Computation of a homogeneous coordinate time series for european GPS-stations by reprocessing of the weekly EPN solutions

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Abstract

Weekly coordinate time series for the all EPN (European Permanent GPS Network) stations for the period of observations beginning from GPS week 834 was obtained by a reprocessing of the official EPN solutions. Comparison of this series with EPN Central Bureau (EPN CB) and the previous IAA two-year solution for selected EPN stations obtained by reprocessing of the original observations is performed. Results of comparison show that new solution based on fiducial-free strategy is most likely free of seasonal errors. Now the new IAA EPN solution is being computed regularly (on availability of the official EPN solution) and is available to any interested group.

1 Introduction

GPS observations collected from the European GPS network are widely used for geodesy and geodynamic researches in the region. The network is coordinated by the EPN CB which also provides the official analysis of the observations. Two EPN weekly solutions are available. The first one is computed at the Bundesamt für Kartographie und Geodäsie, Germany (previously at the Center for Orbit Determination in Europe, Astronomical Institute of the University of Bern, Switzerland) and distributed as SINEX files. Hereafter this solution is referred to as EUR. Unfortunately, this solution is not suitable for high-accuracy geodesy applications because the using of fiducial approach and periodic change of the reference system cause jumps in coordinates and distortion of the network. Direct use of this solution can lead to some confusions (see e.g. [1]). Besides the EUR solution does not contain any information about displacement of the fiducial stations.

The second solution is computed at the EPN CB by reprocessing the previous one and seems to provide high-quality information about the movement of the all EPN stations. Unfortunately, this solution is not distributed in SINEX files, and it is difficult to use it in scientific analysis.

For these reasons, several years ago the IAA undertook a special project aimed at the computation of an independent coordinate time series for all the EPN stations. A detailed description of the project was given in [2].

At the first stage the original GPS observations for a selected EPN subnetwork at two-year interval were reprocessed using fiducial-free strategy. Basic theoretical background for this approach can be found in [3–9]. Previously this strategy was tested during processing of two Baltic Sea Level campaigns [5, 10] Obtained coordinate time series appeared to be more stable in sense of random and systematic errors [8, 9]. It is hereafter referred to as I1.

Unfortunately, this way of reprocessing requires too much resources and we tried two another approaches. The first one is based on reprocessing of existing EUR solutions (the second stage of the IAA project). The processing strategy is described below. Obtained coordinate time series was compared with other EPN solutions and the previous IAA solution I1. Results of comparison show that obtained solution is most likely free of seasonal errors.

At the third stage of the our project we plan to obtain an EPN coordinate time series by an independent combination of individual solutions provided by the EPN Analysis Centers, also using fiducial-free approach. This work is under development and is planned to be completed by the end of 2003.

2 Processing strategy

Our processing was made in two steps. At the first one the EUR solutions are de-constrained using the a priori coordinates and covariance matrices contained in the SINEX files following the strategy proposed in [11].

After this the transformation of the obtained free network solution to the ITRF2000 is made. Unlike EPN CB strategy, we use for the transformation all the stations presented in the solution using weights dependent on their position accuracy (taking into account both errors in position and velocity) in the EUR solution and in the reference ITRF catalogue.

Two solutions were computed: with 6 and 7-parameter Helmert transformation. Solution obtained with 6-parameter transformation is hereafter referred to as I2, solution obtained with 7-parameter transformation is referred to as I3.

Time series of transformation parameters are shown in Figure 1. One can clearly see the seasonal and other peculiarities in these time series which should be investigated separately.

Analysis of the solutions obtained by this method showed that the obtained coordinate time series have a similar quality with the EPN CB solution with some small discrepancies which can be explained by details of used approaches. However analysis of the errors in the station coordinates reveals very large irregularities, caused most probably by inconsistency in SINEX blocks (e.g. wrong scaling of covariance matrices).

To reduce the inconsistency of coordinate errors we used a re-scaling of computed covariance matrices. The re-scaling factor was chosen in such a way that the mean coordinate error of non-fiducial stations in the EUR solution is equal to the mean coordinate error of the same stations of the new solution. The plots of mean coordinate errors of our solution with and without re-scaling of covariance matrices are shown in Figure 2.

3 Comparison and conclusions

Six-year coordinate time series for all EPN stations were computed and compared with two other solutions (EUR solution and our previous two-year solution for selected european stations). Several examples are presented in Figure 3. It is seen that all series provide determination of main details in behavior of station position.

