EUREF Symposium in Chisinau, Moldova, 25 – 28 May 2011

EPN Analysis Coordinator Report

H. Habrich
Federal Agency for Cartography and Geodesy, Frankfurt at Main, Germany

Abstract

Several developments in the realisation of a terrestrial reference frame by usage of geodetic GNSS technology started recently and affect also EPN analysis. This is amongst others the release of the ITRF2008 reference frame by the International Earth Rotation and Reference Systems Service (IERS) and the switch to the IGS08 reference frame and new antenna phase centre corrections by the International GNSS Service (IGS). IGS products that are applied during the EPN analysis steps will now refer to IGS08 and the EPN Local Analysis Centres (LACs) as well as the EPN Analysis Coordinator (AC) need to change the reference frame specification accordingly. A set of reference frame coordinates and velocities has been determined to be used for EPN reference frame specification. It is based on published IGS08 numbers as well as ITRF2008 numbers that have been corrected to fit into IGS08. This correction is necessary if EPN stations belonging to ITRF2008 should be used as reference sites, but don't belong to the published IGS08 set of stations. The "re-processing 1" is an important action under responsibility of the "EUREF Working Group of Reprocessing of the EPN". The benchmark test of 30 common stations analysed by all LACs revealed some inconsistency between different software packages used by the LACs. The weekly combination of the re-processing 1 results is thus considered preliminary. The "EPN LAC Workshop 2010" that was held in Warsaw, Poland in November 18-19, 2010 was an important meeting to adjust EPN analysis activities to new developments. The new EUREF proposal to participate in the future "TIGA Working Group" of the IGS continues the cooperation of EUREF and IGS in the scope of tide gauge monitoring. TIGA is now becoming a permanent service. We welcome a new LAC at the Republic Geodetic Authority (RGA), Serbia.

1 Introduction

This report describes recent activities concerning the analysis of EPN GNSS observations. It will not cover the complete series of EPN products. Comprehensive information on EPN products are available at the EPN Central Bureau.

2 IGS08 Reference Coordinates and Velocities for EPN

The International Earth Rotation and Reference System Service (IERS) announced on May 31, 2010 in IERS Message No. 164 the availability of the ITRF2008 solution. The IGS adopted a new reference frame, called IGS08, as the basis of its products starting with GPS week 1632 (April 17, 2011). This switch was announced in IGS-Mail No. 6354 on March 7, 2011. IGS08 is closely related to ITRF2008. EUREF adopted IGS08 for reference frame specification in the EPN analysis to reach maximum consistency with IGS products simultaneously with IGS. The following two remarks point the impact of the switch to IGS08 up:
i) IGS08 must be considered as an interaction of IGS08.snx and IGS08.atx

(satellite and receiver antenna PCOs and PCVs).
ii) IGS08 is essentially a subset of 232 stable, well-performing IGS stations from ITRF2008 (in total 580 stations)

While ITRF2008 coordinates are consistent with the igs05.atx set of calibrations, IGS08 needs to be consistent with the updated igs08.atx set. The impacts of the igs05.atx to igs08.atx calibration updates on the IGS08 station coordinates were thus assessed by extensive analyses based on the PPP strategy. In some cases, these impacts could not be neglected in view of the precision of ITRF2008. The following thresholds were used: 1.2 mm in horizontal or 3 mm in height component. ITRF2008 coordinates remain unchanged, if the computed correction is smaller than the thresholds. The scheme for the definition of IGS08 is given in Figure 1.

35 EPN stations of the IGS08 network show a significant impact of the updated igs08.atx. This network includes also some historical stations. The corrections are given in Figure 2.

