communications:	Internet
Significant occurrences during 1998:	

Macquarie (1998)

Domes No.	50135M001
4 Character ID	MAC1
Mark description:	Concrete pillar
Receiver:	TurboRogue SNR-8100 (Ashtech Z12 as backup)
Receiver Firmware:	3.2.33.1
Antenna:	Dorne Margolin T
Radome:	Acrylic hemispherical
Communications:	Internet
Significant occurrences during 1998:	

Cocos (1998)

Domes No.	50127M001
4 Character ID	COCO
Mark description:	Concrete pillar
Receiver:	TurboRogue SNR-8100 (Ashtech Z12 as backup)

Cocos (1998) (cont'd)

Receiver Firmware:	2.8.33.2
Antenna:	Dorne Margolin T
Radome:	Acrylic hemispherical
Communications	Telephone & Modem
Significant occurrences during 1998:	In August 1998 the GPS receiver was replace with a similar one running firmware version 3.2.33.1

Hobart (1998)

Domes No.	50116M00
4 Character ID	HOB2
Mark description:	Concrete pillar
Receiver:	TurboRogue SNR-8100
Receiver Firmware:	3.2.33.1
Antenna:	Dorne Margolin T
Radome:	Acrylic hemispherical
Communications:	Dedicated phone line & Internet
Significant occurrences during 1998:	On 26 October 1998 a different TurboRogue receiver was installed. From 21 August to 2 October and from 27 October for the rest of 1998 the receiver was connected to a Hydrogen Maser. At other times the internal oscillator was used

Tidbinbilla (1998)

Domes No.	50103M108
4 Character ID	TID1
Mark description:	Concrete pillar
Receiver:	Turborogue SNR-12
Receiver Firmware:	3.2.32.1
Antenna:	Dorne Margolin T
Radome:	Acrylic hemispherical
Communications:	Internet
Significant occurrences during 1998:	
Comment	AUSLIG and JPL use the same mark and antenna, but have separate GPS receivers and data retrieval.

Yaragadee (1998)

Domes No.	50107M004
4 Character ID	YAR2
Mark description:	1 cm diameter brass rod set in concrete.
Receiver:	Turborogue SNR-12
Receiver Firmware:	3.2.32.1
Antenna:	Dorne Margolin T
Radome:	Acrylic hemispherical
Communications:	Telephone & modem
Significant occurrences during 1998:	In September 1998 a precision local survey was carried out to connect all geodetic marks and equipment at the Yaragadee SLR site.
Comment	AUSLIG and JPL use the same mark and antenna, but have separate GPS receivers and data retrieval.

ARGN Performance

The attached graphs for each ARGN IGS site show the availability and quality trends for 1998. Similar information for all sites for 1998 and 1999 is available on AUSLIG's WWW site (www.auslig.gov.au/geodesy/argn/argn.htm).

The information in these graphs was produced using the TEQC software (UNAVCO, 1999). The vertical bars on the data percentage graphs shows that the data is available and the black dots show the percentage of useful data as determined by TEQC. The MP1 & MP2 multipath graphs show the noise attributable to multipath and other sources (e.g. residual ionosphere). The site performance graphs highlight any trends that may exist for a particular site, such as those due to periodic ionospheric activity. Significant changes in a performance indicator can help to identify problems with a site, such as hardware, software or local environment. For example, the Hobart graph shows a significant change from about 8 August until 27 October when, after much testing, the GPS receiver was replaced.

Reference

UNAVCO, 1999, "*http://www.unavco.ucar.edu/software/*", 23 February 1999.

ARGN Site Performance - CASEY
LON: 110˚ 31´ 10.94´´ LAT: -66˚ 17´ 0.08´´
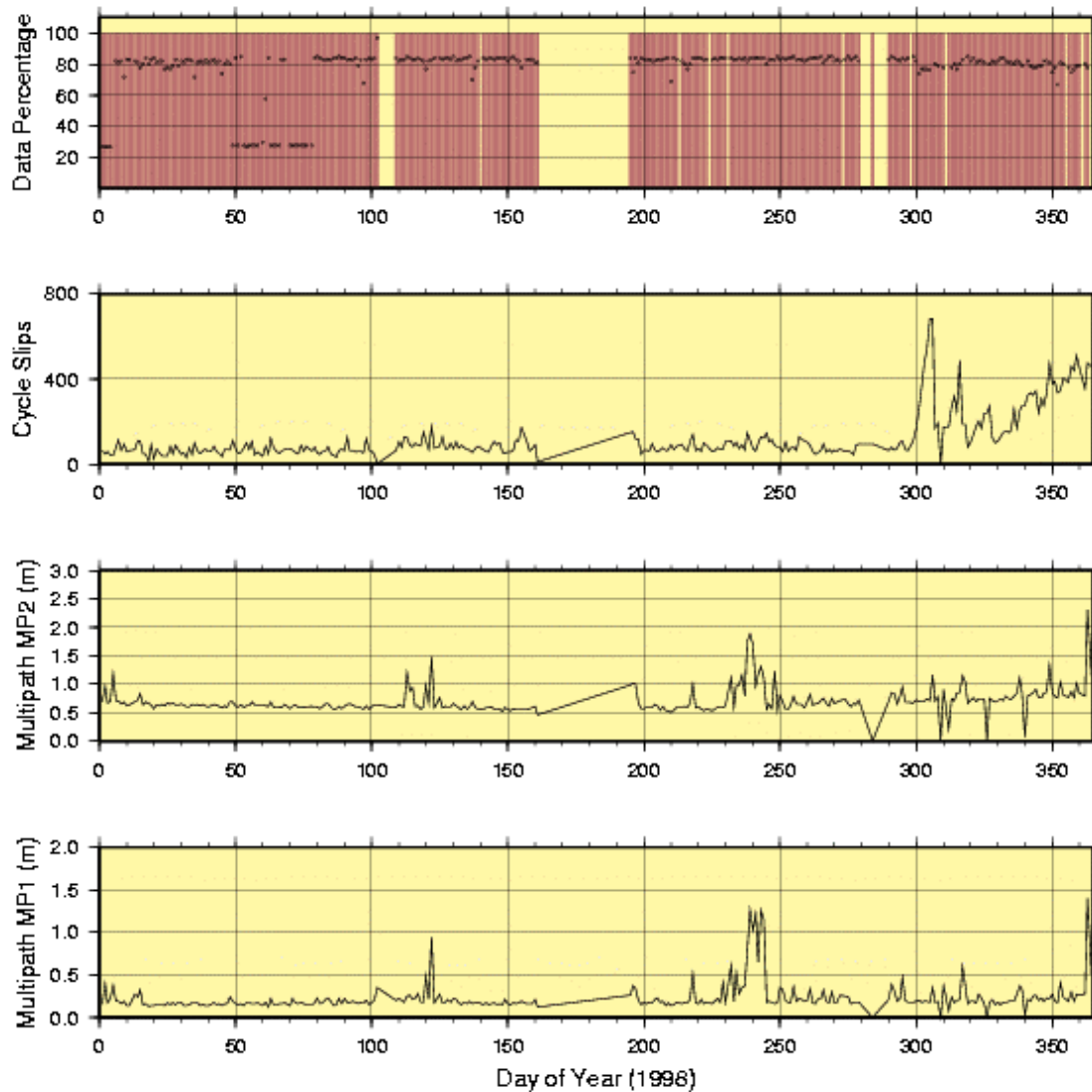
ARGN Site Performance - DAVIS
LON: 77˚ 58˙ 21.41˙˙ LAT: -68˚ 34˙ 38.36˙˙

GMT Jul 19 13:54:31 1999   AUSLIG
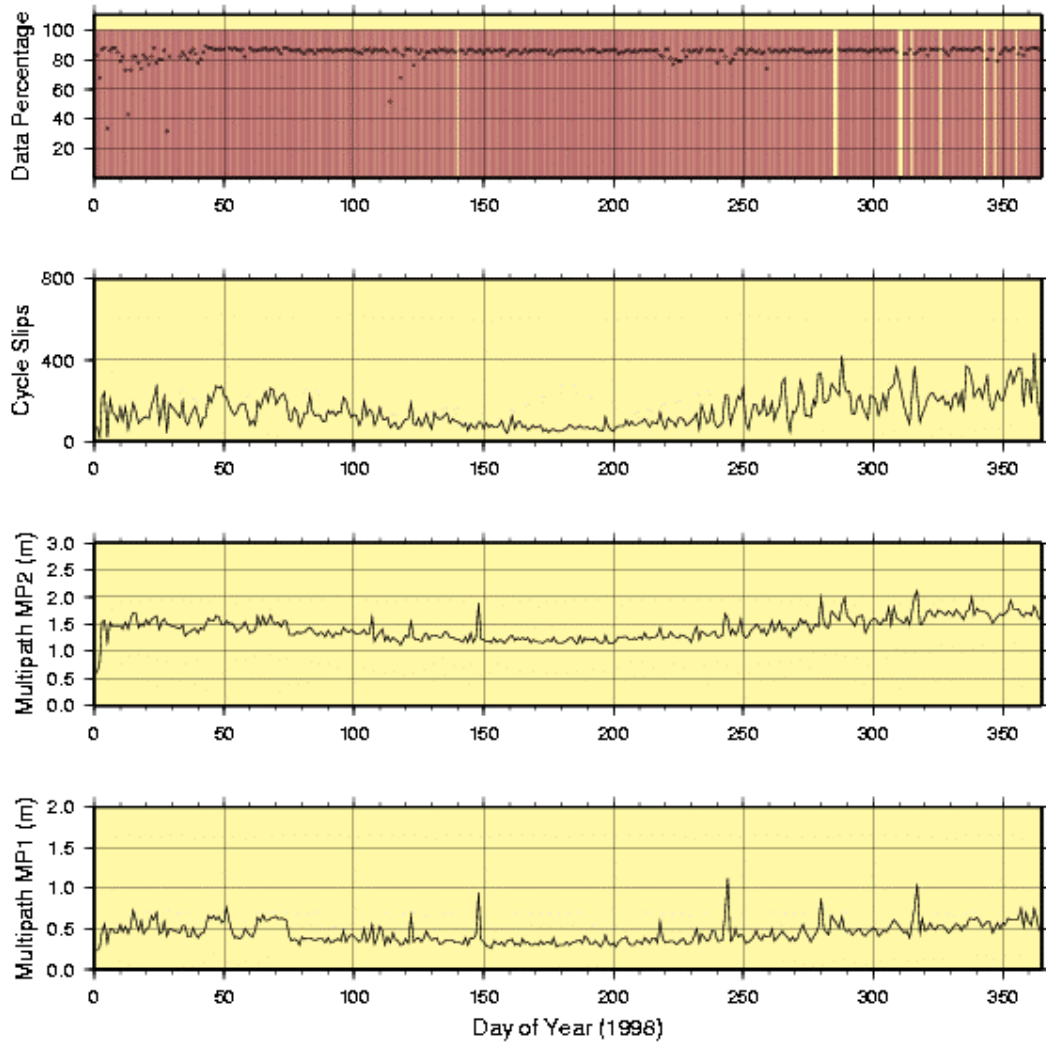
ARGN Site Performance - MACQUARIE Isl

