Today's EPN and its network coordination

C. Bruyninx[1], G. Carpentier[1] and F. Roosbeek[1]
EPN Central Bureau

Presented at the EUREF Symposium, June 4-6, 2003, Toledo, Spain

1. Introduction

This document describes the present status of the EUREF Permanent Network (EPN), concentrating on the major changes since the EUREF Symposium of June 5-8, 2002 in Ponta Delgada, Azores, Portugal (*Bruyninx et al, in press*). In addition, based on case studies, the network monitoring tools developed, and now routinely used at the EPN Central Bureau (CB), are described.

2. Status of the EUREF Permanent Network

2.1 Tracking network

Figure 1 shows the status of the EUREF permanent tracking network as in June 2003. The number of active EPN stations is 137. 50 % of them belong also to the IGS network. Four EPN stations: AMMN (Amman, Jordan), IAVH (Rabat, Morocco), LINZ (Linz, Austria) and SBGZ (Salzburg, Austria) are presently labelled as inactive. They have not been submitting data for more than three months. The 9 new EPN stations that joined the EUREF network since June 2002 are given in Table 1.

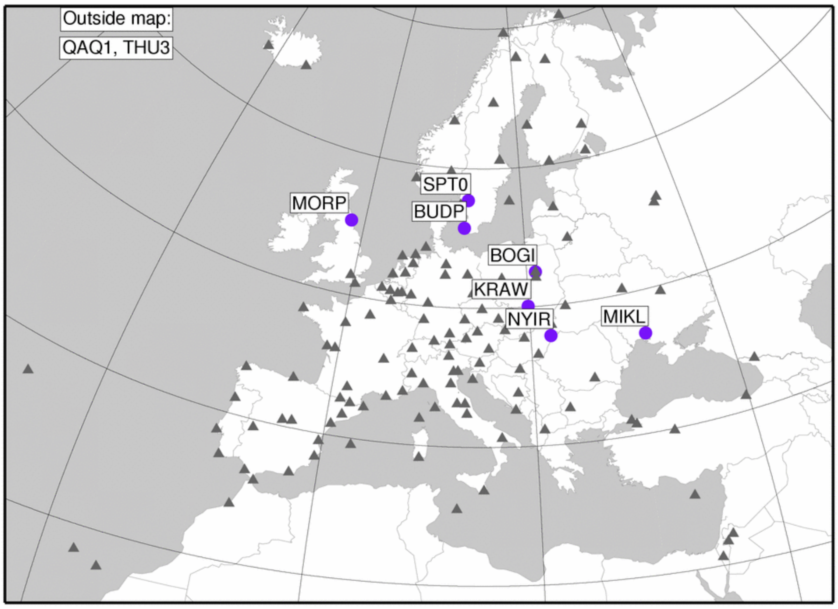


Figure 1 – Stations included in the EUREF permanent network (status June 2003); the big circles show the stations added to the network after June 2002.

Station	4 char ID	Country	Lat. (N)	Lon. (E)	Agency	Incl. Date
Boras	SPT0	Sweden	57.71	012.89	LMV	07.07.2002
Qaqortoq	QAQ1	Greenland	60.71	313.95	KMS	08.09.2002
Borowa Gora	BOGI	Poland	52.47	021.03	IGiK	23.09.2002
Morpeth	MORP	England	55.21	358.31	SCEG	03.11.2002
Mykolaiv	MIKL	Ukraine	46.97	031.97	RIGC	10.11.2002

[1] C. BRUYNINX, G. CARPENTIER and F. ROOSBEEK, Royal Observatory of Belgium, Av. Circulaire 3, B-1180 Brussels, Belgium

Nyirbator	NYIR	Hungary	47.83	022.13	FOMI SGO	08.12.2002
Thule	THU3*	Greenland	76.53	291.17	KMS	12.01.2003
København	BUDP	Denmark	55.73	012.50	KMS	19.01.2003
Krakow	KRAW	Poland	50.06	019.92	UMM DGK	26.01.2003

*: Replacement of existing EPN station

FOMI SGO	:	FOMI Satellite Geodetic Observatory, Hungary
IGiK	:	Institute of Geodesy and Cartography, Poland
KMS	:	National Survey and Cadastre, Denmark
LMV	:	National Land Survey of Sweden, Sweden
RIGC	:	Research Institute of Geodesy and Cartography, Ukraine
SCEG	:	School of Civil Engineering and Geosciences, UK
UMM DGK	:	University of Mining and Metallurgy Department of Geodesy and Cartography, Poland

Table 1- New EPN permanent tracking sites since June 2002

In the past year, several EPN stations have made a considerable effort to deliver hourly tracking data, bringing the total number of stations to 80 (Figure 2), which is 58 % of the EPN stations.

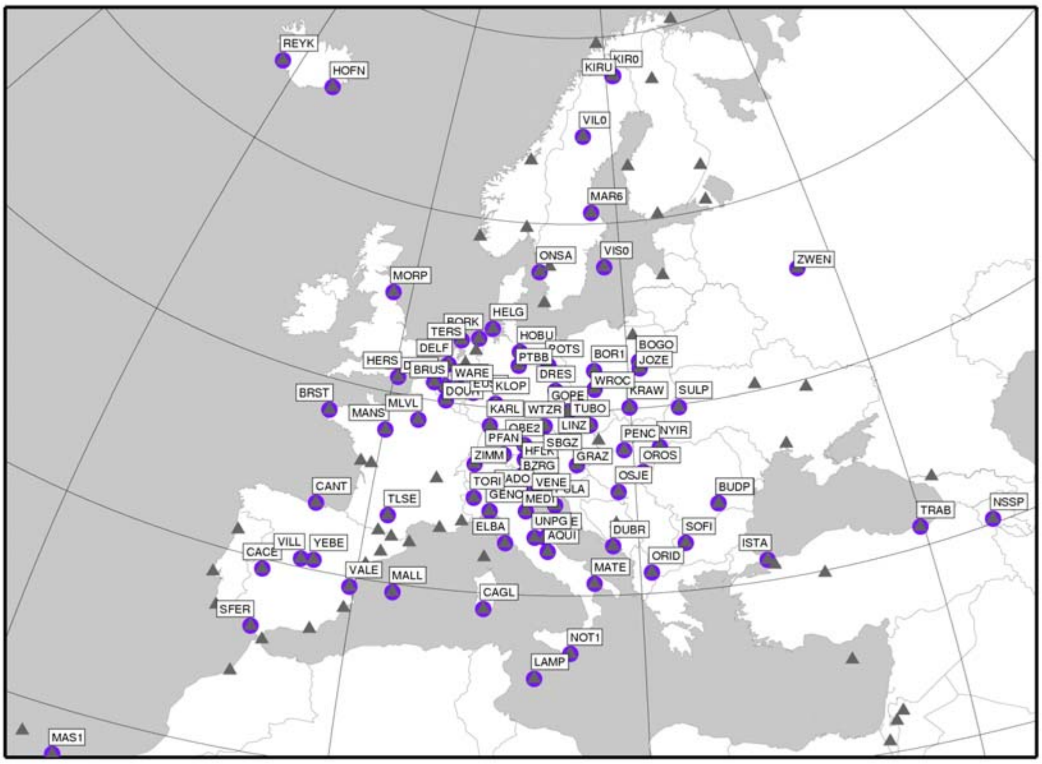


Figure 2 - EPN stations submitting hourly tracking data

Table 2 lists the permanent tracking stations presently classified as candidate stations.