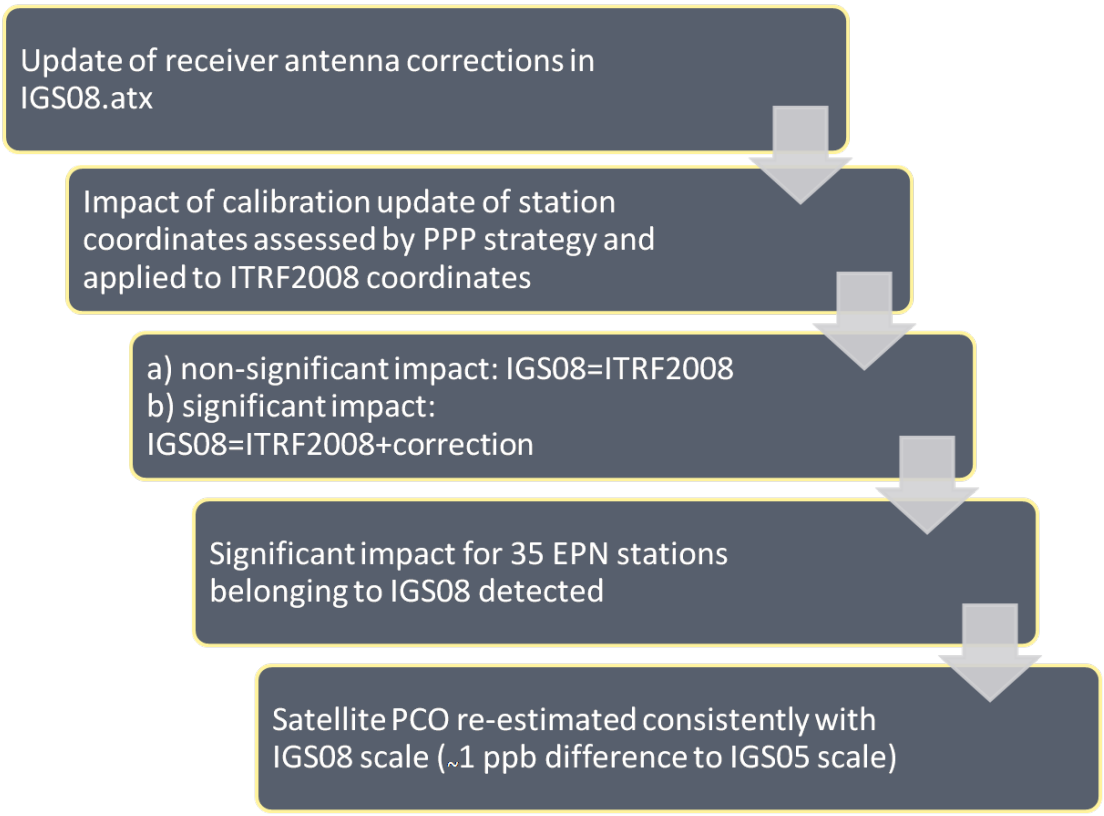


Figure 1: Definiton of IGS08

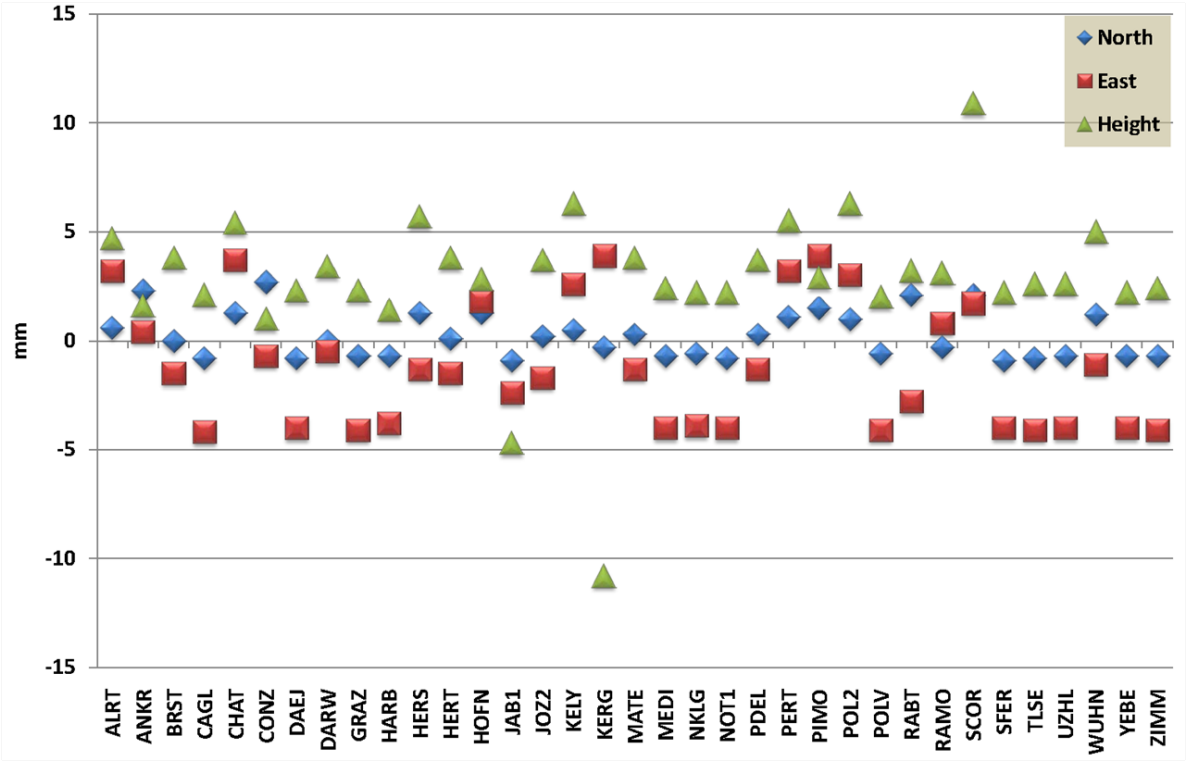


Figure 2: ITRF2008 to IGS08 coordinate corrections for 35 EPN stations

IGS not only provided station-specific corrections for stations included in the global IGS08 network, but also distributed a latitude-dependent correction model by antenna types, as described in IGS-Mail No. 6356. This model has been validated for the 35 EPN station of Figure 2. Differences of station-specific and antenna type specific corrections are given in Figure 3. Differences of the 2 approaches are shown, after applying the mentioned threshold criteria to the computed model corrections. The maximum differences between the two approaches are 0.2 mm for horizontal and 0.9 mm for height components, if we neglect the 2.6 mm height difference for the station HOFN, which might be an exception. It validates the computed corrections to be better than 1 mm.

The model has now been applied to prepare a set of reference coordinates and velocities to be used for reference frame specification of the EPN starting with GPS week 1362. This procedure will be descried in the following and has been distributed in EUREF-Mail No. 5734: I looked first on ITRF2008 stations that are included in EPN. For the week 1622 EPN solution, the reference for the stations selection, there are 101 ITRF2008 stations included. Four of them changed the equipment after the release of IGS08 and has been withdrawn from the list of potential reference stations. These are the stations GRAZ, HERS, TLSE and UZHL.
47 of the remaining 97 stations are included in the IGS08 solution. For these stations the IGS08 solutions will be used. For the remaining 50 stations I computed correction numbers to convert from ITRF2008 to IGS08 by usage of the latitude model. The corrections have been applied to the ITRF2008 solutions. It should be mentioned that for some stations the corrections are zero, because they are not affected by the changes of the igs08.atx w.r.t. igs05.atx file or the corrections are smaller than the thresholds used by IGS, i.e., 1.2 mm for the horizontal and 3.0 mm for the vertical components. The velocity numbers are equivalent to the ITRF2008 solutions.

