COMBINING OF GNSS SOLUTIONS FROM BERNESE AND GAMIT

A. Araszkiewicz, M. Figurski, K. Kroszczyński

Centre of Applied Geomatics, Military University of Technology, Warsaw, Poland

1. INTRODUCTION

In course of preparation to EPN Reprocessing project many processing strategies, models and algorithms were tested in Centre of Applied Geomatics at Military University of Technology (CAG MUT). One of the stages was an effort undertaken to combine GPS solutions from two different software (BERNESE 5.0, GAMIT 10.35) and find an answer to a question how algorithms influence the final results. The reason of comparing these two software was that they will be used in the EPN project. This research presents to what degree the results from such different software can be compared and how they complete each other.

2. PROCESSING STRATEGY

In this study observation files (RINEX) from EPN stations were used. The data from a 2006 year was chosen for the testing. There was processed over 180 stations in BERNESE and in GAMIT we chose only 30 evenly distributed stations (Fig.1). The attempt in the processing was to use similar strategy and models in both software.

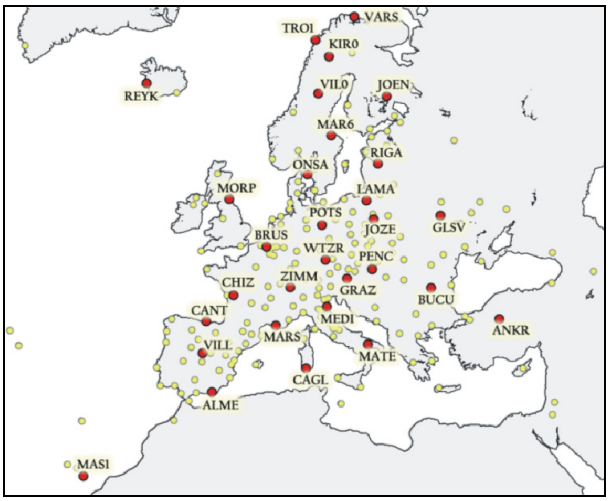

Fig. 1. Common stations processed in GAMIT and BERNESE software.

In BERNESE a phase was pre-processed in a baseline by baseline mode using triple differencing solution. In most cases, cycle slips looking simultaneously at different linear combinations of L1 and L2 were fixed. If a cycle slips could not be fixed reliably, bad data points were removed or new ambiguities were set up.
Using GAMIT the orbits were fixed by choosing BASALINE experiment. Observable was the ionosphere-free linear combination (LC_AUTCLN) and the process was run in two passes.

GAMIT 10.35		BERNESE 5.0	
Experiment:	BASELINE	Mode:	CORECT CORREL.
Orbits:	IGS final repro.	Orbits:	IGS final repro.
Antenna Model:	igs05_1545_plus.atx	Antenna Model:	EPN_05.ATX
Troposphere:	GPT	Troposphere:	Saastamoinen
DRY GMF mapping function		DRY NIELL mapping function	
WET GMF mapping function		WET NIELL mapping function	
Ionosphere:		Ionosphere:	
2nd & 3rd Ion. corr.	NONE	2nd & 3rd Ion. corr.	NONE
Ocean loading:	FES2004	Ocean loading:	FES2004
Atm. loading:	NONE	Atm. loading:	NONE
Elevation Cutoff:	3°	Elevation Cutoff:	3°

Fig. 2. The comparison of GAMIT and BERNESE strategy.

3. COMBINATION IN ADDNEQ2

To combine solutions in ADDNEQ2 daily and weekly solutions in SINEX format was used. Using BERNESE the input files was imported to main analysis by software package – SNX2NQ0. This programme inverted the (constrained) correlation or covariance matrix to the unconstrained normal equation matrix.
Independent of GAMIT and BERNESE results daily solutions were calculated. Reference frame were realized by the stations listed below. Three components of Helmert translation related to IGS05 was estimated by 'minimum constrain' method. Following such a strategy allowed to eliminate the errors in network's geometry trigged by some errors in stations (used for reference frame realization) and also not make any significant changes in reference frame.

STATIONS USED TO REALIZE REFERENCE FRAME:

```
BOR1, BRUS, CAGL, GRAS, HOFN, MATE, METS, NOT1, NYA1,
NYAL, ONSA, POLV, POTS, RABT, REYK, TRAB, TRO1, WSRT,
WTZR, ZIMM
```

The same normal equations were combined to three different weekly solutions (GAMIT, BERNESE, GAMIT+BERNESE – as compared in Fig. 4) according to standard EPN procedure. This procedure allowed to get repeatability of all analyzed stations. Fig. 3 shows common stations in all solutions.