Station	4 char ID	Country	Lat. (N)	Lon. (E)	Agency	Status
Daresbury	DARE	England	53.34	-01.35	Ordnance Survey	Ready
Diyarbakir	DYR2	Turkey	37.91	40.27	UNAVCO	Recent data not yet present
Gjøvik	GJOV	Norway	60.78	10.68	University College of Gjøvik	Data not yet present
Inverness	INVE	Great Britain	57.48	-03.78	Ordnance Survey	Inconsistencies
Kharkiv	KHAR	Ukraine	50.00	36.23	MAO	Data not yet present. Hourly necessary
Obninsk	MOBN	Russian Federation	55.11	36.56	RDAAC-JPL-IRIS	Hourly data necessary (109 km from MDVO)
Forgaria	MPRA	Italy	46.24	12.98	INOGS	Data not yet present. Hourly necessary
Wessling	OBET	Germany	48.08	11.27	DLR-KN-NL	Hourly data necessary
Paris	OPMT	France	48.83	02.33	BNM-SYRTE	Inconsistencies
Plymouth	PLYM	Great Britain	50.43	04.10	Ordnance Survey	Inconsistencies.
Prato	PRAT	Italy	43.88	11.09	TOPOGR.DIC	Hourly data necessary
Redu	REDU	Belgium	50.00	05.14	ESA/ESOC	Data Centre not attributed yet
Sassnitz	SASS	Germany	54.51	13.64	BKG	Data not yet present. Hourly necessary
Smidstrup	SMID	Denmark	55.65	09.70	National Survey & Cadastre	Data Centre not attributed yet
Suldrup	SULD	Denmark	56.85	09.85	National Survey & Cadastre	Data Centre not attributed yet
Reggio Calabria	TGRC	Italy	38.10	15.65	Agenzia Spaziala Italiana	Inconsistencies log-RINEX obs. files
Trento	TREN	Italy	46.07	11.12	Geological Service, Aut. Province Trento	Data not yet present. Hourly necessary
Cercivento	ZOUF	Italy	46.55	12.97	INOGS	Hourly necessary

MAO : Main Astronomical Observatory of the National Academy of Sciences of Ukraine
INOGS : Istituto Nazionale di Oceanografia e Geofisica Sperimentale
DLR-KN-NL : German Aerospace Center Institute of Communications and Navigation Department of Navigation and Guided Systems
BNM-SYRTE : BNM-SYRTE UMR 8630 Paris Observatory
TOPOGR.DIC : Dipartimento di Ingegneria Civile Laboratorio di Topografia e Fotogrammetria
BKG : Bundesamt für Kartographie und Geodäsie

Table 2 - Candidate EPN stations

Since June 11, 2002, with the start of the IGLOS Pilot Project, GPS/GLONASS sites are also accepted within the EPN. Presently four EPN stations: BOGI (Borowa Gora, Poland), GOPE (Pecny, Czech Republic), SPT0 (Boras, Sweden) and WROC (Wroclaw, Poland) are submitting combined GPS/GLONASS data. Within the EPN processing, the GLONASS data are discarded and only the GPS part is processed.

2.2 New Local Analysis Centre

In the past year, one new Analysis Centre started to submit weekly solutions for an EPN subnetwork (Figure 3). It concerns the Slovak University of Technology; Bratislava, Slovakia (SUT) started its contribution to the EUREF combined solution in September 2002 (GPS Week 1130). SUT uses the Bernese software package for the computation of its EPN solutions. The total number of analysis centres contributing to the weekly EPN solution is now 16.

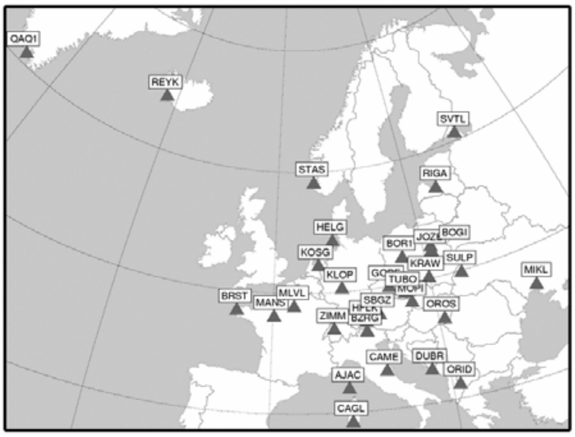


Figure 3 – EPN subnetwork processed by the SUT Analysis Centre

3. EPN guidelines

3.1 Guidelines for EPN stations

Two items have been recently included in the EPN station guidelines (http://www.epncb.oma.be/guidelines/guidelines_station_operationalcentre.html):

1. Stations that submit hourly data can now choose to discontinue the additional submission of a daily data file to the Data Centre. In this case, it is the Data Centre that will concatenate the hourly data files and generate the daily data file from them.

   Operational Centres that want to discontinue the submission of daily data files in addition to their hourly data submission, must adopt the following procedure:
   A. Announce your intention to discontinue the transfer of daily files through e-mail to the Data Centre some days before the discontinuation
   B. Wait for the confirmation of the Data Centre
   C. If the Data Centre agrees, stop the transfer of the daily files

Hourly files, which could not be sent promptly, or have to be updated, must arrive within three days. After that date, updates must be done through the upload of the appropriate daily file.

2. When a station has been excluded from the EUREF combined solution for more than 3 months, the EPN CB will label this station as inactive. As a consequence, the station will be eliminated from the list of operational EPN stations at http://www.epncb.oma.be/siteinfo.html and will be transferred to http://www.epncb.oma.be/inactive.html. Stations can be classified as inactive for several reasons, e.g.:
   - The station is excluded from EPN due to e.g. bad data quality or meta data inconsistencies
   - The station has been destroyed and is in the process of reconstruction
   - The station has temporarily stopped submitting RINEX data

Inactive stations can recover the operational status when they fulfil the requirements for EPN stations again.

3.2 Guidelines for EPN data centres

Simultaneously with the update of the EPN station guidelines about the hourly/daily data flow, the data centres guidelines (http://www.epncb.oma.be/guidelines/guidelines_data_centres.html) have been updated to reflect this change.
The new guidelines recommended the Data Centres to implement the necessary procedures to concatenate the hourly data into daily data. These procedures should run at least once a day and should be repeated in case hourly files arrive late or are resubmitted. Data Centres, that receive a request from

an Operational Centre to discontinue the daily transfer and to switch to only hourly transfer, are encouraged to accept this proposal. After three days, the Data Centre will only accept daily files.

3.3 Guidelines for EPN local analysis centres

Since Dec. 2002, new guidelines for EPN Analysis Centres (AC) have been issued (http://www.epncb.oma.be/guidelines/guidelines_analysis_centres.html).
Next to the general guidelines for the EPN AC's they include information for new local analysis centres as well as an historical overview of all processing options.

