Status and Performance of the EUREF Permanent Tracking Network

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Abstract

This document describes the present status of the EUREF Permanent Network (EPN) by concentrating on the major changes to the EPN since the EUREF Symposium of June 2007 held in London.

1. INTRODUCTION

The EUREF Permanent Network (EPN) is a network of continuously operating GPS or GPS+GLONASS reference stations maintained on a voluntary basis by the EUREF members. The primary purpose of the EPN is to provide access to the European Terrestrial Reference System (ETRS89) by making publicly available the tracking data as well as the precise coordinates of all the EPN stations.
The reliability of the network is based on the principle of redundancy together with extensive guidelines guaranteeing the consistency of the raw GNSS data to the resulting station coordinates. Next to its key role in the maintenance of the ETRS89, the EPN supports a wide range of scientific applications such as geodynamics, sea level monitoring and weather prediction.
The EPN Central Bureau (CB), headed by the network coordinator, is responsible for the day-to-day management of the EPN and acts as liaison between station operators and analysis centres, providing the necessary station configuration metadata and ensuring the datasets meet the requirements of the analysis. The EPN CB maintains and verifies the correctness of the station meta-data information, monitors the quality of the RINEX data, the data flow and the station coordinates and sends notification emails to station operators when abnormal conditions occur. It makes all this information available through its website http://epncb.oma.be/.

2. EUREF PERMANENT TRACKING NETWORK

Today, the EPN network consists of 210 continuously operating GPS or GPS+GLONASS reference stations (Figure 1) distributed over 38 countries. The 22 new EPN stations that joined the EUREF network since June 2007 are shown in Figure 1.; twelve of them stream data in real-time and half of them are equipped with a GPS/GLONASS receiver bringing the total number of the EPN stations providing GPS+GLONASS data to 32%.

In the same period, 11 EPN stations were removed from the network. In all cases, the main reason for the removal of the stations was related to instability of the monument or the way the GNSS antenna/radome was fixed to the monument.

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Figure 1 – EUREF permanent tracking network (status June 2008); triangles: the stations added to the network since June 2007; circles: stations removed from the network since June 2007.

M0SE	Roma, Italy	RT		Type	01/07/2007
SPRN	Sopron, Hungary			Type	22/07/2007
ZIM2	Zimmerwald, Switzerland	RT	GLO	Indiv	16/12/2007
IGEO	Chisinau, Republic of Moldova	RT		Type	05/08/2007
ALBA	Albacete, Spain	RT		Type	09/09/2007
HUEL	Huelva, Spain	RT		Type	09/09/2007
LEON	Leon, Spain	RT		Type	09/09/2007
SONS	Sonseca, Spain	RT		Type	09/09/2007
BORR	Borriana, Spain	RT		Type	21/10/2007
CEU1	Ceuta, Spain			Type	09/03/2008
VALA	Valladolid, Spain	RT	GLO	Type	20/04/2008
KURE	Kuressaare, Estonia	RT		Type	27/04/2008
TOIL	Toila, Estonia	RT	GLO	Type	27/04/2008
TORA	Tõravere, Estonia	RT	GLO	Type	27/04/2008
PULK	St.Petersburg, Russia			Type	18/05/2008
BPDL	Biala Podlaska, Poland		GLO	Indiv.	08/06/2008
BYDG	Bydgoszcz, Poland		GLO	Indiv.	08/06/2008
GWWL	Gorzow Wielkopolski, Poland		GLO	Indiv.	08/06/2008
LODZ	Lodz, Poland		GLO	Indiv	08/06/2008
REDZ	Redzikowo, Poland		GLO	Indiv.	08/06/2008
SWKI	Suwalki, Poland		GLO	Indiv.	08/06/2008
USDL	Ustrzyki Dolne, Poland		GLO	Indiv.	08/06/2008

Table 1- Tracking stations added to the EPN since June 2007, RT: stations streaming real-time data, GLO: stations equipped with GPS+GLONASS receivers, Type: antenna/radome with true absolute type calibrations; Indiv: antenna/radome with true individual absolute calibrations

BORK	Borkum, Germany	06/06/2007
LILL	Villeneuve d'Ascq, France	30/06/2007
HFLK	Hafelekar, Austria	07/07/2007
VENE	Venezia, Italy	28/07/2007
PFAN	Pfänder, Austria	01/12/2007
MANS	Le Mans, France	26/01/2008
NPLD	Teddington, United Kingdom	02/02/2008
SBGZ	Salzburg, Austria	02/02/2008
TRFB	Pernitz, Austria	02/02/2008
OBE2	Oberpfaffenhofen, Germany	09/02/2008
FATA	Taranto, Italy	23/02/2008

Table 2 – EPN stations removed from the EPN since June 2007.