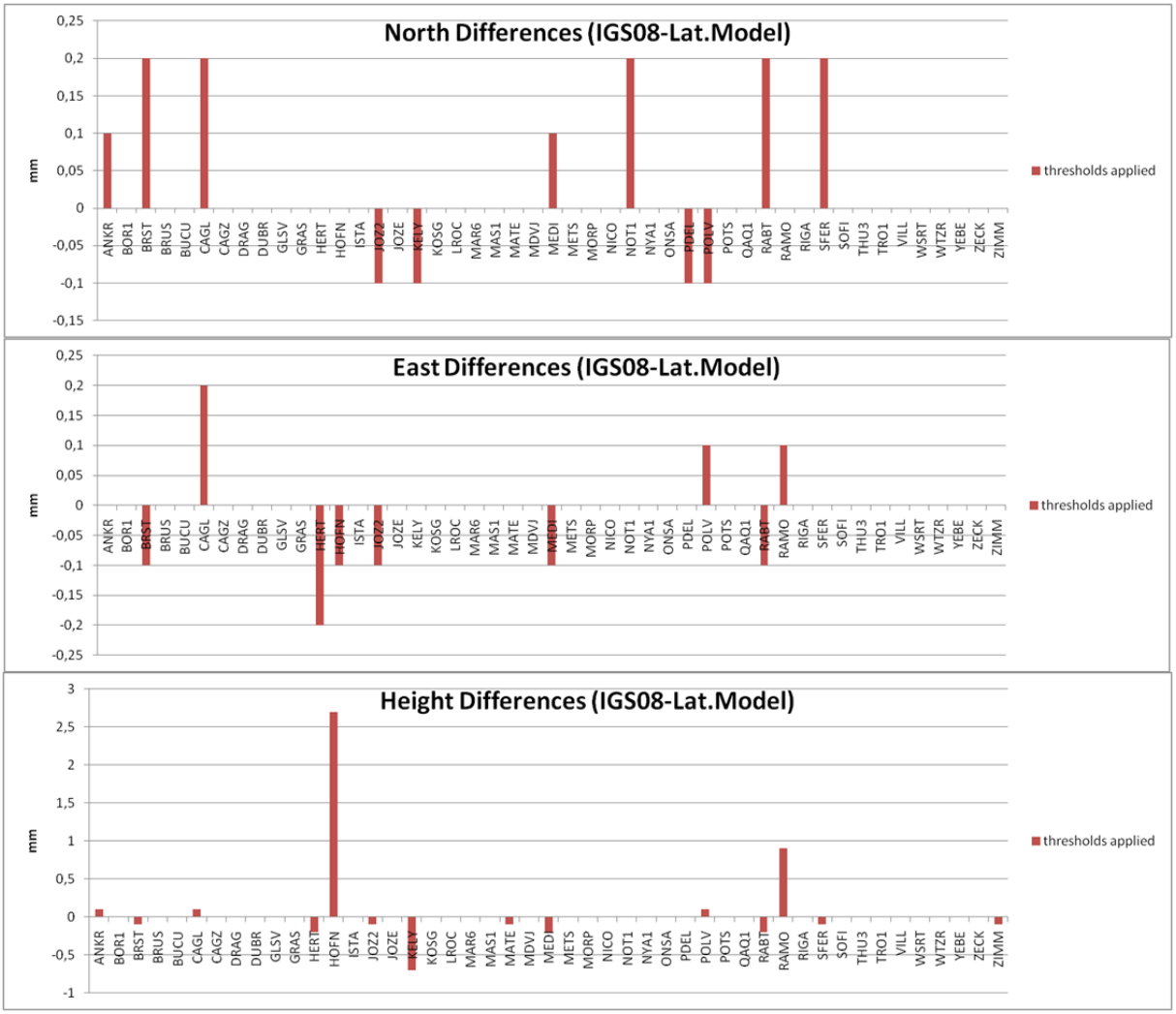


Figure 3: Validation of latitude-dependent model for ITRF2008 to IGS08 corrections

3 EPN Re-Processing 1

The first re-processing initiative of the EPN is coordinated by the "EUREF Working Group of Re-Processing of the EPN", and is divided into 3 phases. The first phase is a benchmark test. 30 common EPN stations has been analysed by all contributing LACs for the period of one week to confirm consistency of the analysis models used. The second phase is the pilot re-processing of all EPN stations of the year 2006, and it is considered as a "proof of concept" of all components of this initiative, e.g., data submission, data holding facilities, and product combination. The third phase performs the full re-processing of all EPN tracking data since 1996.