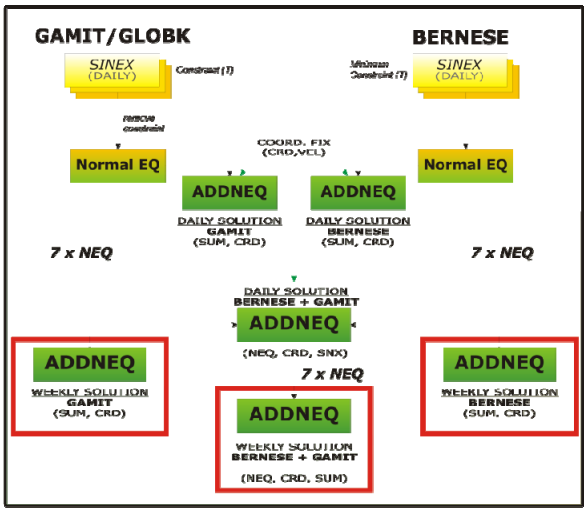

Fig. 3. Simple schema of the strategy used in ADDNEQ2 Software. Marked solutions compared below (Fig. 4).

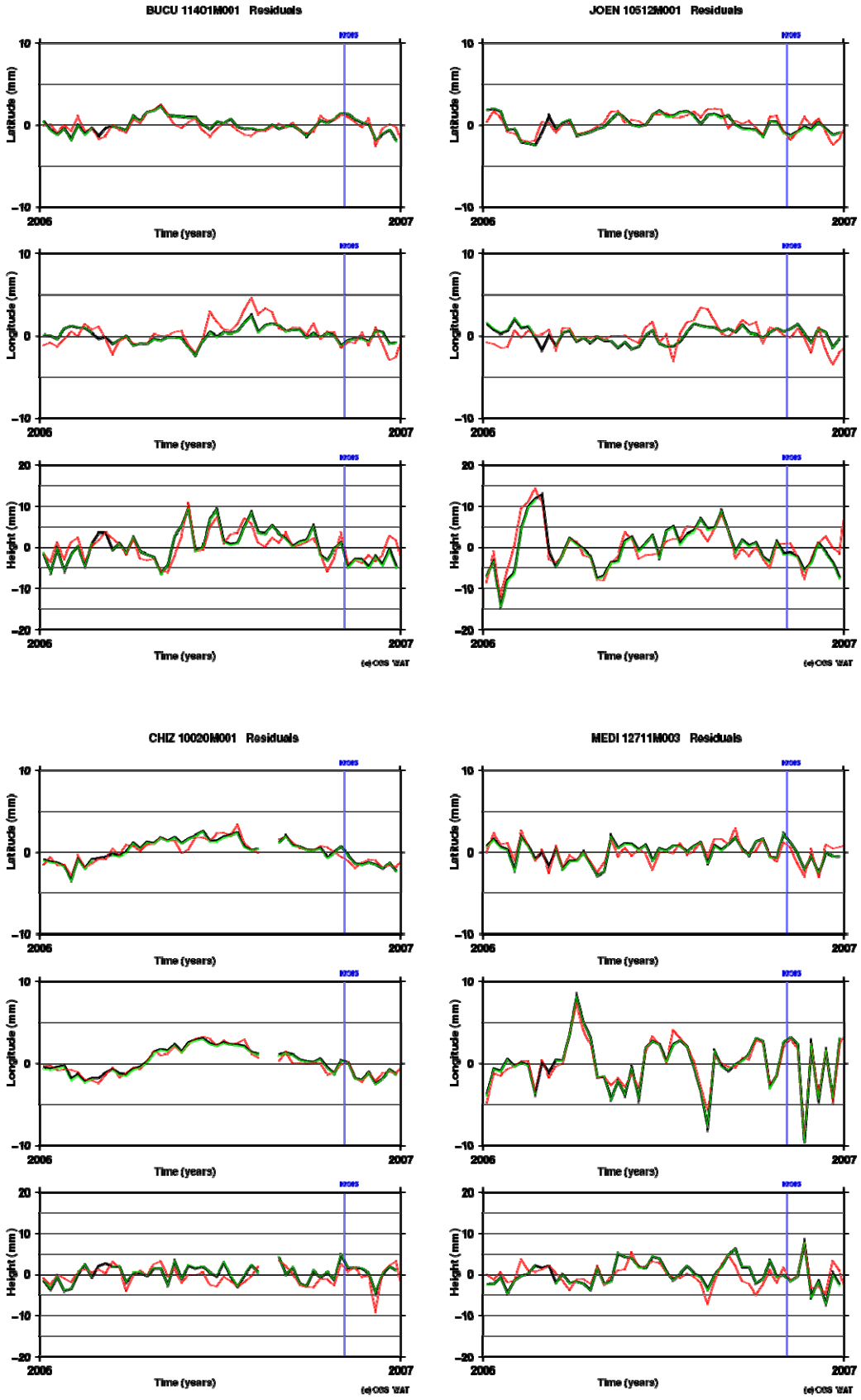

Fig. 4. Comparison of GPS solution from GAMIT (light gray), Bernese (gray), combination (black) processed in ADDNEQ software.