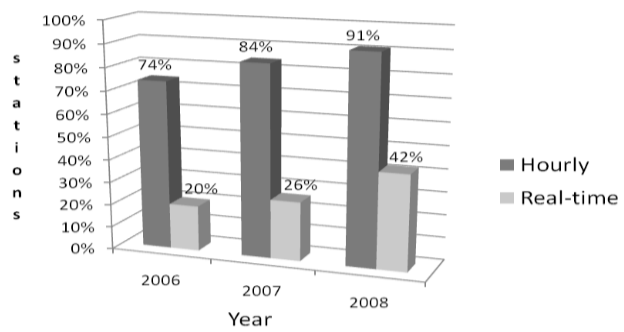


Figure 2 – Evolution of the number of EPN stations providing hourly and real-time GNSS data

The EUREF-IP Special Project ended in the summer of 2007 when the EPN real-time data streams where integrated in the routine EPN data flow. Consequently, today, depending on the station data policy, daily (mandatory), hourly RINEX (91.4% of the EPN stations), 15min high-rate RINEX (from real-time streams) and real-time (42.4% of the EPN stations) data are made available through the internet (see Figure 3). The two Regional Data Centres (RDC), located at BKG (Federal Office of Cartography and Geodesy, Germany) and at OLG (Austrian Academy of Sciences) provide access to the daily and hourly data from all the EPN stations. The regional EUREF broadcaster www.euref-ip.net makes available the EPN real-time data streams. Figure 2 shows the increase of stations providing hourly and real-time data over the last 3 years.

Many of the EPN stations providing hourly RINEX files do not submit data within the required 10 minute latency. In order to give to the station managers the possibility to monitor the latency of their data submission, interactive graphs have been developed and made available at the EPN CB web site (see Figure 4). The input for these graphs is obtained from an hourly scanning of all EPN data centers.

The EPN Central Bureau web site was adapted to include new web pages related to the real-time data flow. They give a real-time overview of the station status and provide basic statistics on the meta-data and the latency of the streams (see Figure 5).

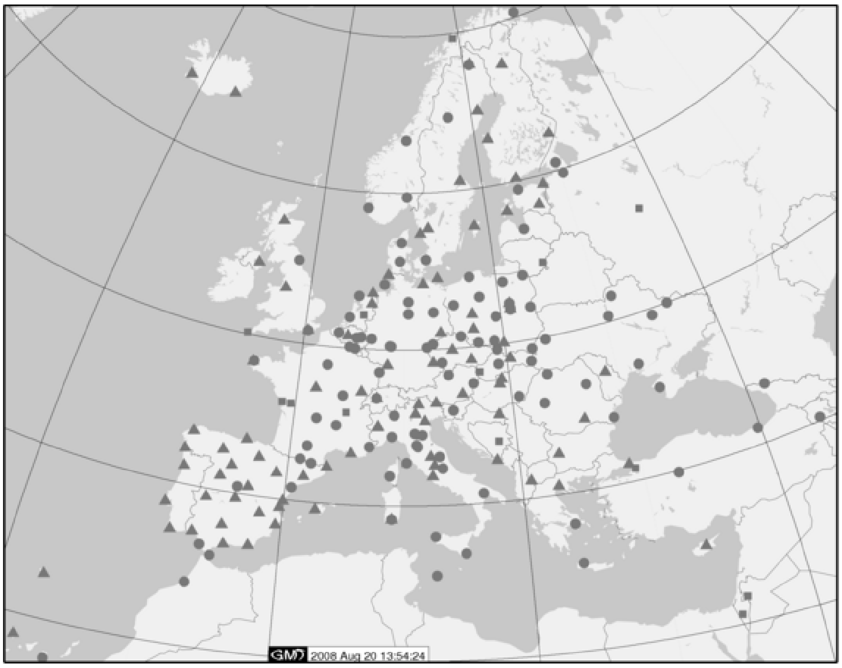


Figure 3 – EPN stations classified following data flow. Triangles: stations streaming data in real-time; Circles: stations making available hourly data and squares: stations make available daily data only.