13 LACs contributed already to the Benchmark test. One of the submitted solutions has been calculated with GIPSY software, another solution with GAMIT software, where the remaining solutions were computed with Bernese GNSS Software. The main characteristics of the normal equations that were constructed from the submitted Benchmark solutions are shown in Figure 4. The number of observations as well as the number of parameters is set to the unknown station coordinates for "Non-Bernese solutions". This fact is considered by an empirical determined re-scaling factor that is applied to these solutions before the combination. It is surprisingly that the LACs show different numbers of observations though

they used identical RINEX files. It may be caused by different data screening. Different numbers of parameters may be caused by different modelling. The individual solutions of the benchmark test have been compared to the combined solution through an estimation of 7 Helmert parameters. It figured out that "Non-Bernese" solutions show a significant larger RMS and absolute Helmert parameters compared to the Bernese solutions. For that reason further investigation is needed. A better understanding of each individual solution is required. The coordinate differences (without Helmert transformation) between the GIPSY sub-network and the combined solution do not show a common shift for all stations. Thus these differences could not be corrected through an "a-priori" Helmert transformation before the combination. The station-specific differences do not repeat from day to day. They are obviously not caused by a configuration error during the analysis, e.g., the specification of wrong receiver antenna corrections. The mentioned inconsistencies were also noticed in the preliminary combination of solutions from 1996 to 2006 (full re-processing). Due to that reason the GIPSY solution has been excluded in the preliminary reprocessed time series, which was presented on the EUREF 2011 symposium. More and detailed investigation is needed, and we are looking for other GIPSY or GAMIT contributions to the benchmark test.

Figure 5 shows the network size of each LAC for week 1407, that is the last week in 2006 and the last week of the repro1 full re-processing period. Three LACs, namely AS_, MU0 und MU_, analysed almost the entire EPN network. The smallest network includes 30 stations and the maximum network 191 stations. The total number of submitted station-coordinate solutions results to 1361 for the 203 stations of the EPN network. We obtain a mean redundancy of 6.7 solutions for each station.