LON: 158˚ 56´ 9.00´´ LAT: -54˚ 29´ 58.32´´

180
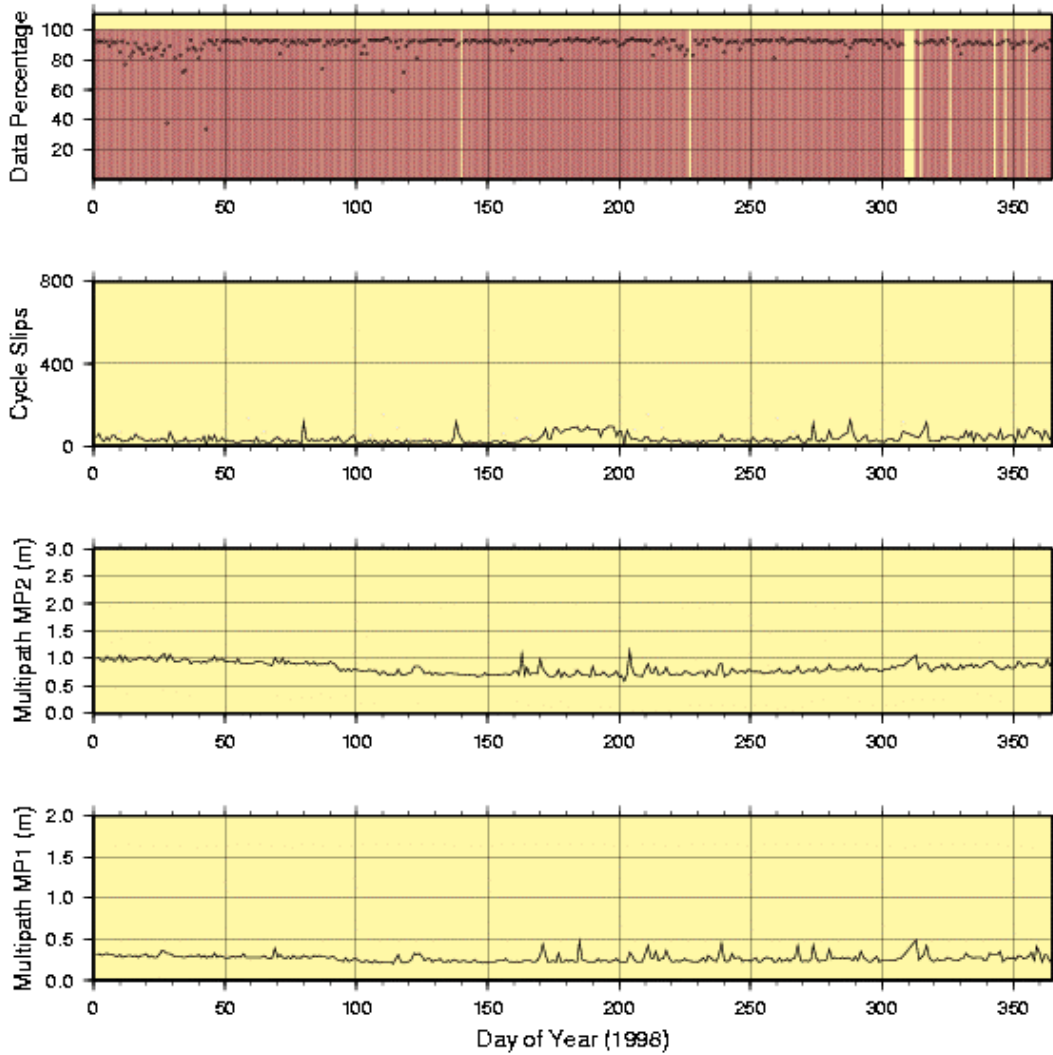
ARGN Site Performance - COCOS Isl
LON: 96˚ 50´ 2.27´´ LAT: -12˚ 11´ 18.06´´