4. New@epncb

4.1 Automated site log test and submission

As announced in EUREF mail 1354 (August 5, 2002), station manager can now test the format and contents of their site logs through an automated e-mail procedure.
To validate a site log, it has to be included in the mail body (NOT as attachment) of an e-mail sent to epncbslt@oma.be. Within a few minutes, the sender will receive a reply-mail with a list of site log errors. Also site logs from non-EPN stations can be tested.
To update a site log in the EPN CB database, the site log has to be sent to a different e-mail address: epncbsls@oma.be. The site log will be included in the site log database only if it has passed the site log checker without errors. An error message or confirmation of the update of the database will be included in the reply-mail.
The update of the EPN CB database will be done on both its ftp and web site.
After six months of operation, the following recurring submission problems were encountered:

- Site log attached to the mail. Only logs included in the mail body are accepted
- Site log in html format. Plain text format should be used instead
- Lines of site log are wrapped because of a line wrapping in the mailer program. The line wrapping option in the mailer program should be deactivated (see also EUREF mail 1476).

4.2 Extension of the RINEX header report

On June 11 2002, the EPN and IGS have adopted a new site log format. This new site log format provides us now additional information about the stations. Especially of interest to us are the North and East components of the antenna eccentricities. Since these values are also given in the RINEX headers, we have now the possibility to crosscheck this information.
This is why, from August 19 2002 on, the EPN CB has extended its error reports with a check on the above-mentioned values.
These reports will as usual be twofold:

- Individual mailings to the station manager reporting the errors and requesting corrections
- The weekly "Station Inconsistencies" distributed through EUREF mail

4.3 RINEX header inconsistencies

As announced in EUREF mail 1378, the EPN CB web site has been extended with new web pages that give, for each station individually, an historical overview of the errors we detected in the headers of RINEX observation files. This information goes back to DOY 100 of 1998 and targeting users who are reprocessing older EPN data. However, this info is also very useful to check for the latest inconsistencies since it is updated several times a day when new data files are made available and it takes resubmissions arriving within 10 days into account. You can access the historical overview from the "Station Description" Web page (e.g. http://www.epncb.oma.be/info/BRUS.html) and by clicking on the link: "Errors in the header of the RINEX observation files".

4.4 Rapid data quality checks

Yearly "Observed versus Predicted" plots

In the past year, the EPN CB has developed rapid data quality checks for the EPN network. As explained in (Bruyninx et al, in press), the generation of the statistics about the number of observed data with respect to the predicted number was under development. Presently, these statistics are on-line and can be accessed through the http://epncb.oma.be/info/SSSS.html (with SSSS=station 4-char abbreviation) by clicking on the link 'Plots of visible satellites'.

We define the number of complete observed data as the number of dual frequency (L1,L2) data observed by the receiver. The number of predicted observations is defined at the theoretical number of observations gathered at this site without any obstructions; it uses navigation message. The number of predicted observations is always computed using the same elevation cut off angle as used for the observations. With that respect two different graphs are displayed: a first one using the cut off angle as input in the receiver (can change over time) and a second one using a constant 15 degree cut off angle. The generated statistics are partially based on the TEQC utility (Estey and Meertens, 1999).

The final result is a yearly plot updated daily when new data becomes available, and this for each EPN station (see Figure 4).

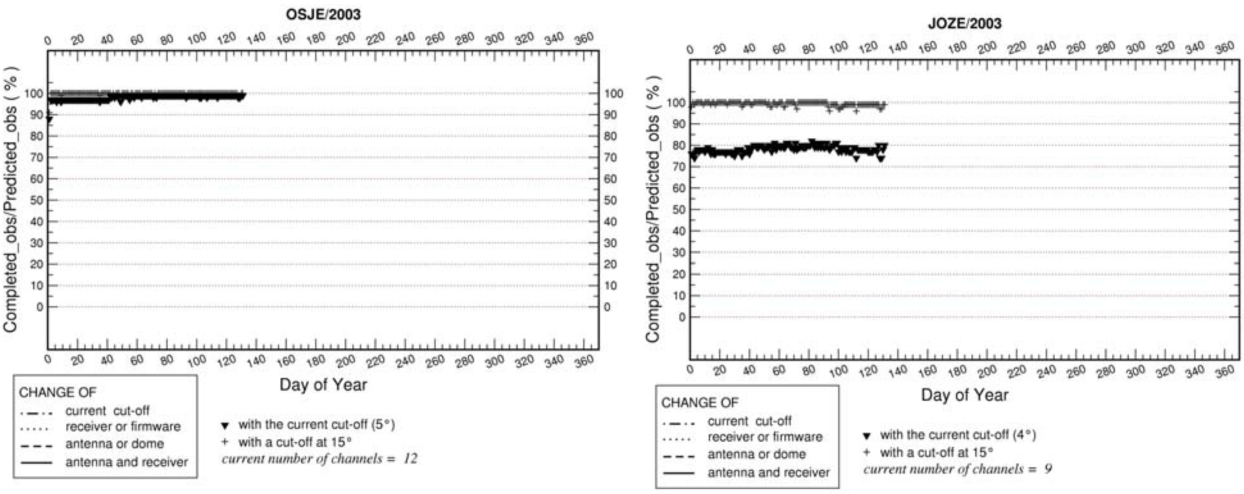


Figure 4 - Percentage of predicted/observed data. The graph on the left gives an example of a station with a minimal data loss below 15 degrees. The graph on the right shows a station where decreasing the elevation cut off angle from 15 degrees to 4 degrees causes a data loss of more than 20%.

Evaluation of an EPN tracking with respect to the other EPN stations

Since June 2003, the EPN CB runs daily the TEQC quality check program on all available EPN RINEX data. By averaging the output from TEQC over 45 days, we created plots that allow evaluating the tracking quality of an EPN station with respect to the other EPN stations. The figures used are output from TEQC's quality check mode. They are :

- the number of complete, dual frequency L1 and L2 observations, gathered at the site. 75 % of the EPN stations have values below 25600.
- the root mean square error (RMS) of the L1 multipath (MP1) and the L2 multipath (MP2). 75% of the EPN stations has MP1 values below 0.57 m and MP2 values below 1 m. However, absolute multipath RMS values do not necessary correlate with site performance.
- the number of observations per cycle slip, inverted and multiplied by 1000. Small values indicate a small amount of cycle slips. Values less than 5.8 are recorded in 75% of the EPN stations

The error bars are the standard deviations from the mean values over the last 45 days. In a lot of cases, they are even more important than the absolute values. They indicate, on a day-to-day basis, how the behaviour of the station changes. High standard deviations should encourage the site operated to have a closer look at the data.