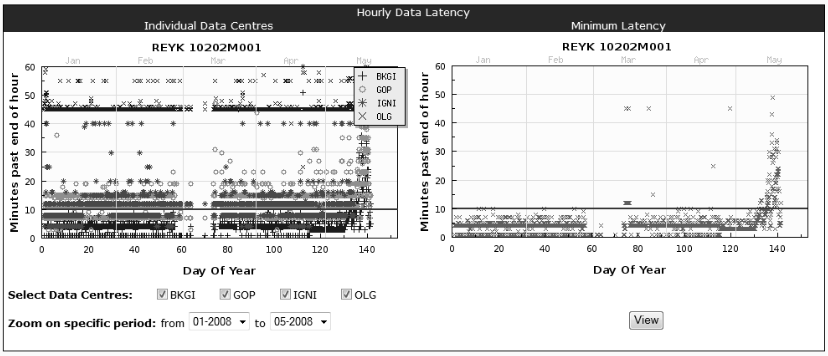
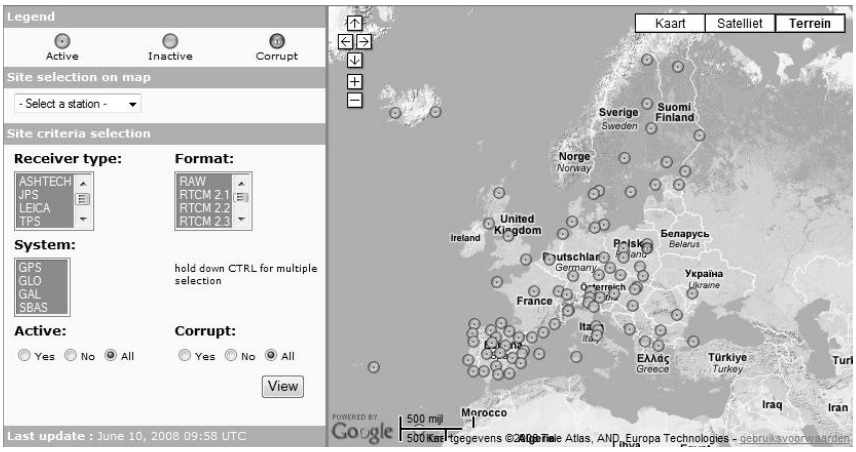


Figure 4 - Interactive graphs to view hourly data latency. They are accessible through the web page describing the individual EPN stations.



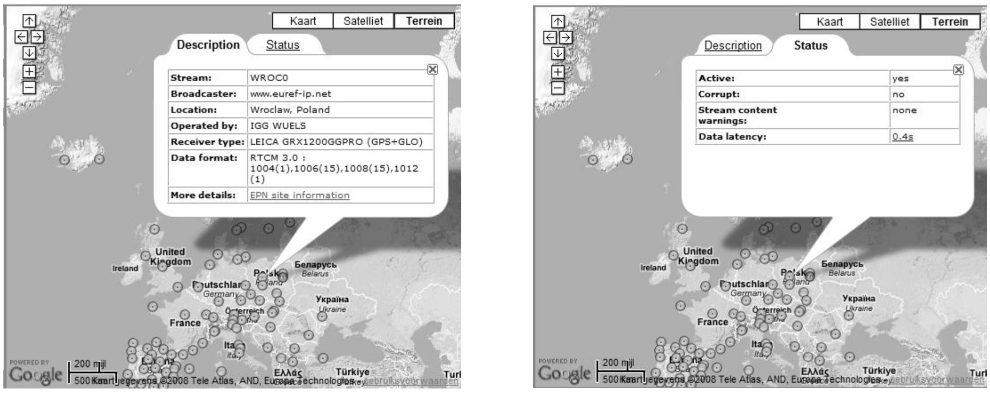


Figure 5 – New web pages for real-time data flow (http://epncb.oma.be/_dataproducts/data_access/)

