# ANALYSIS OF CEGRN 2005 AS THE EIGHTH OF CERGOP OBSERVING CAMPAIGNS

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## ABSTRACT

**Strategy of analysis and results from solution of CEGRN epoch campaign in 2005. Combined solution of CEGRN 2005 based or individual solutions from six analysis centres and its comparison with CEGRN 2003 coordinates. Time evolution of coordinates at some long-term observed CEGRN sites obtained during epoch campaigns since 1994 and the related problems.**

## 1. INTRODUCTION

**The latest observing campaign of Central Europe Geodynamics Regional Network (CEGRN) was performed in June 2005. It was independently processed by 6 analysis centers from following institutions: Darmstadt University of Technology (DUT), FOMI Satellite Geodetic Observatory (SGO), Geodetic Observatory Pecny (GOP), Observatory Lustbuehel Graz (OLG), Slovak University of Technology (SUT) and Warsaw University of Technology (WUT). Observation data from 96 stations, which were prepared by OLG (Stangl, 2003, Haslinger and Stangl, 2005) are analyzed by the Bernese GPS software with a strategy similar to that used for the previous CEGRN campaigns observed in 1994 - 2003. The 2005 campaign solution includes 76 officially adopted CEGRN stations, 4 additional IGS sites are added for the linkage to ITRF. A set of 16 candidate sites with the potential of becoming new CEGRN stations is included in addition to the processing. Geographical distribution of stations included in processing of 2005 CEGRN campaign is in Fig. 1. The combination of all submitted**


**Fig. 1 Status of network processed within the CEGRN 2005 observing campaign. o - permanent stations, ◘ - epoch stations, + - candidate stations. Outside the map are some other IGS permanent stations included in processing, namely ZIMM, KOSG, ONSA and METS.**

solutions is performed at SUT and the official CEGRN solution production is in progress.

## 2. ANALYSIS OF CEGRN 2005

All the centres processing CEGRN 2005 applied similar strategy for network analysis using the GPS software Bernese BV4.2 (Hugentobler et al., 2001) except DUT which used BV5.0. The main attributes of processing are (Hefty, 2004):

- **Processing in daily intervals (0-24 h UT).**
- **Use of IGS orbits and corresponding ERPs.**
- **Simultaneous daily network processing of 91 official and candidate CEGRN sites and 4 outside IGS stations (ONSA, ZIMM, KOSG, METS).**
- **10 degrees elevation angle.**
- **Reference point GRAZ with ITRF 2000, epoch 2005.47 position strongly constrained.**
- **Troposphere zenith delays estimated at each station in hourly intervals, Niell mapping function applied, elevation dependent weighting.**
- **Baseline geometry, ambiguity fixing and combination of daily solutions is under the responsibility of analysis centres.**
- **Antenna eccentricities – PHAS_CEG.03 file prepared by OLG.**
- **Ocean loading corrections are not included.**
- **The a priori site coordinates are available at accuracy of some centimeters.**
- **The choice of baseline geometry and method of ambiguity fixing is in the responsibility of analysis centers.**

**Campaign solutions fulfilled further requirements:**

- **Free network solution constraining GRAZ to 0.0001 m.**
- **Eliminated ambiguities.**
- **Eliminated zenith delays.**
- **Removing outliers *n*/*e* > 10 mm, *up* > 20 mm.**

**The outputs of processing at individual analysis centers were campaign results in form of coordinate files, covariance matrices files and SINEX formatted solution (compatible SINEX is not available from all centers at this moment).**

**Combination procedure was performed with respecting the full covariance matrices of individual solutions. Consistency among individual network solutions obtained by six analysis centres was evaluated. Fig. 2 shows consistency in horizontal position. Solutions of individual centres show slight regional dependence generally not exceeding 5 mm. The exception is the set of stations in Romania, which are biased in DUT solution. This bias is explained by different antenna phase centre model used for stations occupied with LEIAT504 LEIS antenna. The final SINEX formatted output will be produced after correcting minor problems in individual network solutions.**

## 3. COMPARISON OF CEGRN 2005 WITH CEGRN 2003 AND WITH OLDER CAMPAIGNS RESULTS

**Among 92 CEGRN and candidate sites observed in 2005 there are 65 sites which can be considered as identical points with CEGRN from 2003. Networks from 2003 and 2005 were compared by 7-parameter Helmert transformation. The first computation of residuals showed about 0.90 m difference between BRSK height in 2003 and 2005 which can be attributed to wrong value of height in 2003. After elimination of BRSK only considerably smaller residuals are noticed. The residuals exceeding 0.02 m in height and/or 0.01 m in *n* or *e* coordinates are listed in tab. 1. They are defined as: position in 2005 minus position in 2003. Most of the outliers are due to wrong antenna height determination. The large horizontal residual in CLUJ is attributed to local landslide.**


**Fig. 2. Consistency among individual CEGRN 2005 solutions from six analysis centres in horizontal components.**

**Graphical representation of horizontal residuals is given in Fig. 3 and the vertical residuals are plotted in fig. 4.**