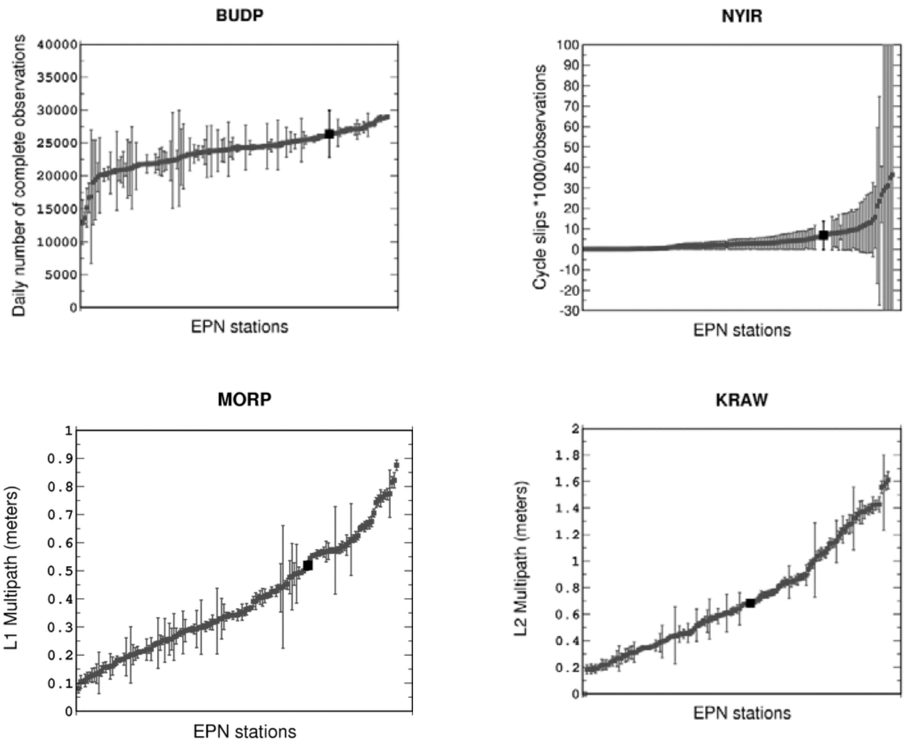


Figure 5 – 45-day averages and their standard deviation from the TEQC SUM output for 4 EPN stations (noted in black on the graph) with respect to the other EPN stations (in grey). Top-left : number of complete observations for the station BUDP (Kobenhavn, Denmark), top-right: cycle slip factor for the station NYIR (Nyirbator, Hungary), bottom-left: L1 multipath for the station MORP (Morpeth, UK), bottom-right: L2 multipath for the station KRAW (Krakow, Poland).

4.5 Monitoring of the availability of the hourly RINEX data

Taking into account that the hourly data are getting more and more important, we have developed at the EPN CB some tools to monitor the hourly data flow. The generated statistics are twofold.

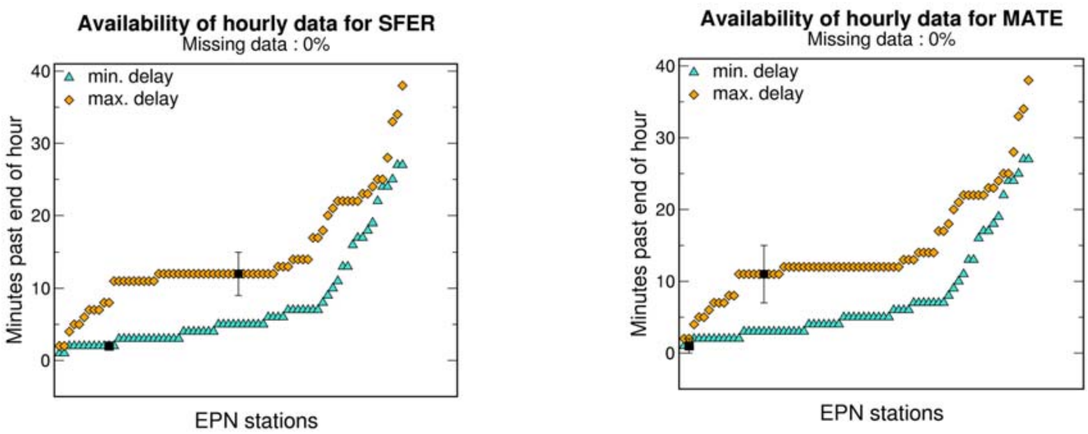


Figure 6 - 3-day average minimal and maximal delay of the hourly data from two EPN stations

First, for each EPN station, the statistics deliver the mean minimal and mean maximal time delay (computed over for the last 3 days) that the hourly RINEX data are available within the EPN data centres. This statistic gives an indication of the time delay between the observation and the availability of the corresponding hourly data file. In addition, it also shows how much time it takes for the hourly data of this station to get distributed among its EPN data centres.

Figure 6 illustrates the station-dependent data flow graphs for two stations whose data are transmitted to their primary data centre (mostly BKG) with a small delay and high reliability. This is the min. delay in the graphs. The max.delay is coming from the last data centre where the data show up. This is mostly the IGS Global data centre at IGN France and the regional hourly data centre at GOP.

Secondly, for each data center, we compute the percentage of hourly data files arriving with a specific time delay. The percentage gives the availability of the hourly RINEX data in that specific data center during the last three days, as can be seen in Figure 7 for the some of European Data Centres involved in the EPN and IGS:

- ASI and OLG are local data centres receiving data from several operational data centres.
- ROB and DUT are local data centres operating under the same responsibility as the Operational Centre managing a local network whose data they make available and they have consequently a high percentage of short delay hourly data files
- BKG, the regional data centre, received, during the tested time period, about 60% of the hourly data files within a time delay of 6 minutes.
- GOP: Regional data centre that only makes available hourly data. For most of the stations, this data centre retrieves the hourly data centres from the other data centres, which explains why the majority of the files at GOP arrive with at least 10 minutes delay.

These graphs can by no means be seen as a general quality check of the data centres although some general tendencies can be seen as explained above.