A comparison of four solutions mentioned above is presented in Table 1. The table contains results of determination of week-to-week repeatability (Allan variance) interpreted as random error and amplitude of seasonal term in variation of station coordinates in the local ENU system.

Comparison shows that I3 solution obtained using 7-parameter Helmert transformation to the ITRF2000 provides minimum random error and seasonal variations. Of course, the latter may mean merely loss of geophysical signal, but comparison with EPN CB series (available at the EPN Web site) and global solutions (T. Springer, private communication) shows that most likely seasonal terms observed in the EPN solution is caused by systematic errors induced by errors in modeling of position of fiducial stations.

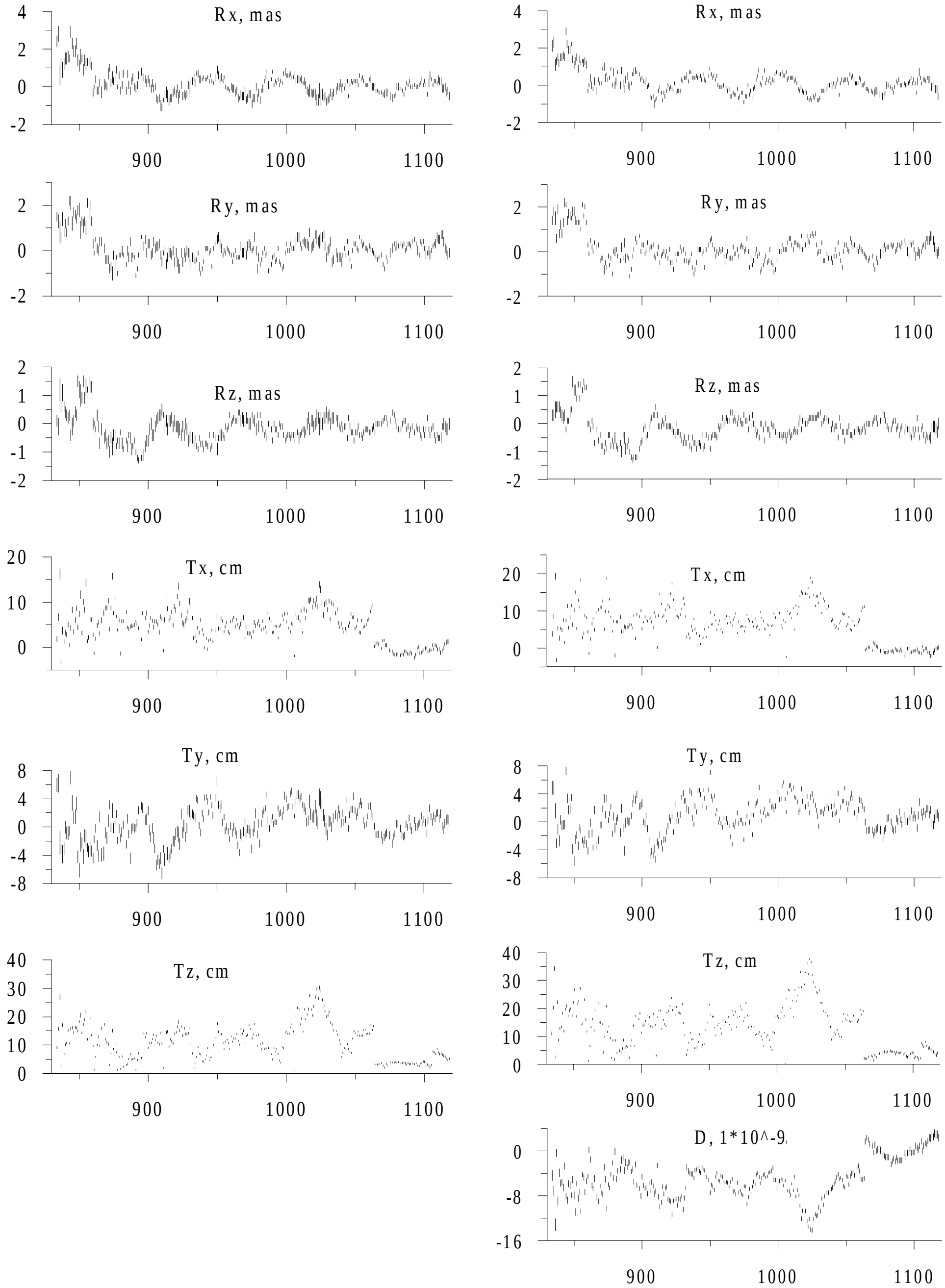

Figure 1: Helmert parameters time series for transformation w.r.t. ITRF2000: with 6 parameters (left) and with 7 parameters (right) (R — rotation parameters, T — translation parameters, D — scale); vertical bars on the plots present parameters errors.