**CEGRN sites are observed in epoch-wise mode since 1994 in annual (from 1994 to 1997) and bi-annual (from 1997 to 2005) cycles. More than 50 sites were observed more than 4 times and 15 sites were observed in each of the 8 performed CEGRN campaigns. The information inferred from time evolution of observed coordinates may serve for critical consideration about the quality of epoch observation. We will show some examples where the set of observed horizontal positions has no unambiguous interpretation. For the sake of mutual comparison the results obtained at various epochs are transformed to common reference.**

**Table 1. Residuals from Helmert transformation between CEGRN 2003 and 2005 for sites where one of components is exceeding 0.02 m in height and/or 0.01 m in horizontal coordinates.**

| Station | North (mm) | East (mm) | Up (mm) |
|---|---|---|---|
| BUCA | -4 | 2 | - 46 |
| BRSK | 3 | - 14 | 898 |
| CLUJ | 25 | 0 | -1 |
| STHO | - 8 | 13 | - 13 |
| DISZ | 6 | -13 | 11 |
| FUN3 | 4 | - 6 | - 56 |
| GRMS | 1 | - 1 | 33 |
| HOHE | - 9 | 9 | - 47 |
| LVIV | - 1 | - 1 | 28 |
| TIS3 | - 10 | 2 | - 65 |
| VRN1 | - 5 | - 2 | -24 |


**Fig. 3. Horizontal residuals from Helmert transformation between CEGRN 2003 and CEGRN 2005 coordinates.**

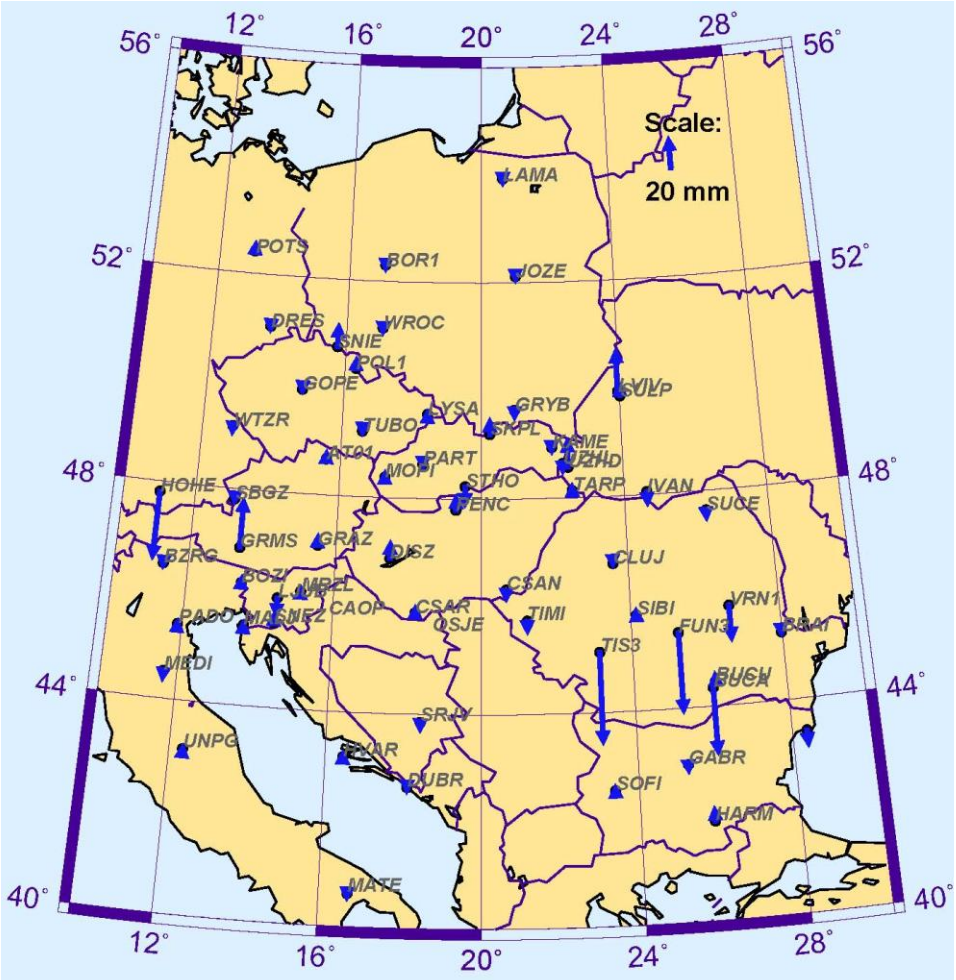


**Fig. 4. Vertical residuals from Helmert transformation between CEGRN 2003 and CEGRN 2005 coordinates.**

**Examples of evolution of horizontal coordinates are in Fig. 5. For the reason of better interpretation the global part of Eurasian plate motion was removed. The vectors in upper left corner represent the estimated linear approximation of horizontal site movement during 11-year observation history. They indicate the possible intraplate motion of the monitored site. The ellipses represent one sigma confidence.**