2. EPN Antenna Calibrations

Since GPS week 1400 (Nov. 2006), the IGS and the EPN use absolute corrections for the antenna phase centre variations (PCV). In the case of the EPN, also individual antenna calibrations are accepted. Within the EPN, from that date on, if a new EPN station is set up or an old antenna/radome is replaced, station operators are requested to choose an antenna/radome pair that shows a true absolute calibration. This calibration can be a true type calibration from the IGS antenna calibration (converted field calibrations are not considered as true absolute calibrations) or an individual calibration from the epnc_05.atx file maintained by EPN CB (see http://epncb.oma.be/_trackingnetwork/equipment_calibration/). The goal of this guideline is to gradually upgrade the EPN to a network with antenna/radomes pairs which all have true absolute calibrations. The fact that this recommendation is the right way to go, was demonstrated by the fact that at the IGS Analysis Centers Workshop, held in Miami from June 2-6, 2008, the IGS also issued a recommendation to urge station managers to install absolutely calibrated antenna/radome pairs.

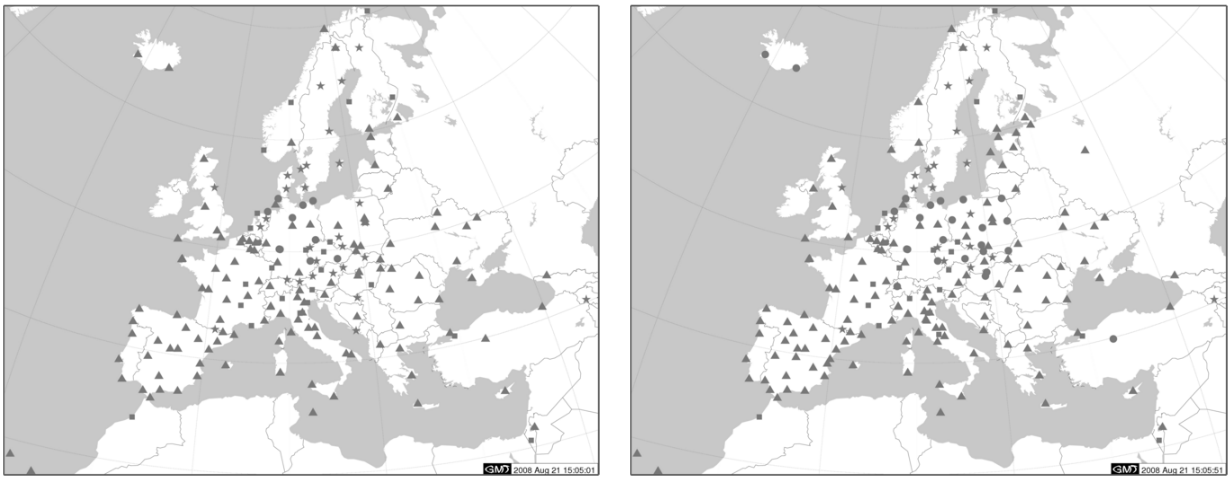


Figure 6 – Left: Antenna/radome calibrations used within the EPN in Dec. 2006, Right: Antenna/radome calibrations used within the EPN in June 2008 (circle: individual absolute robot calibrations; triangle: type absolute robot calibrations; square: absolute calibrations converted from relative field calibrations, star: no absolute calibrations available).

Calibration	*Dec. 2006 (% of stations)*	*June 2008 (% of stations)*
Individual absolute	5	12
Type absolute	64	66
From (relative) field measurements	14	11
No (radome not calibrated)	17	11

Table 3 – Evolution of the type of calibrations available for the EPN stations

As can be seen from Table 3, thanks to the introduction of the guidelines on antenna calibrations, the number of EPN stations without true absolute calibrations is slowly decreasing.

In contrary to the old relative antenna calibrations, absolute antenna calibrations go down to a zero degree elevation cut off angle and are elevation as well as azimuth dependent. Thanks to the improved modeling of the variations of the antenna phase center variations, it is expected that the introductions of the absolute antenna phase center variation models would reduce the coordinate jumps associated with antenna changes. Figure 7 shows that even with these new antenna models, still some coordinate jumps remain visible after an antenna change (line on the graphs).