4. COMBINATION IN GLOBK

H-files from GAMIT and SINEX from BERNESE were the input files in our processing. Firstly SINEX and gamit h-files to globk binary h-files were converted. The next step was to combine daily solution in weekly solution separately for:

```
GAMIT:     sh_glred -s 2006 1 2006 365 -ncomb 7 -expt base -opt
H G E
BERNESE:   sh_glred -s 2006 1 2006 365 -ncomb 7 -expt bern -opt
H G E
```

In analyses the "generalized constraint" method was used. Considering that the analysed network is regional, satellite orbits were constrained in globk:

```
apr_svs all .1 .1 .1 .01 .01 .01
```

Like in ADDNEQ2 just translation of Helmert parameters was estimated, whereas rotation was constrained in globk:

```
apr_wob 0.2 0.2 0.1 0.1
apr_ut1 .25 .1
```

The reference frame was realized by fixed sites (the same like in ADDNEQ2) listed above. As a final step using the same strategy we combined weekly solution (base and bern) into one and compared stations' coordinates from all tree way (Fig.6).

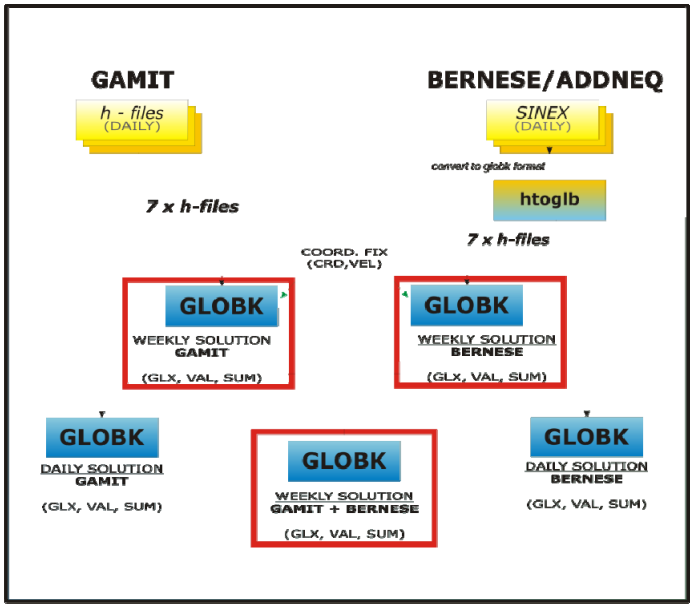

Fig. 5. Simple schema of the strategy used in GLOBK Software.
Marked solutions compared above (Fig. 6).