**It is evident that various phenomena are responsible for the coordinate changes observed. We assume that besides the intraplate motion the position is influenced by unmodelled part of antenna phase centre eccentricities, monumentation changes, site environment changes, receiver and antenna upgrades, etc. The plots in Fig. 5 indicate the problem of outliers which significantly influence the estimate of intraplate motion characteristics. Sites BRSK, HUTB, KIRS, DRES and DISZ are clear examples where one position (in general not obtained in the same campaign) is significantly differing from the other position determinations. Epoch positions of FUN3 are much more scattered than is usual for other sites. These examples show that for the velocity estimation the detailed study of station behaviour is necessary.**

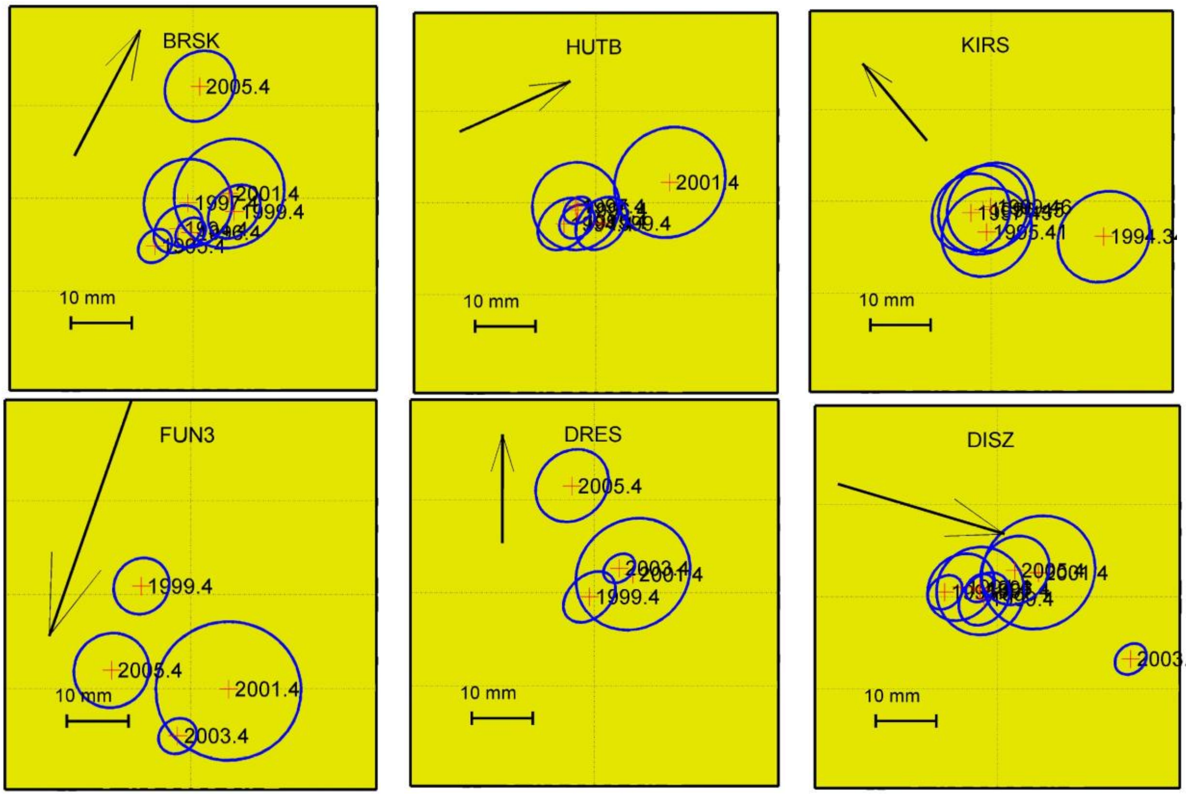


**Fig. 5. Coordinate evolution at some CEGRN stations observed four and more times (Eurasian global plate motion was removed). Vectors in upper left corner indicate the magnitude and direction of estimated intraplate motion during 11 years. These plots point on the problems of outliers which influence the estimate of intraplate motion.**

## 4. CONCLUSIONS

- **CEGRN is the regional network covering Central and South-east Europe with 11-year history of epoch observations. Eight campaigns were performed up to now. The number of observed sites increased from start of CERGOP till 2005 about three times.**
- **Processing and combination of 2005 CEGRN observing campaign resulted in coordinates generally consistent with previous campaigns. The official combined product based on solutions from six analysis centres will be available after correcting some minor problems.**
- **The results at some long-term observed sites indicate clearly the time evolution of station coordinates and intraplate station drift. However results at another stations indicate some station instabilities probably due to station monumentation, antenna and receiver exchanges and station environment changes.**
- **The large differences among coordinates obtained in successive campaigns needs to be explained for reliable velocity estimation.**

**Acknowledgement: This work was supported by grant No. 1/1033/04 of the Grant Agency of Slovak Republic VEGA and by the CERGOP-2/Environment EU contract.**

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