181
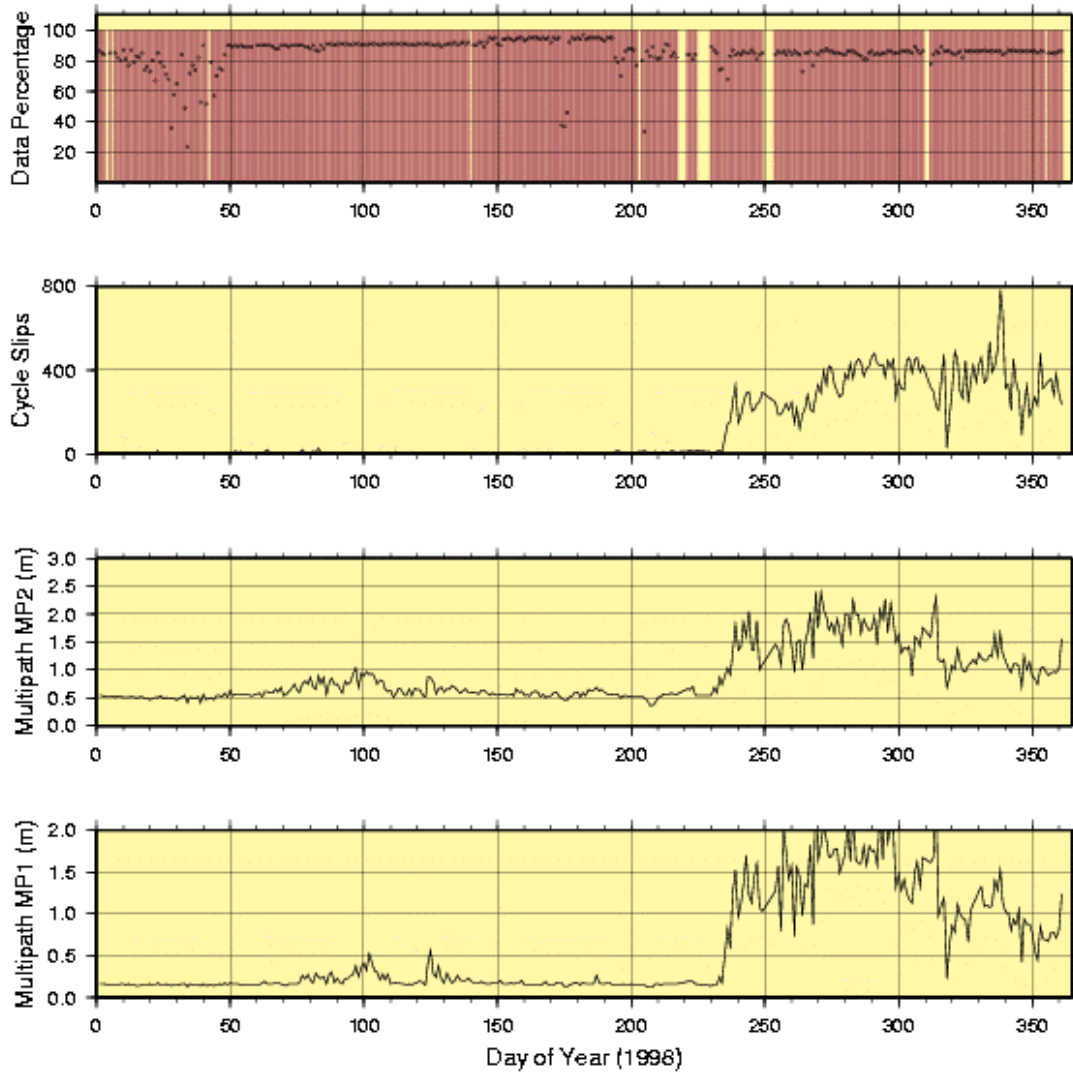
ARGN Site Performance - HOBART
LON: 147° 26´ 19.43´´ LAT: -42° 48´ 16.98´´
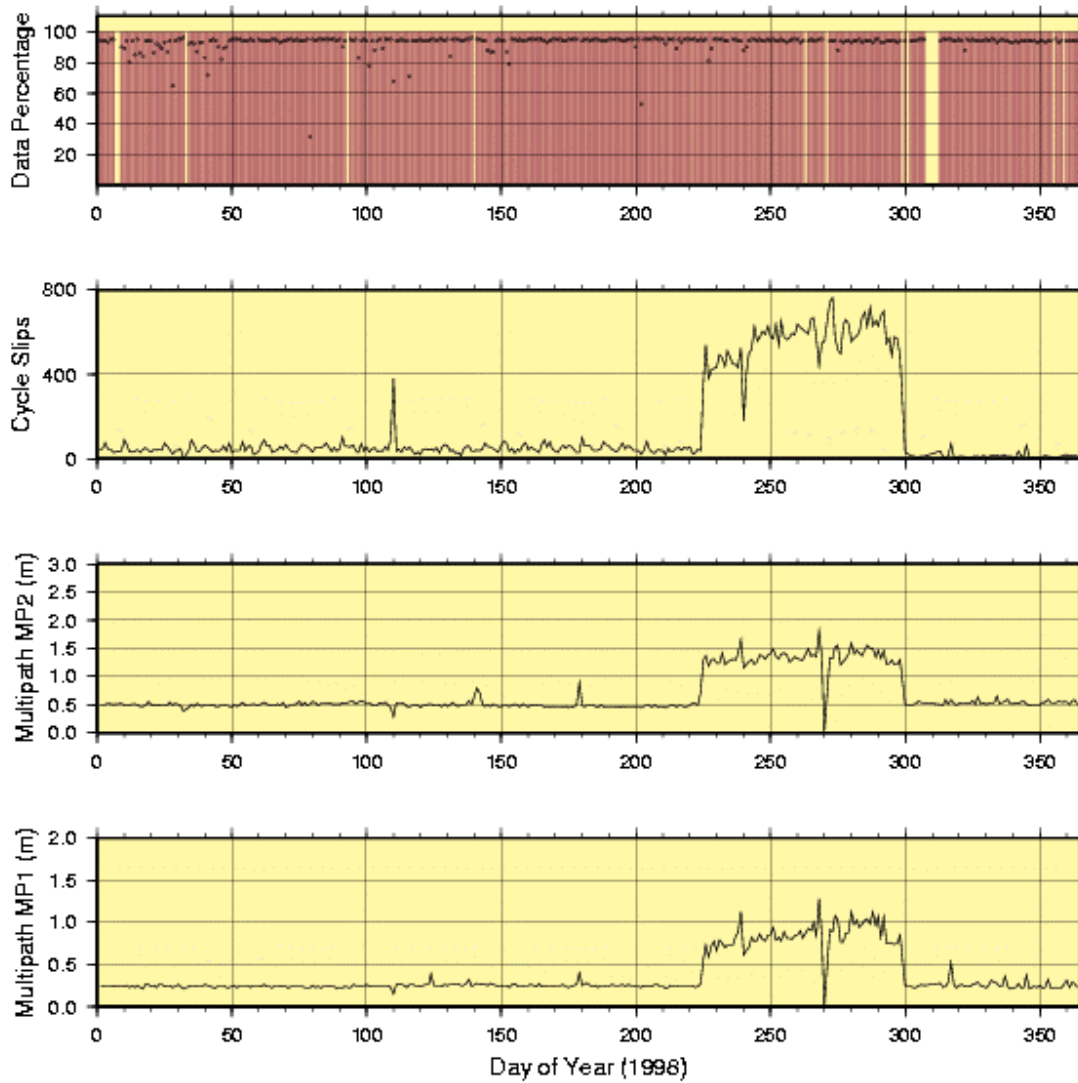
ARGN Site Performance - TIDBINBILLA
LON: 148˚ 58´ 47.98˝ LAT: -35˚ 23´ 57.15˝
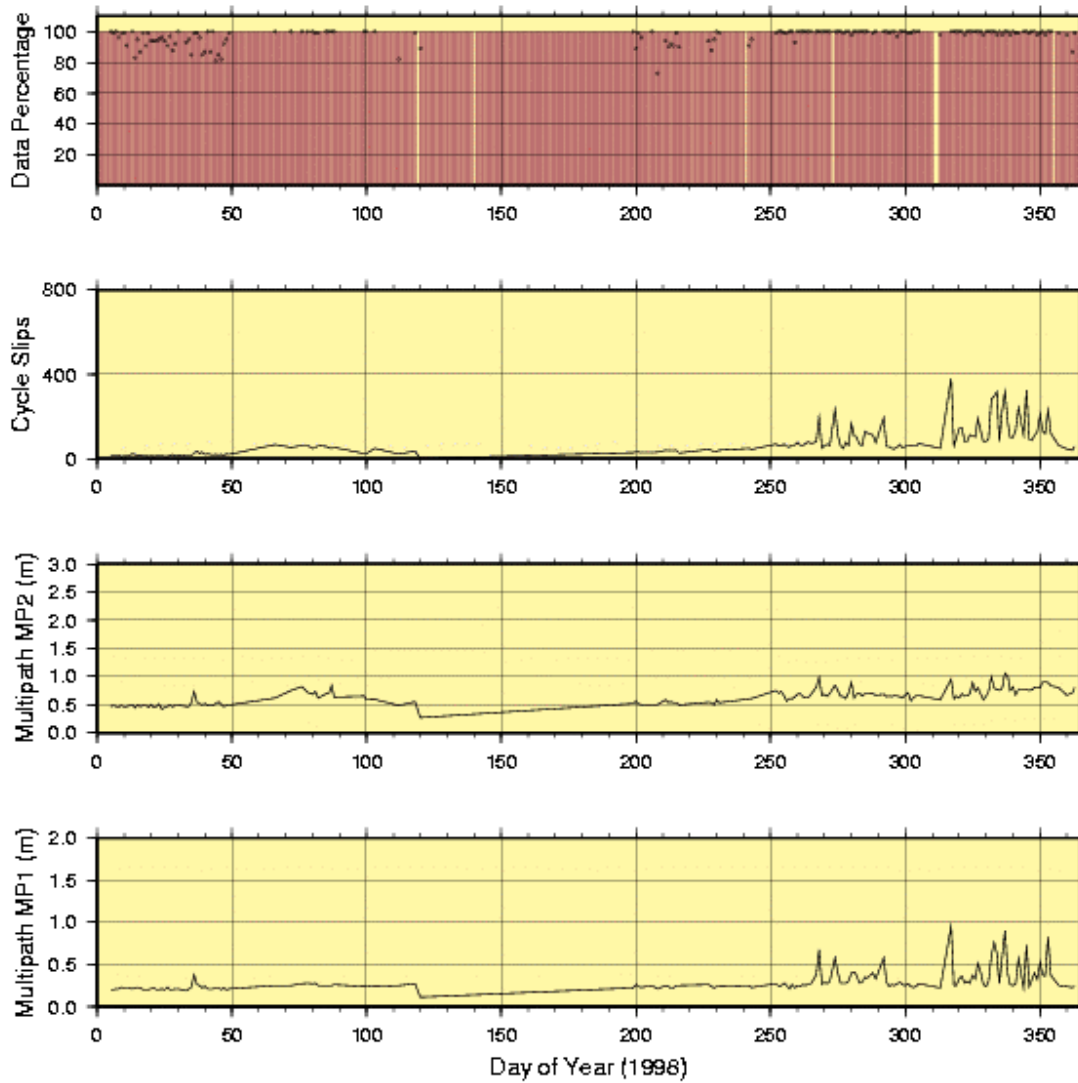
GMT Jul 19 13:66:16 1999   AUSLIG