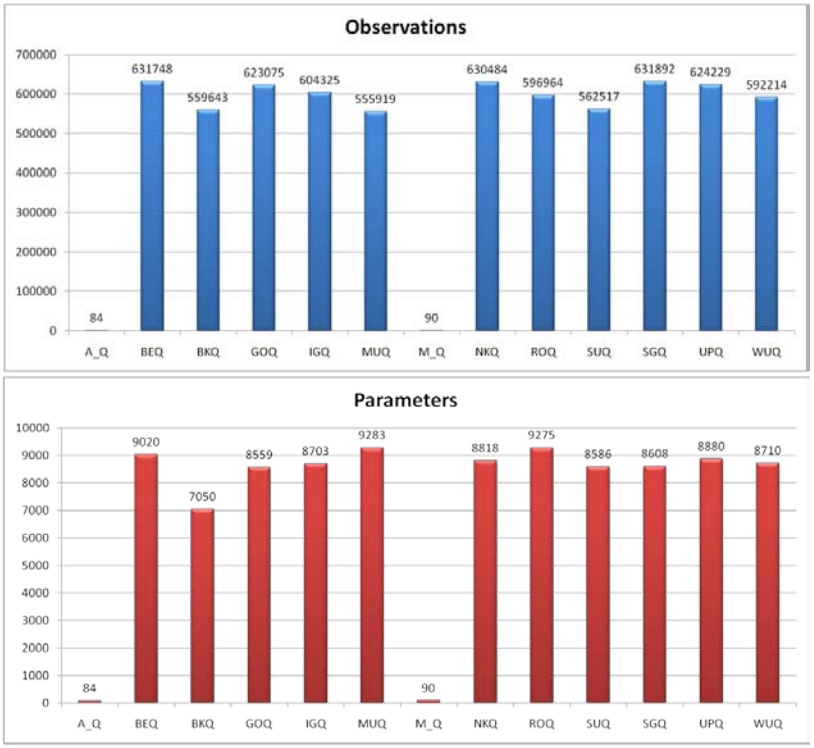


Figure 4: Characteristics of normal equations of benchmark test

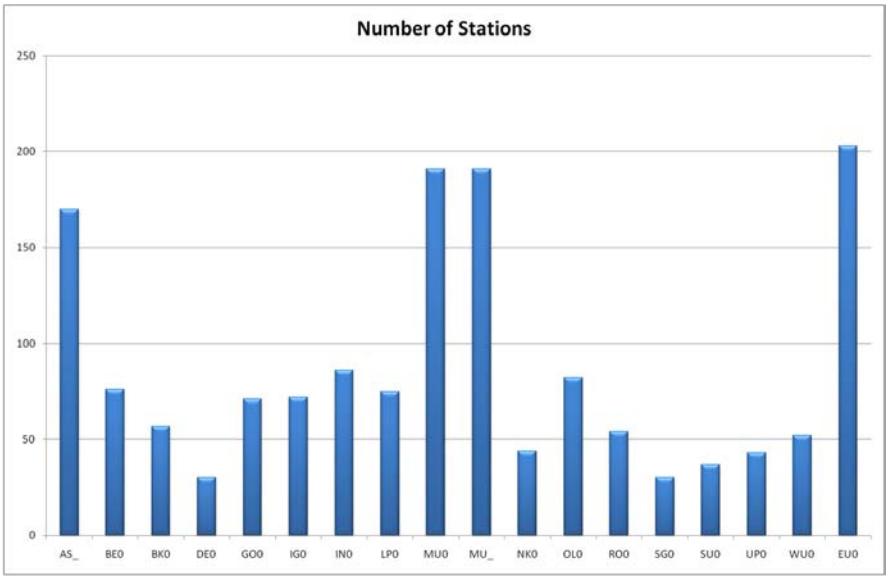


Figure 5: Re-Processing 1 sub-networks of week 1407

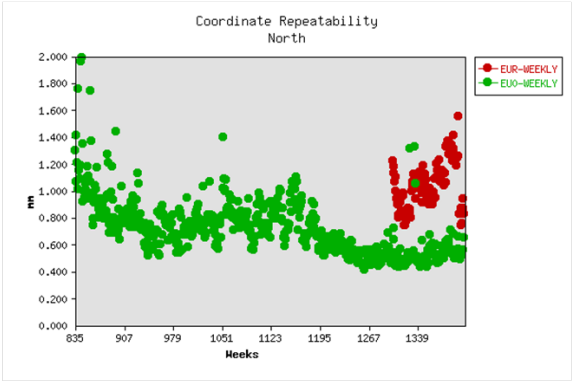
Figure 6 shows the coordinate repeatability as a result of a comparison of a single LAC solution to the combined solution. A mean RMS of such differences over all stations and all LACs has been computed for each week and is shown in the figures. The reprocessed results are shown in green, where red indicates the results from the "operational" processing. The statistics that are needed for such plots are available for the operation solution since week 1302 only, when the combination software had been changed. Such RMS numbers may be used as a quality indicator of the combined network solution, but indicate to a certain level also outliers of individual stations from one particular LAC contribution. I expected for reprocessed results that outliers had already been corrected by the LACs, but actually many outliers remain in the submitted solutions. The figures are based on an outlier notification level of 2 mm for horizontal and 6 mm for height components. Solutions exceeding these thresholds were excluded. The RMS numbers of the re-processed solutions clearly indicate an improvement compared to the operational solutions. As mentioned before this solution is considered as a preliminary solution, because the GIPSY solution was excluded. Further data screening may reduce the RMS numbers as well, e.g., for a couple of outstanding weeks in Figure 6.