Table 1: Statistics for 10 stations presented in all solutions.

Station		Allan variance, mm				Annual term, mm			
		E	I1	I2	I3	E	I1	I2	I3
GLSV	dE	1.2	1.2	2.0	1.6	1.0	0.6	5.7	1.2
	dN	1.1	1.1	1.1	1.3	1.7	1.4	1.7	1.3
	dH	3.7	3.0	2.4	2.0	7.0	3.5	3.5	2.7
JOZE	dE	0.9	0.9	1.0	1.8	0.7	0.9	1.5	0.5
	dN	0.8	0.8	0.8	0.8	0.9	0.4	0.3	0.5
	dH	3.1	2.9	2.5	1.9	3.7	1.6	0.9	1.3
LAMA	dE	1.2	1.1	1.1	1.5	0.4	0.4	2.3	0.4
	dN	0.9	0.9	0.9	1.0	0.3	0.7	1.1	0.7
	dH	2.9	3.0	2.0	1.6	5.6	2.8	2.5	1.9
MDVO	dE	1.5	1.4	2.2	2.5	0.3	0.6	5.2	0.2
	dN	1.1	1.3	1.1	2.3	0.5	1.0	0.8	1.0
	dH	5.6	5.1	5.4	4.3	6.6	6.4	1.2	1.3
MEDI	dE	1.8	1.7	2.0	3.2	1.9	1.8	1.6	1.8
	dN	2.4	2.6	2.5	2.0	1.9	2.2	1.4	3.4
	dH	2.7	2.8	2.7	1.8	3.3	1.7	2.0	1.3
METS	dE	1.1	1.3	1.4	1.8	2.2	0.3	2.8	0.5
	dN	1.8	1.9	2.0	1.2	2.6	1.6	2.9	1.1
	dH	4.0	3.5	2.9	2.8	4.9	0.9	3.5	3.0
NOTO	dE	1.2	1.4	1.1	2.1	1.1	0.8	1.4	0.9
	dN	1.3	1.5	2.2	1.0	3.0	0.9	7.5	1.7
	dH	3.0	4.7	2.7	2.0	2.2	4.1	2.3	3.1
SVTL	dE	1.3	1.7	1.8	1.9	1.1	1.1	4.2	0.7
	dN	1.0	1.2	1.3	1.2	1.0	0.6	2.7	0.5
	dH	4.4	3.2	3.4	3.0	6.9	1.9	2.6	1.9
WSRT	dE	0.6	0.9	0.8	1.3	0.4	0.6	0.9	0.1
	dN	0.8	1.1	0.9	0.7	0.3	0.6	0.9	0.6
	dH	2.3	2.7	1.9	1.6	1.0	2.1	2.0	2.3
ZECK	dE	1.4	1.5	2.6	2.1	2.1	0.6	7.8	2.4
	dN	1.4	1.7	2.0	1.7	1.2	1.0	5.0	1.9
	dH	3.8	2.6	3.8	2.8	11.8	0.5	5.3	3.2
Mean	dE	1.3	1.6	1.6	1.1	1.6	1.2	3.3	0.9
	dN	1.2	1.5	1.5	1.2	1.4	1.1	2.4	1.3
	dH	3.5	3.5	3.0	2.9	5.0	2.6	2.6	2.2