ARGN Site Performance - YARAGADEE
LON: 147° 3´ 20.46´´ LAT: -19° 16´ 9.42´´
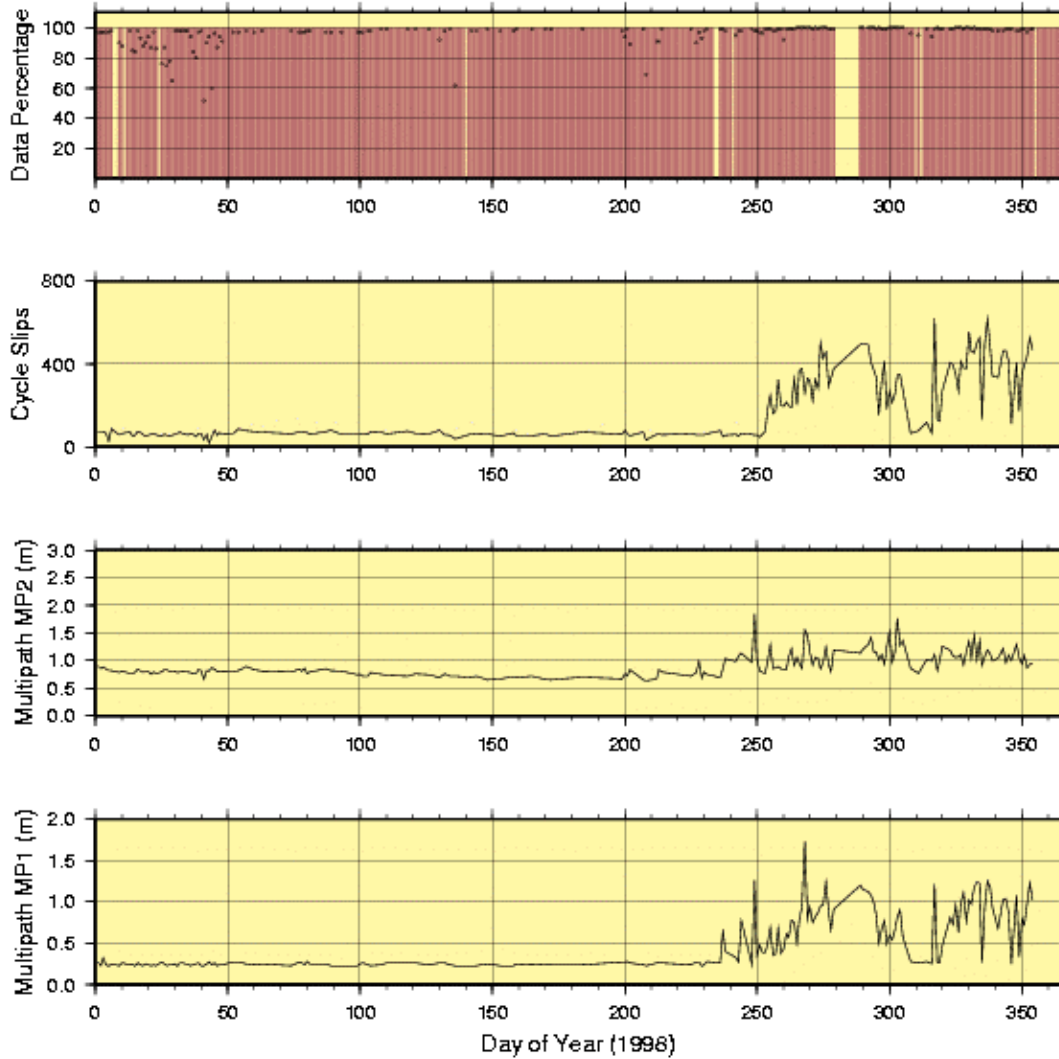
The GPS Receiver Network of ESOC:
Malindi , Maspalomas, Kourou, Kiruna, Perth, andVillafranca

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

ESA/European Space Operations Centre.
Darmstadt, Germany.

Overall Hardware Configuration

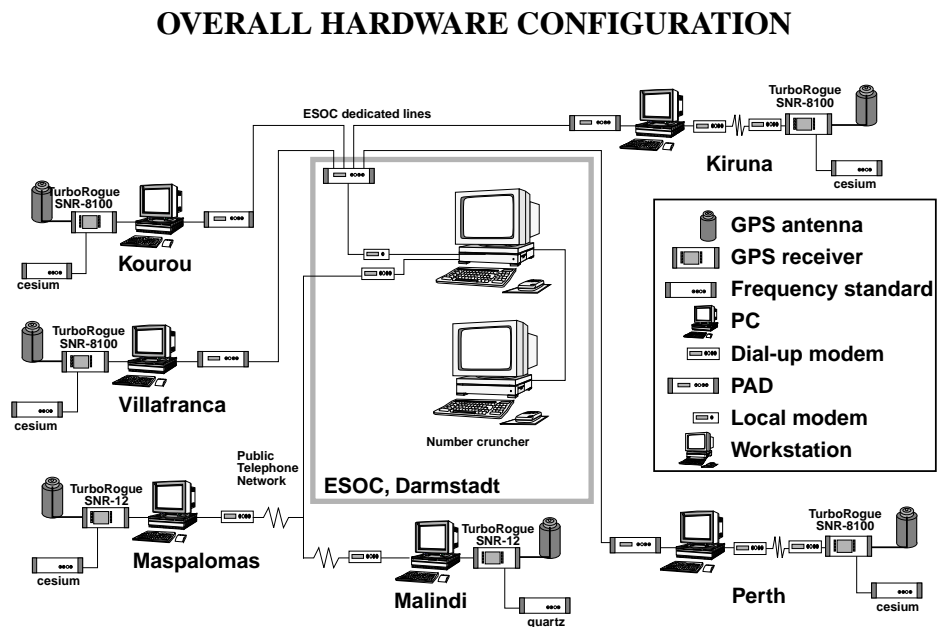Figure 1 shows the configuration of the ESA stations by the end of 1998.

OVERALL HARDWARE CONFIGURATION

Figure 1

Data Flow

Figure 2 presents the data flow from the ESA stations.

DATA FLOW FROM THE ESA STATIONS
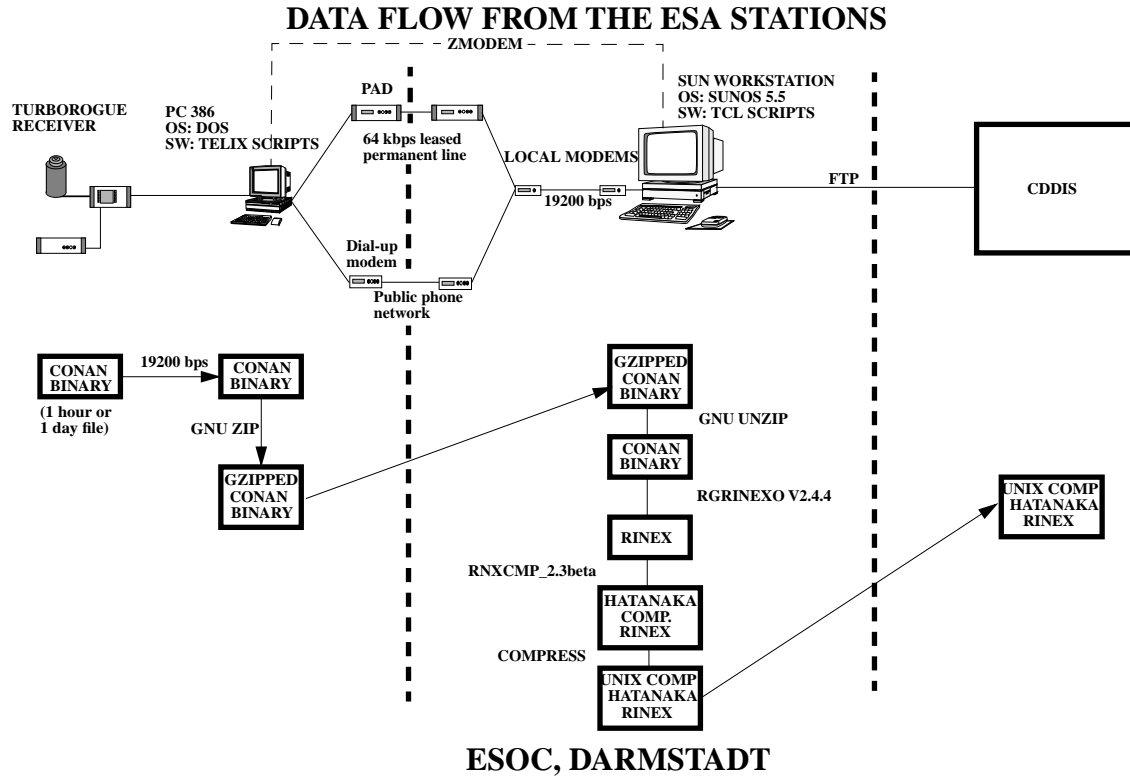

ESOC, DARMSTADT

Figure 2.

Receiver Performance

1998 was a quiet year for the ESA stations. We only have to regret the bad performance of the Kourou antenna which had to be replaced in January.

As it was reported in the IGS Network Systems Workshop, held in Annapolis 2-5 November 1998 the TurboRogues located at equatorial stations showed many limitations in the cross correlation mode tracking during the solar maximum. That means that for many of the visible satelites only one frequency was locked for many hours of the day. Ionospheric activity is increasing as we approach to the solar maximum. The daily interval when L2 is not locked is currently increasing. The only solution for this problem is a receiver replacement to one of the last models.