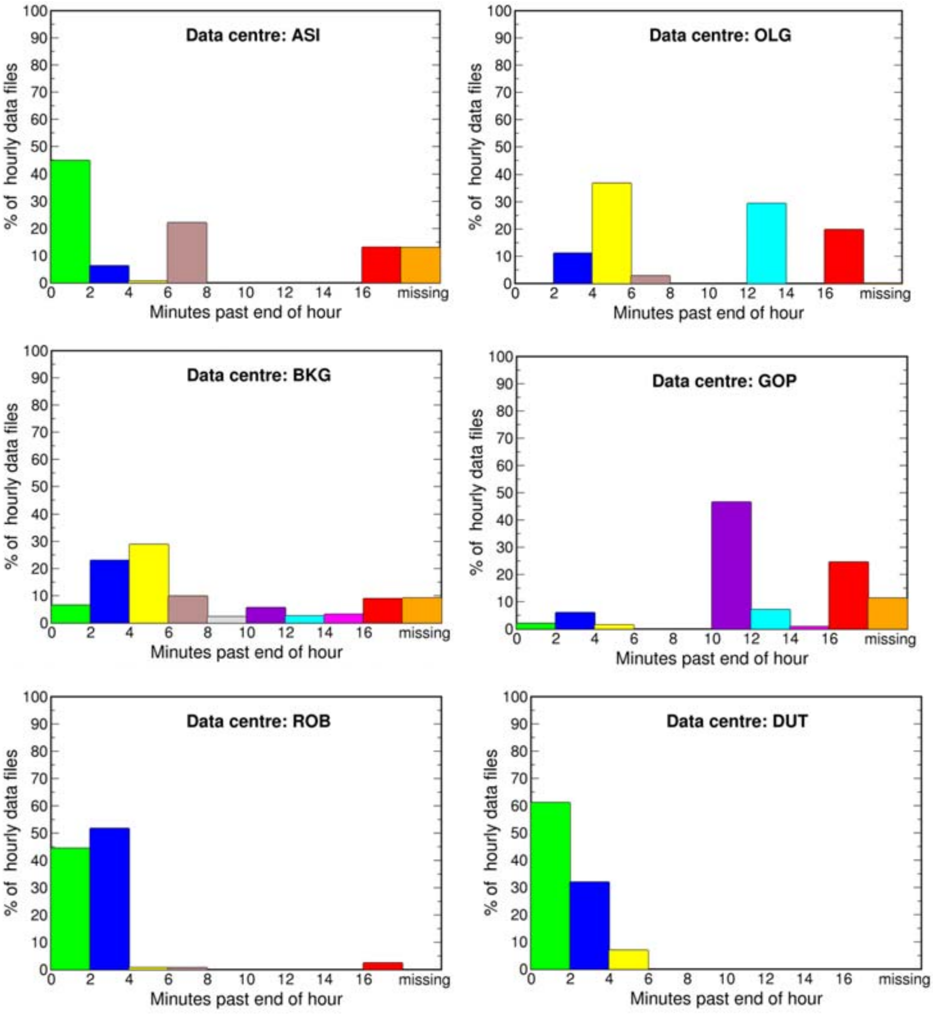


Figure 7 – Availability of the hourly data files in the different EPN /IGS data centres in Europe

5. Monitoring of the station tracking performance – case studies

During the previous years, the EPN CB used the different types of time series and the Azimuth/elevation graphs (Takacs and Bruyninx, 2002) for data quality checking purposes.

5.1 Degraded tracking

The standard coordinate time series for the station Borkum (Germany), displayed in Figure 8, do not suspect any tracking problems at this station. However, the new "Observed versus Predicted" plots indicate a slowly degrading tracking capability, especially at low elevations. Our experience has shown that finally a receiver replacement or firmware upgrade will be necessary.

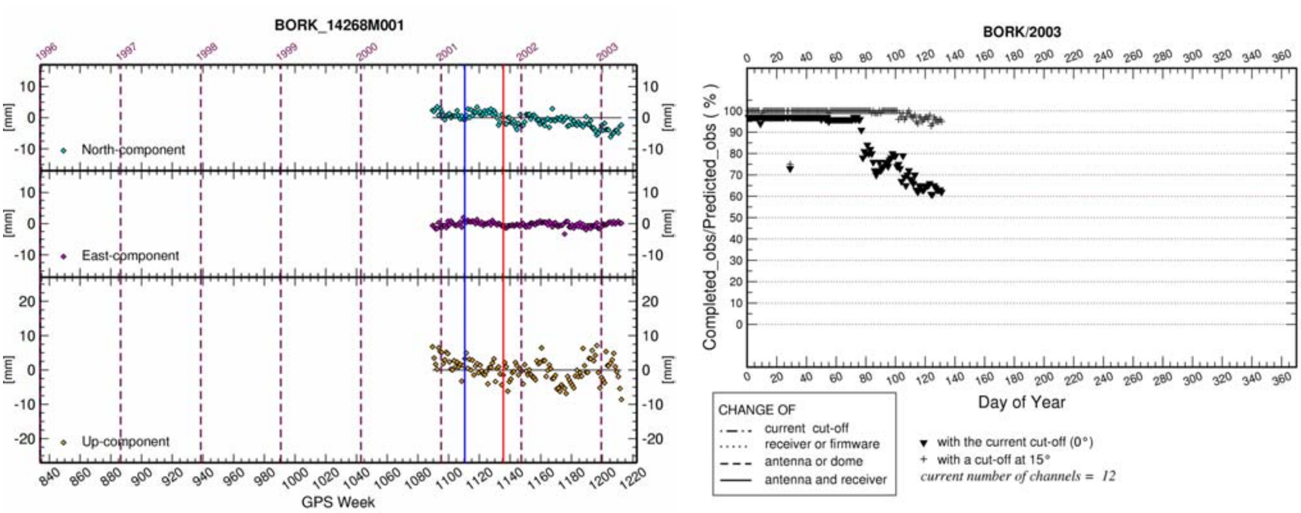


Figure 8 – Left: Standard time series for Borkum (Germany); Right: Percentage of predicted/observed data showing a negative slope.

The slow degradation of this BORK receiver is also illustrated through the azimuth/elevation graphs of this station in Figure 9.

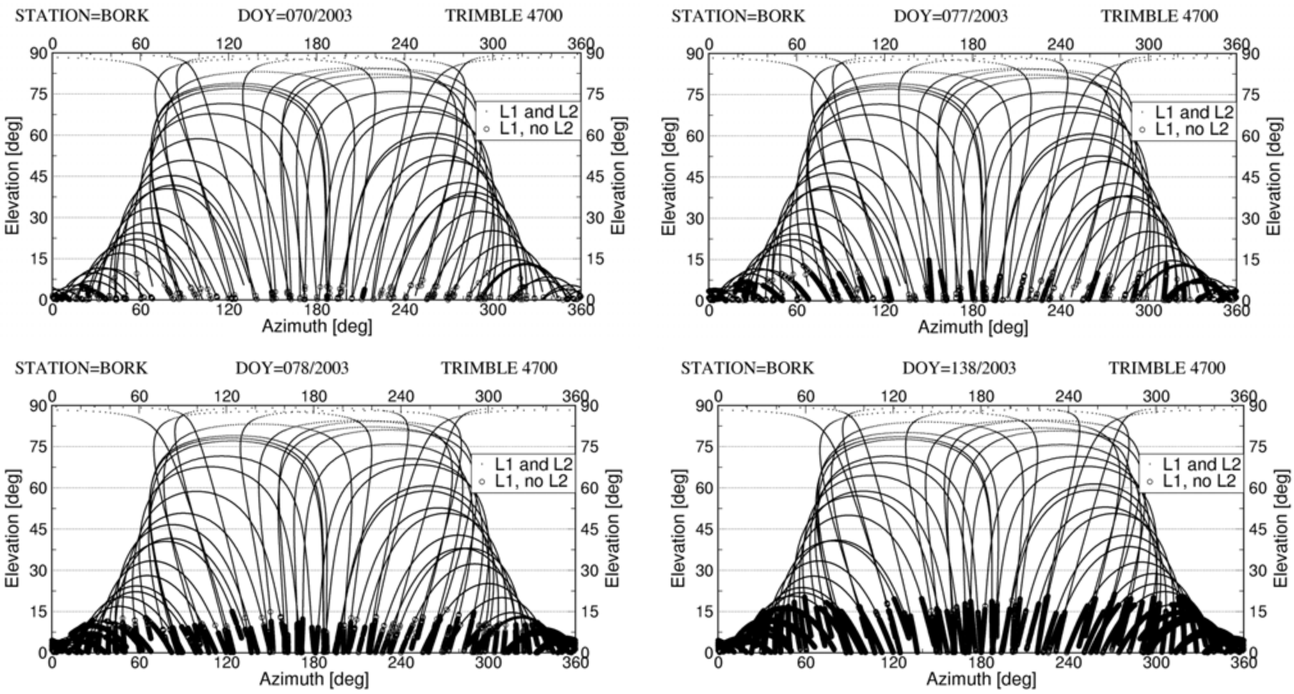


Figure 9 – Azimuth/elevation graphs for Borkum for DOY 70, 77, 90 and 138 illustrating the slowly degrading tracking on L2 at low elevations.