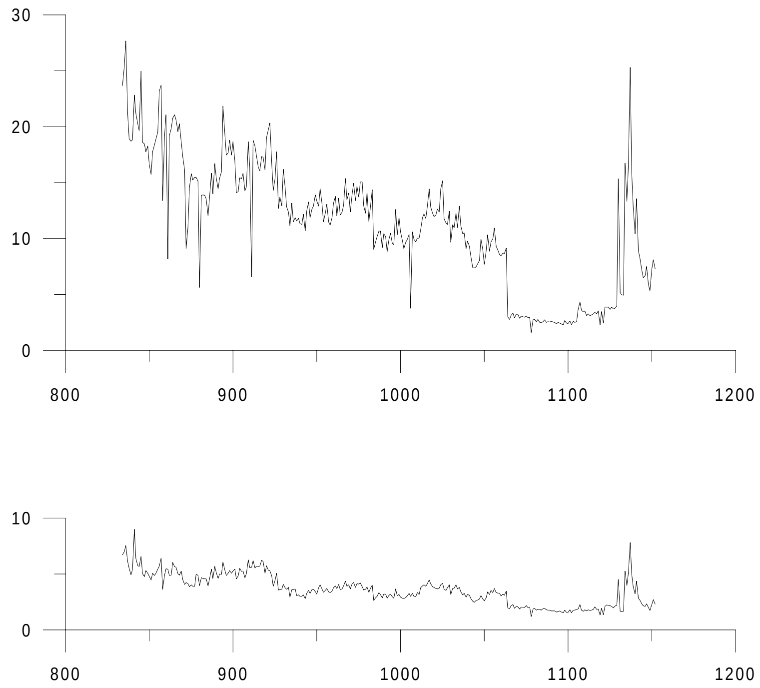

Figure 2: Mean coordinate errors without (top) and with (bottom) re-scaling, mm;

Evidently, more thorough consideration should be made to make a choice between using 6 or 7-parameter Helmert transformation of free network solution to ITRF. The first impression is that it is more reasonable to apply 6-parameter transformation to a global network, whereas 7-parameter transformation is more adequate to regional data.

Now the IAA EPN solutions are being computed regularly using described strategy, on availability of the official EPN solutions, and the results are available to any interested group (on request at the moment, later it will be put to the Internet).

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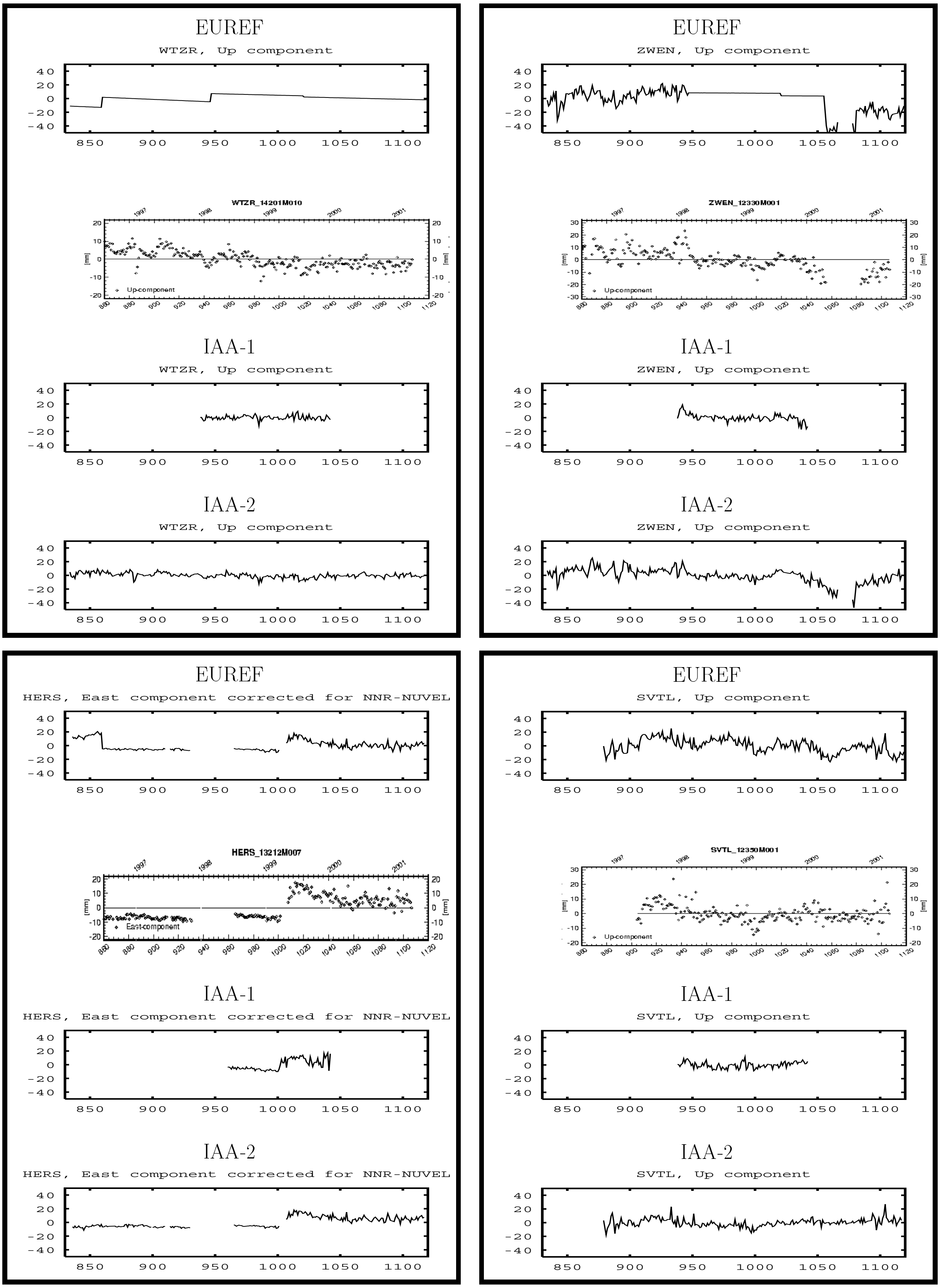