Figure 3 shows the typical performance of a TurboRogue located in low latitude station (Malindi). Towards the middle of the day (solar maximum at Malindi) L2 and P2 are not available for most of the satellites.

```
SV+----------------------------------------------------------------------+ SV
 30|o-M__                                        __^-1,oooooooooooooo|  30
 23|oo---__                                       _^-,,,2ooooooooooo|  23
  6|Mo11M--_                               _^,,,,,,,,I,o,I,o,Iooo,11|   6
 17|----------___                           _^,--,,Moooooooo,,I|  17
 29|ooooooooooooo--_                             _____^-2,Moooo|  29
 21|ooooooM---_____                         _^1,ooooooo|  21
 25|ooIoooooooooooM12o-M-_                          _+m2,,,,Io|  25
 22|oooooooooooooo,,-m1MMI----_                       _^2MoM|  22
  3|_-2,oooooooooooooo,---_____                            |   3
  1|    _-,oooooooooo,,,,I-----------___                   |   1
 31|    _^-omooooooooooo,,22,1---------__                  |  31
 14|    __^+,1I-M+_--11,,,,,,,,oo,,,,,--__                 |  14
 15|      _^--,,oooooooooo,,---__                          |  15
 18|        _^-1,,,IM,,--,,,12,,,,-1M,,-M---__             |  18
 19|         __-M,oooooo,,,,,,2---,--I---M--__             |  19
 16|          _^--,,,,,,,oooooo,-M--__                     |  16
 27|          __-,,,,,,,,,,,2,2,,,I--I--1M-12--__          |  27
  2|            _-,,,,,oooo,,,,------_____               |   2
  4|             __-,,,I,,,,,,,,,---,,,,,,-11M,2-_         |   4
  7|              _____^-,-M,,,,,,,,--,,,,,,-__           |   7
 13|               _^--,,,,,,--ooooooo,,-__              |  13
 24|               __^_^^^^I-M-,,,,,,o,ooooooooo,-__      |  24
 10|                __--,,---,,,,,,,,,,,,-M-M111M--__     |  10
 26|                 _^-,,,,,oooo,,,,,,2I----1--____      |  26
  5|                 __^^,,-,M--M11I,ooooooooooooM--__|   5
  9|                  _^1,oooooooooooM,,,,---__          |   9
  8|                  _^-2ooooooooI,,,,,,,--___    |   8
-dn|  111    1                1 1 22 1111      1111  1    21          1  1       |-dn
+dn|23433332331221222333222332333322333222138893432124441111333422321342 1213|+dn
+10|899888999988867889998999999aaaaaabb9999aa9abbaa89aaa8888899a9999abba89988|+10
Pos|o              o                  o                           o          |Pos
Clk|                                                                         |Clk
   +---------|--------|--------|--------|--------|--------|--------|--------+
00:00:00.000                                                  23:59:30.000
1999 Nov  1                                                   1999 Nov  1
```

Figure 3. Output from the UNAVCO utility teqc.
  o represents: phase and/or code data for SV is L1, C/A, L2, P2 & A/S is on.
  , represents: phase and/or code data for SV is L1, C/A only & A/S is on.

For the meaning of the other symbols:

  http://www.unavco.ucar.edu/software/qc/#teqc

IGS Core Network

In the Darmstadt workshop a set of 47 stations with well distributed location and good performance over the previous years was selected to constitute the IGS Core Network. Five of the ESA stations are part of the Core: Kour, Malindi, Maspalomas, Perth and Villafranca. Kiruna was not selected due to the presence of other stations in the same area with a similar performance and adding collocation techniques.

One-Hour Downloads

Anticipating the future requirements of IGS, with the need of more quickly available data for the production of near real time products, the data of four of the ESA stations is made available with only one hour latency.

The new system required the upgrades:

• to the software of the remote station PC's to download and store data every hour

• to the software of the ESOC control centre to retrieve, preprocess and distribute the data.

One-hour data of Kiruna, Kourou, Perth and Villafranca are available since September 1998. These stations have permanent leased data links to ESOC.

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.

• 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.

Technical Improvements of the IGS Stations Monitored by GFZ

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Introduction

The automatic downloading and data transfer as well as the remote control of a permanent GPS station are prerequisites to fulfil the requirements of an IGS station /1/. GFZ is monitoring 8 stations within the IGS network. The stations LPGS, OBER, POTS, URUM, RIOG, ZWEN have been equipped with new hardware and software components for improving the data quality and data availability in time and for reducing the data gaps in the continuous recording. The stations KSTU and KIT3 will follow at the end of this year.

Technical Concept for the Automatic GPS Station

The technical concept is based on the download (Rogue receiver) /2/ and logging (Ashtech receiver) /3/ software. Around these software tools additional programs and scripts have been developed to fulfil the following requirements for an automatic GPS station.

- Remote control of the station
- Supervising of the operation of all programs (download/logging, data compression, data transfer, file clean up)
- Restart of all programs after power interruption
- Setting of the receiver, download/logging and data transfer parameters by configuration files
- Start of the active file transfer to the Operational Data Centre (ODC) Potsdam via Modem/Internet connection after finishing of downloading or logging of the data.
- File transfer check. Restart of the file transfer in case of unmatched original and transferred files
- Clean up of data files after a predefined age.

Technical Status of the Stations

The stations LPGS, OBER, POTS, URUM, RIOG, ZWEN are equipped with new hardware components according to Figure 1. GPS receiver, notebook and DC-DC converter with a battery-buffered power supply are mounted in a rack with dimensions 55 cm wide, 50 cm high and 40 cm deep. In case of power interruption the hold time of the external battery (80Ah) is about 2 days. The present configuration of the stations is summarised in table 1.

Five Turbo Rogue stations have been equipped with upgraded AOA SNR 8000 ACT receivers. For these receivers the offload format has been set from Conan Binary to Turbo Binary because the Conan Binary format does not include C1 for these receivers.. Turbo Binary includes all observables including C1 **/4/** . For the URUM station the format will be changed to Turbo Binary soon.

For compression of Turbo Binary data the programs tcomp **/5/** and zip are used. The compression factor is about 3 for 30 s data and about 10 for 1 s data..

The availability of the Internet or phone connections to an Internet provider at the GPS stations has been used for station automation and automatic data transfer (ZWEN in October 1998, LPGS in November 1998, RIOG in November 1998, URUM in October 1999). The station KIT3 will be connected to Internet at the end of this year. The availability of Internet at the KSTU station is announced for early 2000.

The stations deliver now daily files. All stations are prepared to send hourly files and the standard sampling interval of 30 s can be set to 1s.. The stations LPGS, OBER, POTS will deliver hourly files at the end of this year. Depending on the communication improvements other stations will follow. The stations KSTU and ZWEN will be equipped with meteorological sensors and deliver meteorological data in January 2000.
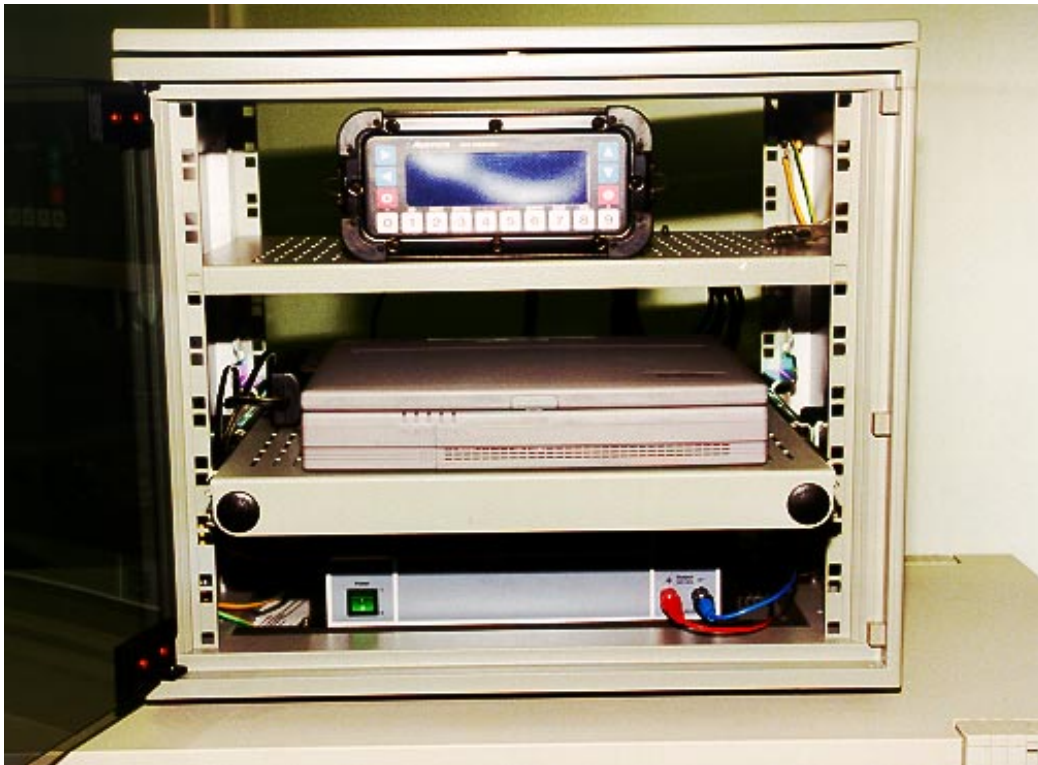

Fig.1 Hardware of GFZ permanent GPS stations

Table 1   Status (11/99) of IGS Stations Operated by GFZ

Station	Receiver	Download software	Receiver Format	Operating System	Compression	File size	Data transfer via	Transfer time to analysis centres	Meteo. data
KSTU (Russia)	ROGUE SNR-8000	trMonitor	CB	MSDOS	zip	daily	Internet (offline)	<2 days	no
KIT3 (Uzbekistan)	ROGUE SNR-8000	trMonitor	CB	MSDOS	zip	daily	Inmarsat C	<2 h	yes
LPGS (Argentina)	AOA SNR 8000 ACT	trMonitor	TB	LINUX	tcomp and zip	daily (hourly)	Internet	<1 h	no
OBER (Germany)	AOA SNR 8000 ACT	trMonitor	TB	LINUX	tcomp	daily (hourly)	Internet	<1 h	yes
POTS (Germany)	AOA SNR 8000 ACT	trMonitor	TB	LINUX	tcomp	daily (hourly)	Internet	<1 h	yes
URUM (China)	AOA SNR 8000 ACT	trMonitor	CB	LINUX	tcomp and zip	daily	Modem and Internet	<1 h	yes
RIOG (Argentina)	Ashtech Z12	GBSS	Ashtech	WIN/NT	zip	daily	Modem and Internet	<2 h	no
ZWEN (Russia)	AOA SNR 8000 ACT	trMonitor	TB	LINUX	tcomp and zip	daily	Modem and Internet	<2 h	no

New Stations

The station RIOG (Rio Grande/Argentina) got the IGS status in March 1999. It strengthens the IGS network in the southern hemisphere. The station is equipped with an Ashtech Z12 receiver which operates according to the above requirements automatically **/6/**.