5.2 Rogue tracking problem

As explained in previous reports, ROGUE SNR-8000 and ROGUE SNR-12 equipment that have not upgraded their firmware to the 3.2.32.11 version, experiences degraded tracking on L2. Presently, only one active EPN site is still affected by this problem, namely RABT (Rabat in Morocco) where the new firmware version has not yet been installed. Another site whose tracking was dramatically degraded due to the problem mentioned above, GRAS (Grasse in France) replaced its ROGUE SNR 12-RM receiver with a TRIMBLE 4000SSI receiver. The tracking improvement is demonstrated in Figure 10.

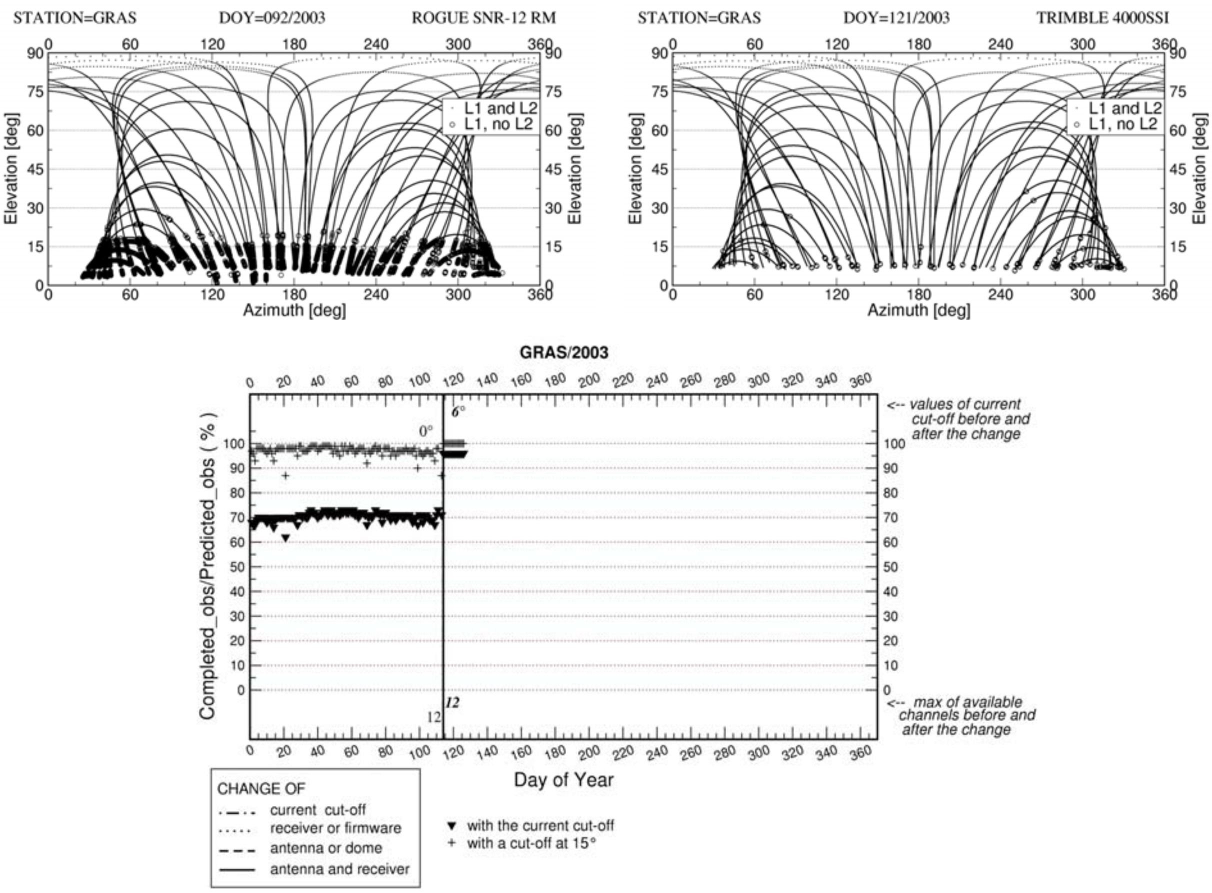


Figure 10 – Azimuth/elevation graphs for GRAS. Top left: degraded tracking on L2 (beginning of April 2003); top right: tracking improvement on L2 after the firmware upgrade (May 2003). Bottom: Percentage of complete observations versus predicted.

5.2 Ashtech smoothing problem

In the beginning of 2003, Kristine Larson and her student John Plumb, after some discussions they had with Lou Estey and Ashtech, noted that Ashtech RINEX data, when the available Ashtech smoothing corrections are applied, may contain incorrect P1 and P2 values. One detectable manifestation of this is that the L1 multipath figure (P1-4.09L1+3.091L2) versus time has a negative slope with respect to time, within a given satellite arc. More details can be found in IGS mail 4379 or EUREF mail 1648.

Evidently this causes problems to a noticeable extent for GIPSY users, depending on the study. GAMIT does not seem to be affected. It is unclear whether Bernese users are affected by this problem, with a probably dependence on the application.

During the month of March, 2003, both the IGS and EPN CB investigated respectively the data of all the IGS and EPN Ashtech stations to see whether they are smoothed or not. When smoothing was detected, the station managers were contacted with the request to switch of the smoothing.

The following EPN stations had smoothed data, but are presently not smoothed anymore: AJAC, BOGO, BRUS, CHIZ, DENT, DOUR, GOPE, HERS, JOEN, LROC, METS, MLVL, PTBB, QAQ1, SODA, THU3, VAAS, WARE, and WROC (see

Figure 11). Some stations did not yet remove their smoothing or started smoothing since March 2003: BUCU, DUBR, HELG, ISTA, OSJE, TRAB, UNPG and VILL.