Figure 3: Some examples of the coordinate time series, mm (top to down: EUR solution, EUREF CB solution (copied from the web page [12]), I1 solution, and I2 solution.).

References

[1] Lanotte R., C. Ferraro, A. Nardi, C. Sciarretta, F. Vespe. The CGS VLBI EUR98 Geodetic Solution and Compari-son with the CGS GPS Results, 1999, In: W. Schlueter, H. Hase (eds.) Proc. 13th Working Meeting on European VLBI for Geodesy and Astrometry, Viechtach/Wettzell, Feb 12–13, 1999, 101–107.

[2] Panafidina N. A., Malkin Z. M. On computation of a homogeneous coordinate time series for the EPN network. In: Proceedings "Vistas for Geodesy in the New Millennium", IAG 2001 Scientific Assembly, Budapest, Hungary, 2–7 September 2001, 2002.

[3] Blewitt G., M. Heflin, W. Bertiger, F. Webb, U. Lindqwister, R. Malla. Global Coordinates With Centimeter Accuracy In The International Terrestrial Reference Frame Using The Global Positioning System, Geophys. Res. Lett., 1992, **19**, 853–856

[4] Heflin M. B., W. I. Bertiger, G. Blewitt, A. Freedman, K. Hurst, S. M. Lichten, U. Lindqwister, Y. Vigue, F. Webb, T. Yunck, J. Zumberge. Global Geodesy Using GPS Without Fiducial Sites, Geophys. Res. Lett., 1992, **19**, 131–134.

[5] Springer T. A., Z. M. Malkin. Analysis of the Baltic Sea Level 1993 GPS Campaign.In: J. Kakkuri (ed.), Campaign. Rep. Finn. Geod. Inst., 1995, **95:2**, 87–104.

[6] Zumberge J., M. Heflin, D. Jefferson, M. Watkins, F. Webb. Precise Point Positioning for the Efficient and Robust Analysis of GPS Data from Large Networks, J. Geophys. Res., 1997, **102**, 5005–5017.

[7] Dong D., T. A. Herring, R. W. King. Estimating Regional Deformation from a Combination of Space and Terrestrial Geodetic Data. Journal of Geodesy, 1998, **72**, 200–214.

[8] Malkin Z.M., A. V. Voinov, 2001, Preliminary Results of Processing EPN Network Observations Using a Non-Fiducial Strategy. Phys. Chem. Earth (A), 2001, **26**, 579–583.

[9] Malkin Z. M., Voinov A. V. The First Results of Processing EUREF observations using non-fiducial strategy. Trans. IAA RAS, 2001, **6**, 255–270.

[10] Voinov A. V., Z. M. Malkin. Preliminary Results of the BSL 1993 and 1997 GPS Campaigns. In: M. Poutanen, J. Kakkuri (eds.), Final results of the Baltic Sea Level 1997 GPS Campaign. Rep. Finn. Geod. Inst., 1999, **99:4**, 51–68.

[11] Brockmann E., Combination of Solutions for Geodetic and Geodynamic Applications of the Global Positioning System (GPS), Ph. D. Dissertation, Bern, 1996.

[12] http://www.epncb.oma.be/

[13] Mareyen M., M. Becker. On the removal of a priori restrictions from GPS network solution in a SINEX format. Algemeine Vermessungs-Nachrichten, 2000, **11-12**, 405–411.