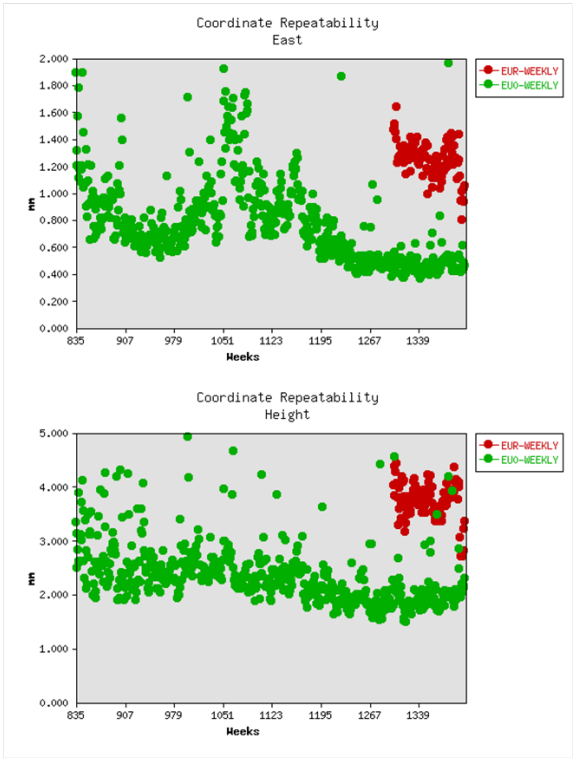
4 7th EPN LAC Workshop

The 7th EPN LAC Workshop was held on November 18-19, 2010 in Warsaw, Poland. Sincere thanks are given to the Military University of Technology for hosting this workshop. Main activities were reported by the LACs during the workshop. The most important round table discussion results are

- the introduction of IGS08 at the same time as IGS changes from IGS05 to IGS08,
- to provide RINEX version 3 observation files in preparation for the future Galileo system, and
- to ask LACs to include GLONASS for routine EPN analysis.

The second day of the workshop was reserved for re-processing issues. Minutes and detailed information about the workshop are available at the EPN-CB.





Solution: EUR
Type: WEEKLY
Inspected solutions: 106

Median North: 1.035 mm
East: 1.25 mm
Height: 3.76 mm

Solution: EU0
Type: WEEKLY
Inspected solutions: 573

Median North: 0.69 mm
East: 0.70 mm
Height: 2.24 mm

Figure 6: Coordinate comparison of operational (EUR) and re-processed (EU0) solutions

5 IGS Working Group for Tide Gauge Benchmark Monitoring

In 2001 the IGS Governing Board accepted the EUREF proposal for "Tide Gauge Benchmark Monitoring Pilot Project (TIGA-PP)". EPN contributes since that time to TIGA through providing weekly EPN operational solutions. In 2011 a transition of the pilot project into an "IGS Working Group" (a permanent service) was initiated with a new Call for Participation (CfP). EUREF submitted a Proposal on March 15, 2011 in response to the CfP that was circulated on February 2, 2011 in IGS-Mail 6341. The focus of the EUREF proposal is now on "repeated reprocessing" as asked for in the CfP. It has been accepted by the IGS Governing Board.

6 Republic Geodetic Authority, Serbia, Local Analysis Center

A new LAC located at the Republic Geodetic Authority, Belgrade, Serbia in cooperation with the University of Belgrade, Faculty of Civil Engineering in Belgrade, Serbia contributes to the EPN weekly combination since week 1632. The assigned sub-network consists currently of 45 stations with special focus on the region close to the Serbian territory. The network will be extended by 4 additional stations in Serbia, as soon as these proposed EPN stations will be included in the operational EPN network.

7 Outlook

It is planned to publish the first EPN re-processing results before end of 2011, even it not all open questions could be resolved. This decision is based on the urgent need of an EPN re-processed solution and the

requirement to start a second EPN re-processing referred to the IGS08 terrestrial reference frame and the IGS08.atx antenna phase center corrections. All current and future EPN re-processing activities are candidates for contributions to the TIGA Working Group.

8 References

EPN Central Bureau [2011]: http://www.epncb.oma.be

International Earth Rotation and Reference System Service (IERS) [2010]: http://www.iers.org

International GNSS Service Central Bureau [2011]: http://igs.org

Working Group of Re-Processing of the EPN [2011]: http://epn-repro.bek.badw.de/