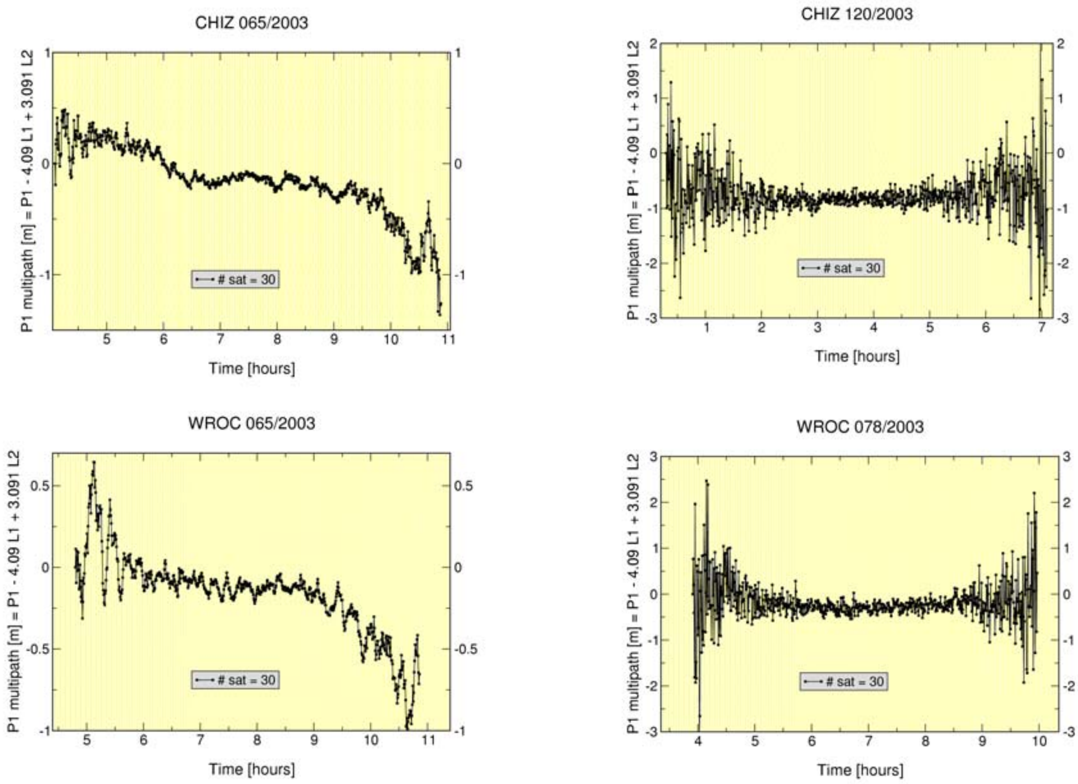
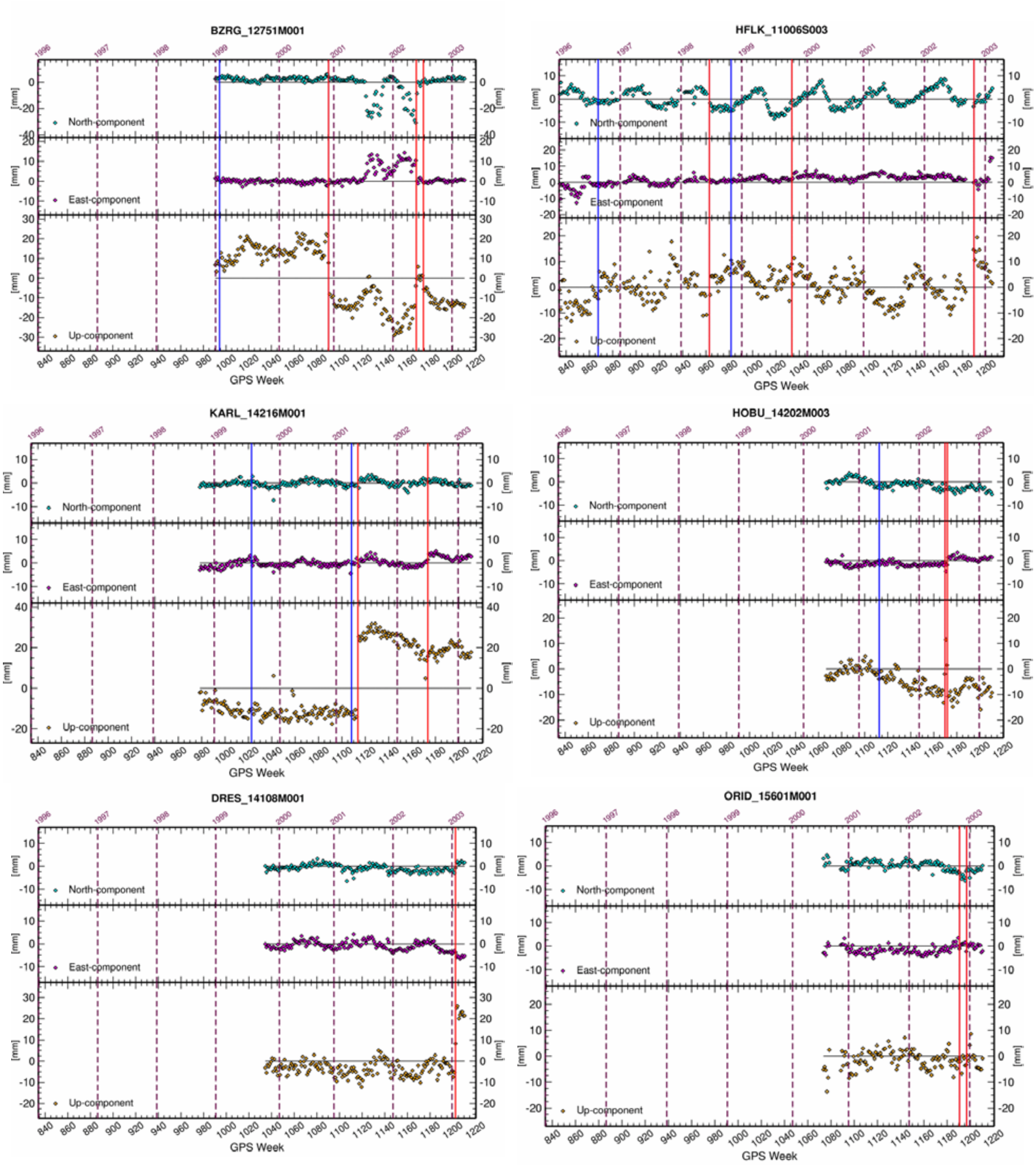


Figure 11 – Left graphs: L1 multipath showing a negative slope due to Ashtech smoothing algorithm; Right: Normal L1 multipath with smoothing turned of.

5.3 Antenna changes

Antenna changes typically cause coordinate discontinuities, mostly in the height component. For this reason all unnecessary equipment changes are highly discouraged. Since May 2001, several EPN stations changed antenna, most of them for well-considered reasons such as Rogue equipment upgrades: GRAS (Grasse, France), KIRU (Kiruna, Sweden), NSSP (Yerevan, Armenia), and WARE (Waremme, Belgium) or replacements of damaged/malfunctioning antennae: BZRG (Bolzano, Italy), HFLK (Hafelekar, Austria). A few stations changed antenna for reasons unknown to the EPN CB: DRES (Dresden, Germany), HOBU (Hohenbuenstorf, Germany), KARL (Karlsruhe, Germany), KLOP (Kloppenheim, Germany), MARS (Marseille, France), ORID (Ohrid, Macedonia) and WTZR (Wettzell, Germany). As can be seen from Figure 12, some of the antenna changes caused a coordinate offset.