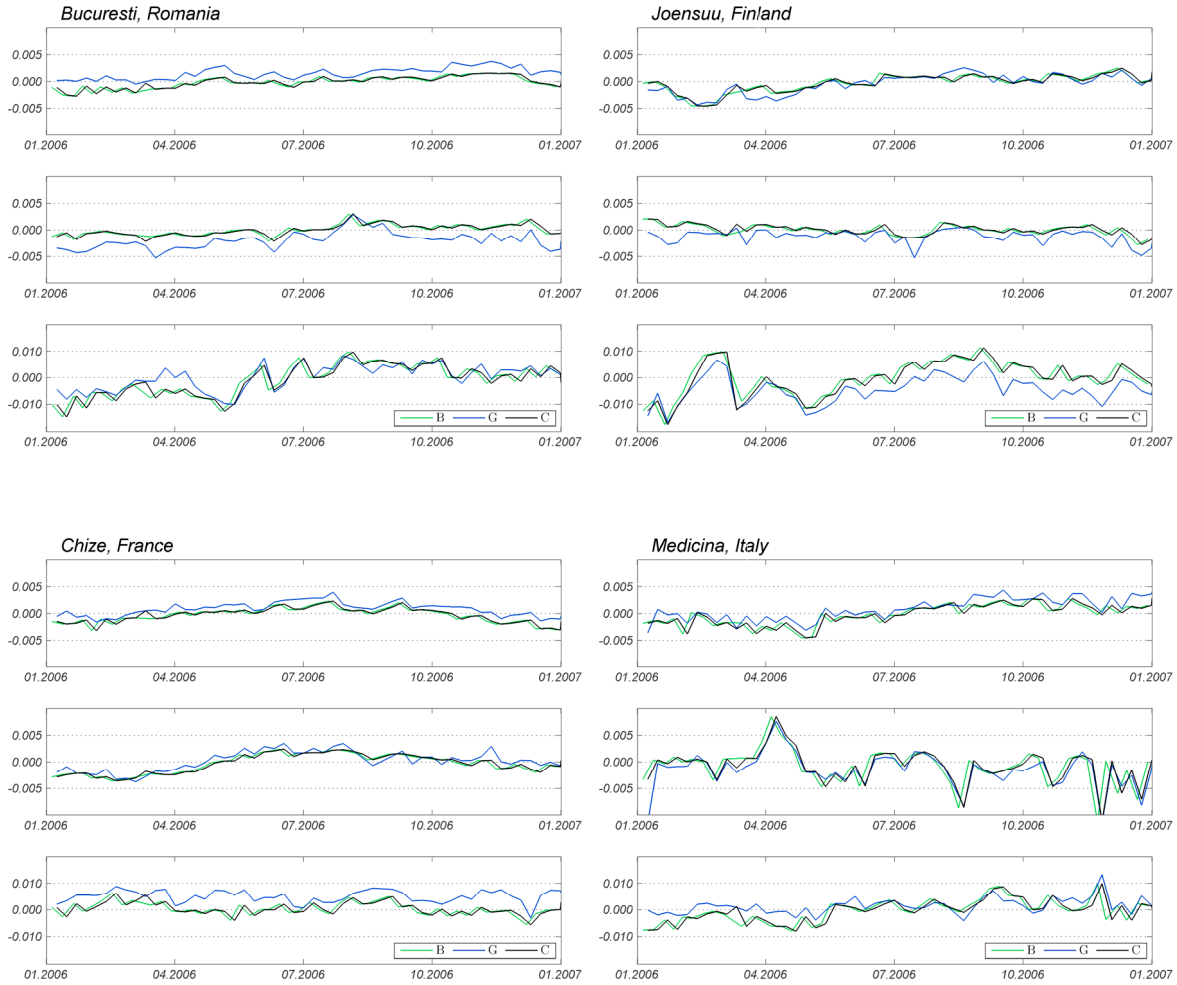

Fig. 6. Comparison of GPS solution from GAMIT (gray), Bernese (light gray), combination (black) processed in GLOBK Software.
From up: North component, East component and Height.

5. RESULTS

Time series coordinates from GAMIT and BERNESE differ only in few millimetres and what is more these changes have a rather aperiodic character (both from GLOBK (Fig.4) and ADDNEQ2 (Fig.6)). This indicates that the results are quite comparable.
Time series from combined method look very similar. BERNESE and COMBINED solution are more coherent than comparing with GAMIT, but it should be remembered that this depends on size of the network and a number of stations chosen for the process (only 30 in GAMIT and over 180 in BERNESE and COMBINED).
Repeatability of stations' coordinates (Fig. 7) proves that all three solutions get similar results and accuracy.

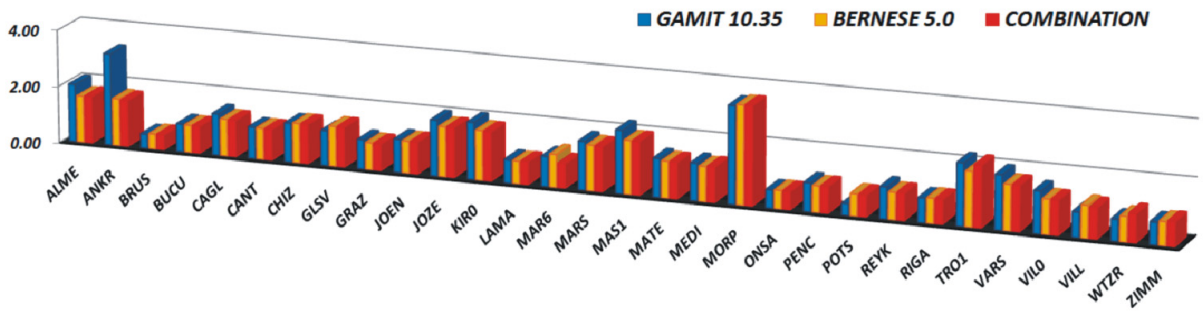

Fig. 7. Repeatability [mm] of weekly solution.

6. CONCLUSIONS

This study showed that the results from GAMIT and BERNESE could be easily compared, without any fear for a discomfort of a headache. It might be a very important in a future EPN Reprocessing, where both software will be used. The time series achieved in a presently used method are correlated between each other. The methods we used fit quite good to basic solutions and they improve and increase the authenticity of the results. All notes and interpretations from this research might improve the upcoming EPN project.

ACKNOWLEDGEMENTS

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