ODC Improvements

The ODC software is based on the teqc translator **/7/**. Improved UNIX scripts have been developed for data managing and parameter settings of teqc and ftp. The processing time of the data at ODC is a few minutes and the received data are transferred to the analysis centres in time.

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   http://igscb.jpl.nasa.gov/network/guide_igs.html

2. Galas R.: program "trMonitor", 1999

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4. IGS mail Message Number 2320

5. Koehler W.: program " tcomp" 1999

6. Neumeyer J. and Nischan Th.: Remote-Controlled GPS Station Based on Ashtech GBSS Software, Proceedings IGS Network Systems Workshop, 167-168, Pasadena, USA, November 2-5, 1998.

7. teqc http://www.unavco.ucar.edu/software/translation/#teqc

NASA-Sponsored GPS Global Network Activities

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Activities in 1998

NASA continues to sponsor the maintenance and expansion of a significant fraction of the global GPS network (Figure 1). Following the initial establishment of IGS sites prior to 1994, NASA's contribution has included new sites at the rate of about 8 or 9 per year. Currently (November 1999) there are 61 IGS sites that are at least partially funded by NASA.

Table 1 indicates the sites established in 1998 (files in ftp://igscb.jpl.nasa.gov/igscb/station/log and ftp://igscb.jpl.nasa.gov/igscb/station/oldlog are used to determine the times of commissioning). Those in Russia (petp and tixi) are in collaboration with IRIS/RDAAC.

Beginning in 1998, JPL began to deliver hourly data (IGS mail message 1946, July 14, 1998) from a subset of its sites. Based on recent (1999 day of year 306-311) files in JPL's local hourly disk area, the set of sites includes aoa1, auck, bogt, cic1, cord, eisl, fair, gode, gol2, guam, hrao, jplm, kokb, kwj1, mad2, mcm4, mkea, nlib, pie1, pimo, sant, suth, tid2, and usud.

In the fall of 1998, loss of L2 tracking at a number of sites with the TurboRogue receiver revealed a problem in the tracking software (IGS mails 2071, 2075, 2190, 2240, 2241, and 2336) that is evident when the line-of-sight electron density is sufficiently high. The symptom disappears when tracking at 1 sec instead of the nominal 30 sec.

The recommended solution is to replace TurboRogues with more up-to-date receivers; we have so far used a mixture of Ashtech Z12s and AOA ACTs. A second option is to operate a TurboRogue at 1 sec and form 30-sec observables in a process external to the receiver ("L2 workaround").

Finally, 1998 saw the planning and initial development of a configuration to support high rate (1 Hz) and low latency (15 min) data.

This configuration will be established at approximately ten to twenty sites, and will be used to support interpretation of data from low-Earth-orbiting satellites that carry GPS receivers.

Activities in 1999 and Beyond

In 1999 seven new sites were established (cic1, pimo, cord, and ykro, plus artu, yssk, and bili in collaboration with IRIS/RDAAC).

Replacement of TurboRogues with Ashtech Z12s or AOA ACTs was initiated. The L2 workaround was implemented at several TurboRogue sites. Several LEO support sites were established.

Details will appear in next year's volume.
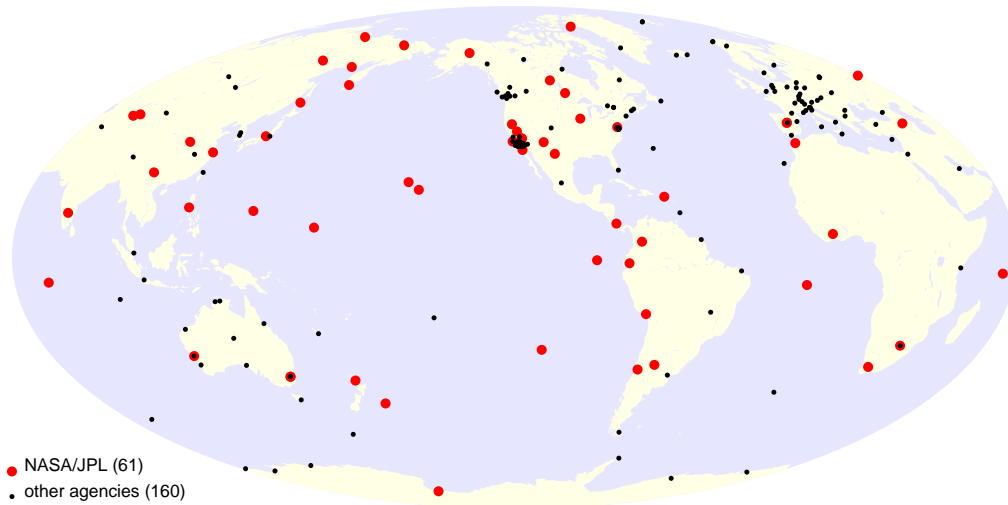
IGS sites as of November 1999 according to files in ftp://igscb.jpl.nasa.gov/igscb/station/log. Included in the "NASA/JPL" categorization are seven sites in Russia (artu bili mag0 petp tixi yakz yssk) and two sites in Canada (flin dubo) with partial NASA support.

Table 1 NASA-Supported IGS Sites Established in 1998

4-Character ID	Country
nssp	Armenia
suth	South Africa
kunm	China
iavh	Morocco
riop	Ecuador
petp	Russia
tixi	Russia

NRCan 1998 IGS Annual Report
Network and Stations

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Natural Resources Canada (NRCan) - formerly Energy, Mines and Resources (EMR) Canada operates two GPS Networks which combine to form the Network of "Canadian Active Control Points" or CACP's. The Real Time Canadian Active Control System (RT-CACS) is operated by the Geodetic Survey Division (GSD) while the Western Canada Deformation Array (WCDA) is operated by the Geological Survey of Canada (GSC). Table 1 lists the IGS sites operated by these agencies.

RT-CACS	WCDA
ALGO	ALBH[*]
CHUR	CHWK
NRC1	DRAO
PRDS	DUBO[**]
SCH2	FLIN[**]
STJO	HOLB
YELL	NANO
	UCLU
	WHIT
	WILL
	WSLR

Table 1: NRCan IGS Sites
[*] *indicates WCDA sites operated as RT sites*
[**] *indicates sites operated cooperatively with NASA/JPL*

Data flow (1 Hz) from the RT-CACS sites is provided in real time using either frame relay or VSAT links to the Master Active Control Station in Ottawa, Ontario. Standardized GPS instrumentation is used at all sites. The AOA Turbo Rogue receivers deployed at the RT-CACS sites utilize the NRL versions of the firmware available from the manufacturer. Sampling at these sites are at 1 Hz; the 30 sec. data provided to the IGS community is then derived from the 1 Hz data using software developed by the GSD. Wide area real time corrections are generated from the nation wide network

The WCDA network uses conventional telecommunications, i.e. data lines combined with modems. Thirty second data files are offloaded 6 times daily forming 4-hour station data files. The RINEX version of these 4-hour data files are posted on anonymous FTP (sikanni.pgc.nrcan.gc.ca). At the end of the UT day, 24-hour RINEX data files are generated and forwarded to CDDIS.

As with the RT-CACS sites instrumentation standardization has been maintained. AOA Turbo Rogue receivers and AOA Dorne Margolin T choke ring antennas used at all sites. All sites except CHWK employ concrete piers. In order to mitigate the near field multipath effects RF screens have been installed at all of these sites. CHWK installed in November 1998 uses a newly designed stainless steel pier (see fig. 1).

The WCDA network is an active partner in the Pacific Northwest GPS Array (PANGA). It is expected that during 1999-2000 the WCDA will be expanded by up to four stations. Plans also call for additional WCDA sites to contribute to the Real Time CACS network.

The Stainless Steel pedestal designed at the Pacific Geoscience Centre, GSC, is intended to provide robust placement of GPS antennas for crustal deformation studies. The design is intended to minimize the effect of solar radiation by shielding the stainless steel pipe by a reflective, white PVC cover. An air space is provided between the PVC pipe and stainless steel pipe. In addition the stainless steel pipe has been filled with dry sand to provide additional mass to the pier as well as to moderate the diurnal effects of solar heating. Antenna security is provided by a security mechanism which attaches the antenna to a "security ring" using special bolts.
Additional information can be obtained by emailing schmidt@pgc.nrcan.gc.ca
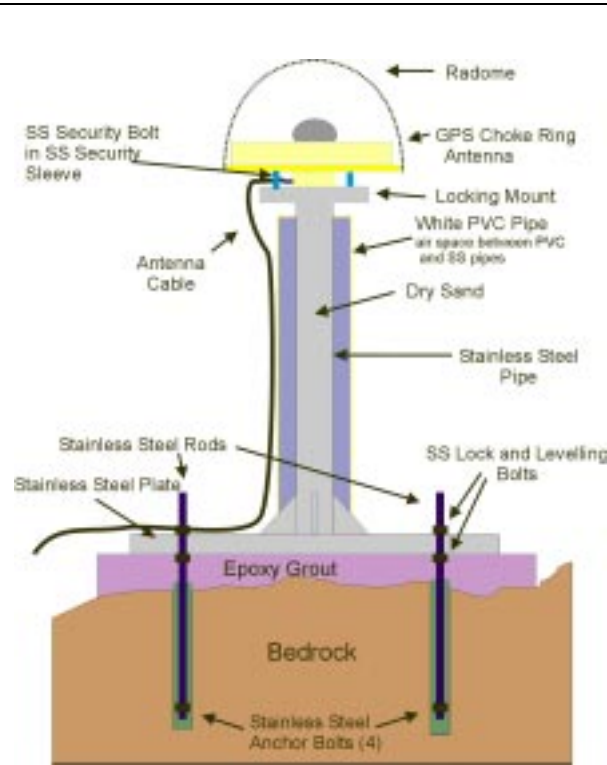
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INDIVIDUAL STATION

The BOR1 IGS Station

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Antenna Problems at BOR1

At the beginning of the year 1998 it happened sudden worsening in the work of receiver operating at the permanent station BOR1 as well as in the quality of received GPS signals, particularly in the L2 band.