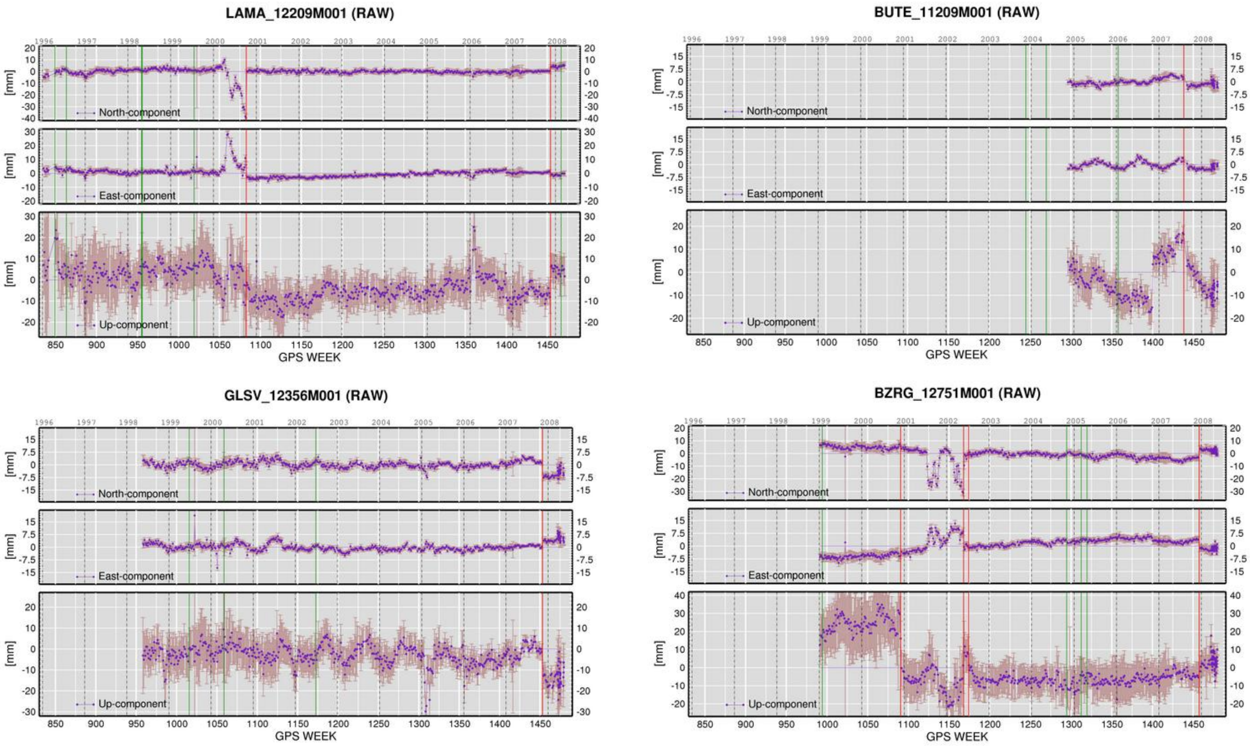


Figure 7 – Example of EPN stations with coordinate jump after an antenna change using the absolute antenna phase centre models in the data analysis (introduced from GPS week 1400 on).

3. REQUIREMENTS FOR NEW EPN STATIONS

In an attempt to verify all facets of the proposed EPN stations, the EPN CB has developed new tools that provide, in addition to the verification of the meta-data in the daily and real-time streams, also statistics on the data availability and latency for the daily, hourly as well as real-time data submissions. For that purpose the EPN data centers are hourly scanned to verify the availability and latency of the hourly and daily RINEX data in the two Regional Data Centers. We request that 90% of the daily data are available and, for the hourly data, we in addition request that 90% of the data are submitted with a maximal delay of 10 minutes. Candidate EPN stations providing real-time streams are requested to have a 90% data availability at regional broadcaster.

4. SUMMARY

Since last year, 22 new EPN stations joined the EPN bringing the total number of EPN stations to 210. The EPN tracking network continuously improves with a growth of the number of GPS+GLONASS tracking stations and a spectacular growth of the number of EPN stations providing real-time data. Also the number of EPN stations equipped with antenna/radome pairs with absolute calibrations is growing demonstrating the importance of strategic guidelines aiming at slowly upgrading the EPN.
Future upgrades to the EPN Central Bureau monitoring system will include an upgraded monitoring of the GLONASS tracking and the development of detailed data flow and data quality statistics for all EPN stations.

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