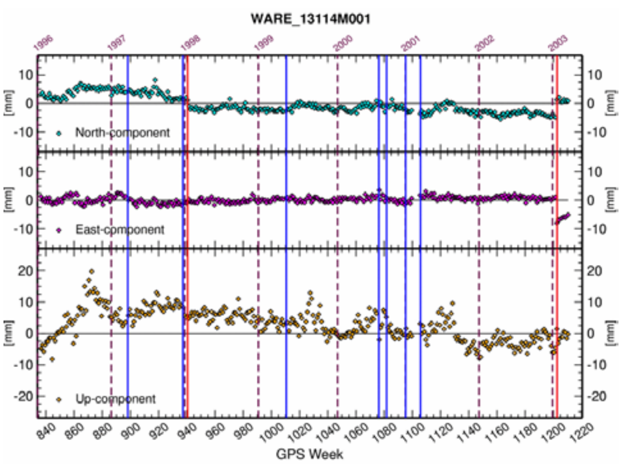


Figure 12 – Two top time series: examples of replacement of damaged antennae; Two times series in the middle: examples of an antenna change and radome removal; Time series on bottom: example of Rogue equipment change.

6. News from the IGS

6.1 Monumentation documentation

The IGS Central Bureau has compiled a list of the many types of monumentation developed around the world. The initial draft of this document can be found at:
http://igscb.jpl.nasa.gov/network/monumentation.html.

6.2 Absolute phase centre variations

Markus Rothacher and Ralf Schmid, from the Technical University of Munich have put together a test set of absolute phase centre variations (PCV) (see IGS mail 4324). These absolute PCV are presently NOT included in any of the routine analysis, but are distribute mainly to stimulate any tests and comparisons.
The ANTEX format description (antex10.txt) and the test set of PCVs (pcv_abs_proposed.tst) may be downloaded from the IGS CB information system at
ftp://igscb.jpl.nasa.gov/pub/station/general/pcv_proposed

The following remarks concerning this new set should be considered:

- The set of PCVs contains now absolute antenna patterns and no longer patterns relative to the AOAD/M_T antenna.
- Values for satellite and receiver antennae are given in the new ANTEX format.
- Not only elevation- but also azimuth-dependent PCVs are available for some (not all) of the receiver antenna types. PCVs with elevation-dependence only are also given (see keyword NOAZI in ANTEX).
- GPS satellite antenna PCVs are included and have to be used together with the absolute receiver antenna PCVs to avoid a wrong scaling of the GPS results by about 15 ppb.
- Offsets and PCVs have to be used consistently, for the receiver as well as for the satellite antennae.
- The set of PCV corrections given here is a test set that should only be used to perform tests at present. After thorough testing it will be decided, whether the new set will become the new official IGS set.
- The satellite antenna PCVs were computed from global GPS data, which means that only the ionosphere-free PCVs are presently available. The L1 and L2 PCVs were set to the ionosphere-free PCVs.

6.3 New orbit format

In December 2002, the IGS introduced a new orbit format (see the complete description at ftp://igscb.jpl.nasa.gov/igscb/data/format/sp3c.txt). The format offers a significant enhanced flexibility e.g. characterizing the variable accuracy of the given data points within the Ultra-rapid IGU orbits, and it is used by some of the IGS Analysis Centres submitting orbit solutions to the IGS.

6.4 EPN Participation to TIGA

Since the end of August 2002 (GPS week 1181), EUREF submits a subnetwork solution of EPN to the IGS GPS Tide Gauge (TIGA) Benchmark Monitoring Pilot Project TIGA (http://op.gfz-potsdam/tiga/) The subnetwork consists of currently 9 TIGA Observing Stations (TOS): AJAC (Ajaccio, France), BORK (Borkum, Germany), BRST (Brest, France), CREU (Cap de Creus, Spain), HELG (Helgoland, Germany), MARS (Marseilles, France), METS (Metsahovi, Finland), MORP (Morpeth, UK), LROC (La Rochelle, France), and VAAS (Vaasa, Finland) and 8 connection sites: MATE, VILL, WTZR, ONSA, REYK, KOSG, and NYA1 (see Figure 13).
The goals of the TIGA-PP are identified as follows (from TIGA Call for Participation):

1. Establish, maintain and expand a global CGPS@TG network

2. Contribute to the procedures in which IGS realizes a global reference frame in order to improve its utility for global vertical geodesy.
3. Compute precise station coordinates and velocities for the CGPS@TG stations using a processing stream that runs months behind real-time in order to include the largest possible number of stations.
4. Establish a secondary processing stream with much reduced latency in order to support operational activities that cannot tolerate large processing delays.
5. Monitor the stability of the network.

The number of TOS stations in the EPN submission will grow, as soon as more EPN stations are accepted as TOS. In order to be accepted as TOS stations, EPN stations need to complete the TOS form available from http://op.gfz-potsdam.de/tiga/HELP/TOS_Form.html and send an e-mail to the EPN analysis coordinator (H.Habrich@bkg.bund.de) for notification. At the same time, already existing TOS stations are encouraged to join the EPN.

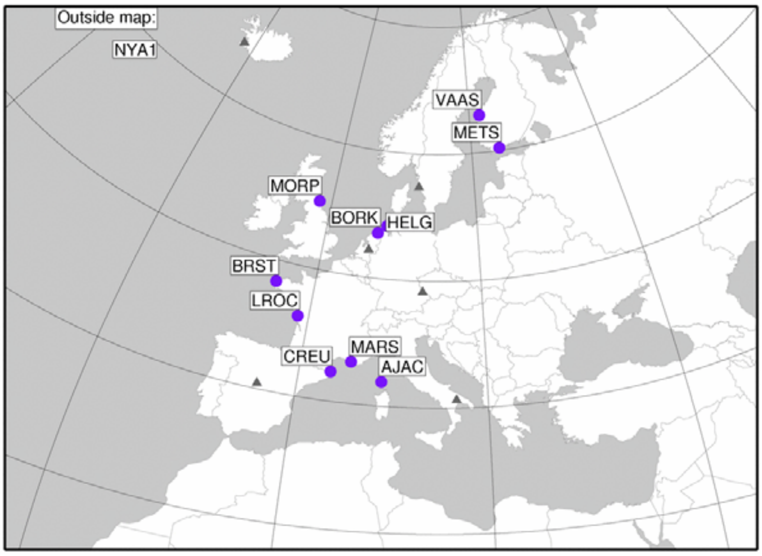


Figure 13 - Stations included in the EPN submission to TIGA; the big circles show the TOS stations

6.5 IGS workshop

The IGS will hold an IGS Symposium and Technical Workshop in Berne, Switzerland from March 1 to March 5, 2004. This event will consist of a one-day Symposium on Wednesday March 3 and Technical Workshop Series on March 1-2 and 4-5.

7. Acknowledgements

Special thanks to the members of the EPN CB team working behind “the scenes”: Dominique Mesmaker, Ann Moyaert and Robert Laurent.

8. References

Bruyninx C., Carpentier G and F. Roosbeek (in press)
EPN Monitoring: Status and Plans
Proc. of the EUREF 2002 Symposium, Azores, June 2002

Estey L.H. and C. Meertens (1999)
TEQC: The multi-purpose toolkit for GPS/GLONASS data
GPS Solutions, 3, No 1, 42-49