Special tests (details in Fraczyk et al. 1998) showed that the disturbances were mainly brought about by two sources of signals situated in the distance of some kilometres of the point BOR1.

The first source (I) had a significant component of the signal in the range 1300 - 1350 MHz, and it worked in the days 32 – 295 '1998. The second source - relay station of cellular phone, works in a narrow band at a frequency of about 900 MHz - has started at DOY 50 (1998) and it works till now.

Fig. 1 shows daily residuals mp2 (Zumberge I.F., 1996) for the period 1997.0–1999.5. They are well correlated with the P–code residuals, published by the JPL (Heflin M., 1997–1999).
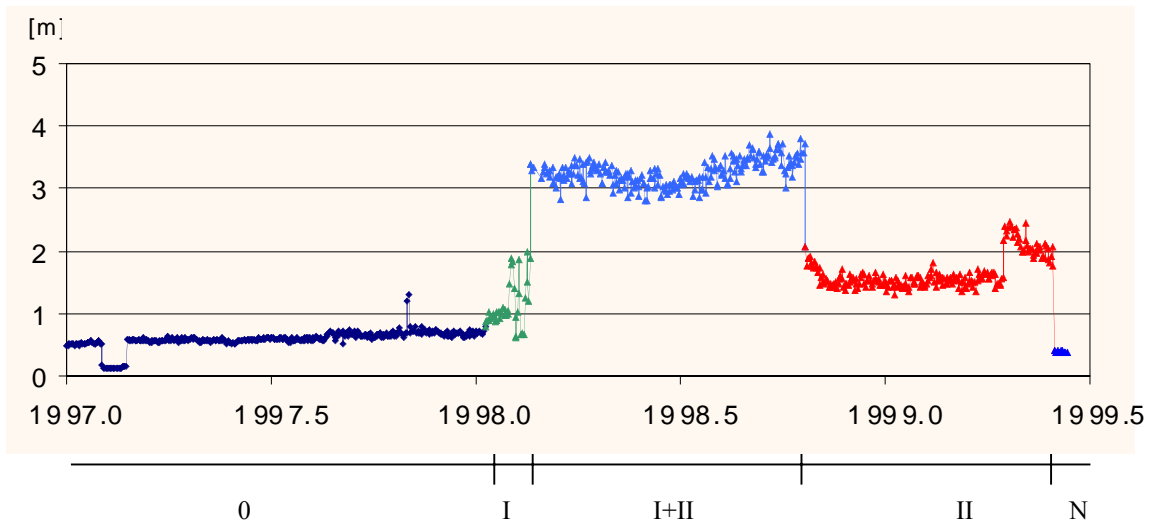

Fig.1. Daily residuals mp2 of the observations at BOR1:
0 – no disturbed observations; I – source I; II – source II; N – new antenna AOAD/M_T.

These disturbances didn't bring about alterations besides increase of dispersion, general course of observed variations of the height H of BOR1 site according to WUT solutions (Figurski M. 1997-1999) – see Fig. 2.
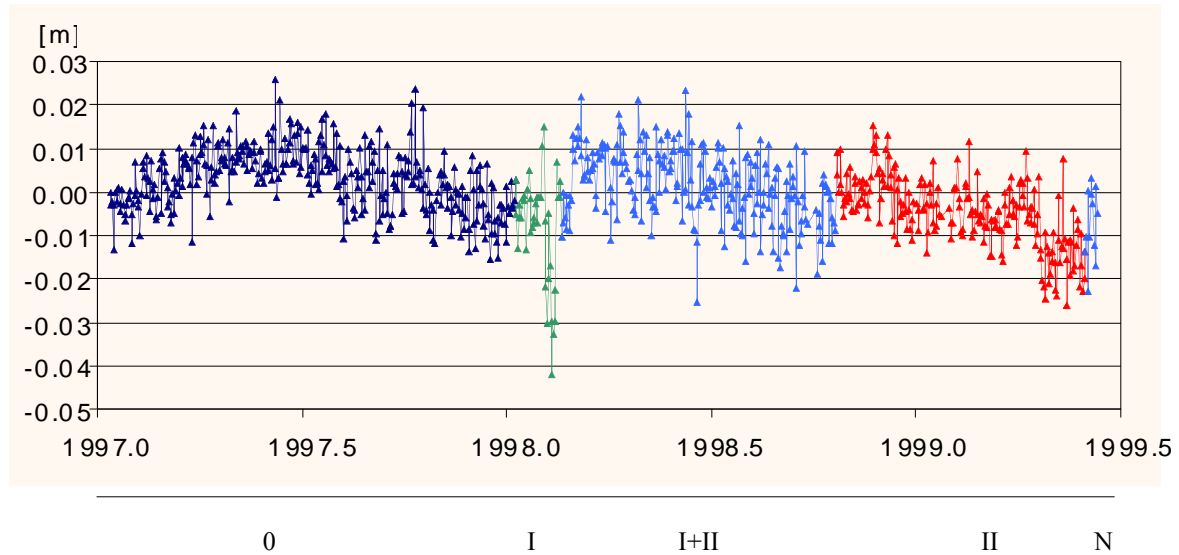

Fig. 2. Daily changes of the height H of BOR1 site, according to WUT solutions.

At the DOY 151, of the year 1999 one has installed the new Dorne–Margolin (AOAD/M_T) antenna with pre-amplifiers. It has eliminated the influence of discussed sources of frequency upon the observations at the permanent station BOR1.

Conclusion

It is necessary to carry on the measurements of the radio background on the permanent GPS observation point.

References

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Report on IGS Global Station Jozefoslaw (JOZE)

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The IGS permanent GPS station Jozefoslaw (JOZE) is located at the Astrogeodetic Observatory of the Institute of Geodesy and Geodetic Astronomy of the Warsaw University of Technology, 14 km southwards from the Warsaw city centre. The Observatory was established in 1959; at present the following permanent services are maintained:

- GPS permanent service is maintained since August 1993. Earlier, the station participated in the IGS Epoch'92 Campaign. As a basic GPS equipment the Trimble 4000SSE receiver serial No. 3249A02090 and antenna Trimble Geodetic L1/L2 No. 3247A66429 are used. Three rubidium frequency standards are available at the station; one of them is used as an external standard for IGS service. On January 1, 1995 the second GPS receiver, a TurboRogue SNR8000, serial No. 339 with the antenna type Dorne Margolin T No. 439 was installed at the station. The permanent GPS IGS service is maintained by both receivers (Trimble 4000SSE and TurboRogue SNR8000). The Trimble 4000SSE serves as the main receiver and the observations collected by this receiver are transmitted to the international data centres. The observations from Jozefoslaw are used for IGS service and for maintenance of the EUREF system. The observations of the TurboRogue SNR receiver are available upon request for all interested centres for scientific research. In some periods also other types of GPS receivers are temporary installed at the station Jozefoslaw. The observations are performed to study some instrumental effects, multipath and atmospheric (ionosphere and troposphere) influences.

8. Gravimetric permanent tidal observations are carried out using LaCoste & Romberg, mod. G gravity meter. This service has been maintained since November 1993. The Observatory is incorporated to the international network of tidal observatories (No. 0909) The Observatory Jozefoslaw is one of the fundamental points of the Polish national gravimetric network, many absolute gravity determinations have been performed by Polish and international observing groups. A meridional gravimetric baseline, 26 km long, was established at the Observatory in 1976; periodic observations are made four times a year. The observations are used jointly with classical astrometric determinations for monitoring of the changes of the vertical. Since 1993 thirteen independent absolute gravity determinations have been performed at Jozefoslaw using a ballistic gravimeter designed and constructed by Prof. Zbigniew Zabek, Institute of Geodesy and Geodetic Astronomy. These observations are of accuracy of 3 µGal and serve as a basis for the analysis of gravimetric tidal observations

conducted at Jozefoslaw and determinations performed at the local gravimetric station.

- Astrometric latitude observations have been carried out since 1959 in the international cooperation with BIH and IPMS and now the observations are used by Shanghai Observatory (international coordinator of the optical astrometry) and GOSTSTANDARD, Moscow. These observations are still used as complementary ones for the analyses of the time variations of the plumb line.

- At the end of 1994 a new NAVI meteorological station was installed and it began to perform permanent routine observations in 1995. The observation data are translated into the RINEX format and sent to CDDIS. Meteorologic service maintained at the station can also be supported by nearby permanent meteo service of the Warsaw airport (Warszawa-Okecie). The station Jozefoslaw is located in a distance of a few kilometres from the Warsaw airport. In 1998 a meteorological database was set up to cover the territory of Poland. The data is used to determine both the height changes of the station due to the effect of deformation resulting from the atmosphere and the gravity changes. Based on the meteorological data for Poland, an analysis of the changes of the parameters that describe atmospheric tides was carried out and their accuracy of gravimetric measurements of the Earth tides by eliminating the external environmental effects. The station JOZE takes part in the works of the IGS Ionosphere Working Group. We estimate ionosphere parameters for particular processing sessions, by development into spherical harmonics of 12th degree and 8th order. Results are stored in IONEX format and compared to the daily ones. For each session we also generate normal equations which serve as a basis for combining hourly to daily solutions.

- In some periods the observations of atmospheric electricity are made at the Observatory by the team of the Polish Academy of Sciences.

The monumentation of the reference point for IGS GPS observations was made according to the IGS standards. The network of control points is available. Due to the geological situation the pillar could not be monumented on the bedrock. Station Jozefoslaw is the reference point of several international GPS networks, e.g. EUREF-POL (European Reference Frame), EXTENDED SAGET (Satellite Geodetic Traverses), CEGRN (Central Europe GPS Reference Network) realised in the frame of the project CEI CERGOP (Central European Initiative Central Europe Regional Geodynamics Project) and BSL (Baltic Sea Level Project). The eccentricity of the EUREF point with respect to that of other campaigns is X = 0.079 m, Y = 0.030 m, Z = 0.108m. In the 1960ties, 1970ties and 1980ties the Observatory also participated in other astrometric as well as satellite Doppler and GPS campaigns.

The Institute's Processing Centre acts as IGS Regional Network Associate Analysis Centre, EUREF Local Analysis Centre and as CEI CERGOP and EXTENDED SAGET Processing Centre. The routine permanent GPS data processing and transmission are

made for IGS and EUREF; also other GPS campaigns organised in Central Europe for geodynamic studies of the Teisseyre-Tornquist Contact Zone, the Carpathian Belt and Subalpine Regions are processed in the Centre. The WUT EUREF LAC (Warsaw University of Technology EUREF Local Analysis Centre) deals with day-to-day data processing for the regional subframe EUREF consisting of 20 stations located in Central Europe. The works are performed within the framework of IGS and they are aimed at developing a new strategy for the distribution of sites within the ITRF (IERS Terrestrial Reference Frame) by combining local and regional solutions with the global IGS one. Today the WUT EUREF Local Analysis Centre is one the 11 centres of this kind operating in Europe.

The base station at Jozefoslaw was equipped in 1998 with devices which make the transmission of the differential corrections possible in the standard of RTCM S.C.-104 (Radio Technical Commission for Maritime Services, Special Committee No. 104), thereby allowing us to perform GPS measurements in real time with an accuracy of single centimetres. The system thus developed uses cellular phones operating in NMT-450 system as a transmission medium, which is due to the fact that their range practically covers the entire territory of Poland. Attempts at using RTK technology in ship handling training have been made. The growing number of potential customers for this kind of system seems to indicate that works on the improvement of this technology will be continued.

LAMA Permanent IGS Station Status Report for 1998

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The first permanent GPS observations at Lamkowko Satellite Observatory were carried out on early 1994. The Observatory has taken part in IGS since December 1st, 1994.

A new observational point (LAM5) was constructed in 1998. It is placed on the roof of the Observatory building and plays a role of reference station in experiments with RTK technology. Receiver TurboRogue SNR-8000 has got damage on May 1998 and Ashtech ZXII3 replaced it.

The results of permanent GPS observations, obtained in Lamkowko and other Polish and European IGS stations, are the bases of own studies in 1998:

1. Monitoring of the Lamkowko-Borowiec vector, perpendicular to Teisseyre-Tornquist's Zone.

2. Monitoring of the vectors connecting Lamkowko with two other European stations (Matera, Italy and Onsala, Finland) situated on different geological structures. Matera station was chosen because of its location on seismic activity area. Monitoring of the Lamkowko-Onsala vector seems to be very interesting owing to fact, that there are post-glacial vertical movements on Fennoskandia area. Obtained results show, that in spite of large distances between stations, permanent GPS observations permit high precision positioning.

3. The ionospheric researches were started in 1995. The main goals are to determine Total Electron Content - TEC and to investigate the influence of TEC changes on positioning precision. The TEC can be obtained on the basis of simultaneously two frequency observations with use of algorithm shown in (Baran et al., 1997). Precision of TEC determination is $(2-3)*10^{16}$ el./m^2. The bases of ionospheric studies are permanent GPS observations carried out by IGS and EUREF stations.
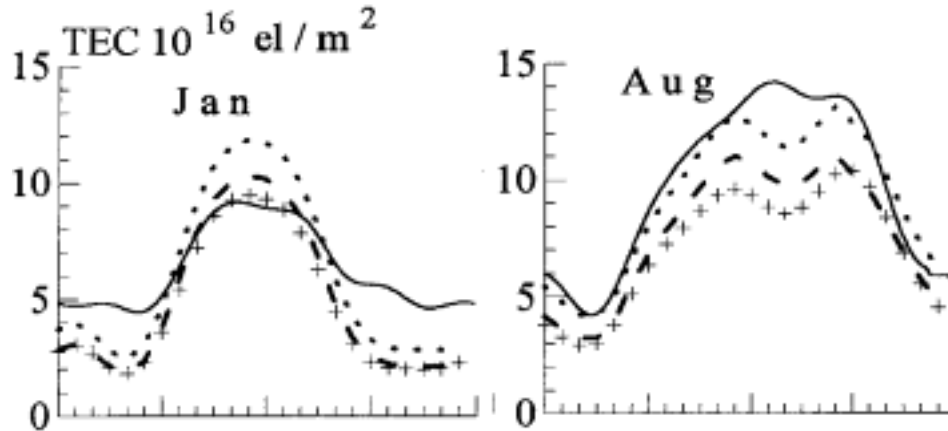
Fig. 1 - Comparison of seasonal TEC over MATERA station in 1996 derived from GPS (solid line) with IRI90 (up to 2000km – dotted), IRI90 (1000km – dashed) and IRI95 (1000km – crosses)

Our studies (Baran and Shagimuratov, 1998), carried out at minimum solar activity, show that two frequency GPS observations are useful for monitoring periodical (daily and seasonal) changes of TEC (Fig. 1) and for monitoring TEC at solar storms periods.

The results of permanent GPS observations, carried out in 1995-1998 by three polish IGS stations: Borowiec, Jozefoslaw and Lamkowko, were used to create regional TEC model over Poland. The model is valid at minimum solar activity.

4. Study of the GPS orbits' quality influence on positioning precision. Mentioned below orbits were analysed (Krankowski, 1998):
   - CODE final orbit,
   - CODE 1-day orbit (available with 3-day delay),
   - CODE rapid orbit (available with 16-hour delay),
   - CODE orbit predicted for 24 hours.

The results were compared with those obtained from final, precise IGS orbits ones.

Mentioned below vectors were analysed:
   - Lamkowko - Borowa Góra,
   - Lamkowko – Borowiec,
   - Lamkowko – Matera,
   - Lamkowko – Onsala.

The analysis is based on the results of the permanent GPS observations carried out by mentioned IGS and EUREFF stations in January 1998 (939-942 GPS weeks). Software Bernese v 4.0 was used for all calculations. The results are shown in Table 1.

Table 1. The Influence of the Orbits' Quality on Vector's Co-ordinates

Type of Orbits	Extreme Differences of Co-ordinates	Extreme Differences of Length
CODE — IGS	2 mm	0,5 mm
CODE 1-DAY — IGS RAPID ORBIT — IGS	6 mm	2,5 mm
CODE 24-pred. — IGS (D<300 km)	5 mm	1,0 mm
CODE 24-pred. — IGS (D>600 km)	25 mm	10,0 mm

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Status Report of the IGS Station GLSV

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General Information

The GPS Station GLSV has conducted permanent observations since December 16, 1997. It is operated by the Main Astronomical Observatory (MAO) of the National Academy of Sciences of Ukraine. Prior to April 1998, GLSV has worked in autonomous level. Since May 1998 this station was included in IGS and EUREF networks.

The station GLSV is located at MAO in the southern part of city of Kiev. The antenna is placed at the top of steel pillar mounted on the roof of the Observatory office.

The station works in a fully automatic mode and data is sent to the Regional Data Center in BKG (Frankfurt am Main, Germany).

GPS Station Configuration

Station name:	Golosiiv, Kiev
4-char ID:	GLSV
DOMES Number:	12356M001
Receiver type:	Trimble 4000SSI
Firmware version:	7.15
Antenna type:	TRM29659.00 (choke ring design)
Antenna height:	0.000 m
Antenna reference point:	ARP
Approximate coordinates (WGS–84):	
Latitude:	50.3642 N
Longitude:	30.4967 E
Height:	226.8 m
On-site PC:	Pentium (Linux)
UPS:	Patriot 420
Collocation:	SLR 1824 Kiev

Future Plan

In 1999, MAO is going to start permanent observations at the new stations in Uzhgorod (West Ukraine) and Evpatoria (Crimea).