LONG-TERM POSITIONAL MONITORING OF STATION VYHL OF THE SNĚŽNÍK NETWORK

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ABSTRACT

In the article the results of repeated satellite positional measurements of station VYHL of the Sněžník Network over period 1994 – 2006 are presented. Altogether 17 Brno University of Technology measuring campaigns were carried out and evaluated. The observation data (acquired mostly with Leica GPS receivers) were processed with the scientific Bernese GPS Software and the commercial Leica SKI-Pro software packets. Unified procedure for campaign data processing including the alignement of the resulting positions to respective EUREF Permanent Network weekly solutions had been adopted. Only the stability in horizontal direction was analysed.

Positional stability of the VYHL station was considered in respect to the surrounding IGS, EPN, and local stations which were used for a local reference frame definitions, at three different levels. First level information was obtained from relations to surrounding stations of the Sněžník Network in distances up to 10 km, second level represent the relations to nearest EPN stations in distances about 100 km, and finally third level represent the relations to surrounding IGS Network stations in distances about 300 – 400 km. Another approach to VYHL stability assessment was the analysis of slope distances time series from VYHL to neighbouring GPS stations. Outlined are also possibilities of exploitation of the recently completed CZEPOS Network.

KEYWORDS: geodynamics, GPS, stability monitoring

1. INTRODUCTION

Use of GPS for detection of possible displacements of points representing the earth crust has already long tradition, and gives more and more accurate and reliable results. With hardware progress, with improvements in measuring and evaluating procedures, and with better modeling of the disturbing influences the GPS measuring technology becames increasingly effective also in this field, and today it actually outdoes the classical terrestrial measuring technologies which remain effective only for small area deformation surveys. An example is the Czech-Polish geodynamic Sněžník Network.

The experimental local geodynamic Sněžník Network was established in 1992. The network is situated along the Czech - Polish frontier in Králický Sněžník massif - see e.g. (Švábenský and Weigel, 2002). Brno University of Technology (BUT) had organized and co-organized measuring campaigns and processed data of all the campaigns in Czech part of the network since 1994, with help of commercial Leica SKI-Pro and scientific Bernese GPS software.

The central point of the Czech part is the VYHL station, the positional stability monitoring results of which over the period 1994-2007 are reported. Only the BUT campaigns results evaluated with Bernese GPS Software v. 4.2 and Leica SKI-Pro v. 3.0 are presented here. VYHL station horizontal position stability is considered in two ways. Firstly the ETRF89 position evolution in time is evaluated, and secondly the baseline slope distances time series are analysed with aim to detect possible significant movements of the VYHL station.

2. VYHL STATION CHARACTERISTICS

The VYHL station was reconnoitred and monumented in August 1992, along with all the Sněžník Network stations. Its concrete monument is placed at solid rock outcrop on top of the eastern ridge of the Moravia river valley above the Dolní Morava village, at 993 m elevation above sea level - see Figure 1. Its approximate position is 50º 08′ 43″ N latitude and 16º 49′ 27″ E longitude. VYHL station is the central point of Czech part of the Sněžník Network with greatest amount of collected data. It had been used as a reference point in processing of all the BUT campaigns.

In years 1992-1993 the network was completely measured within a packet of Polish grant projects. In years 1996 - 1998 the works within the scope of a Czech research project oriented on problems of the common processing of GPS and terrestrial measurements were carried out, in cooperation of TU Brno and Research Institute of Geodesy, Topography and Cartography Zdiby - Geodetic Observatory Pecný.

Table 1 History and instrumentation of BUT GPS campaigns at VYHL station.

YEAR	DOY	RECEIVERS	ANTENNAS	# OBS
1994	134	LEICA 200	LEISR_299INT	2.5 h
1995	133,134,135	ASHTECH Z12 LEICA 200	ASH700718 LEISR_299INT	8.2 h
1996	137,139,140	ASHTECH Z12 LEICA 300	ASH700718 LEISR_299INT	7.5 h
1996	255,256,257	GEOTRACER LEICA 300	TRM14532.00 LEISR_399INT	27.0 h
1997	125,131-132,134-135,138	LEICA 200	LEISR_299INT	64.6 h
1997	265-266,267,268	LEICA 200	LEISR_299INT	50.8 h
1998	129-132,136,137	LEICA 300	LEISR_399INT	83.0 h
1999	139,140, 142-143	LEICA 200 LEICA 300	LEISR_299INT LEISR_399INT	38.6 h
2000	128,129.134-135	LEICA 300	LEISR_399INT	48.5 h
2001	126,127,132-133	LEICA 300	LEISR_399INT	48.7 h
2002	129-130,132-133,138-139	LEICA 200	LEISR_299INT	73.6 h
2003	134,135,136,137-138	LEICA SR520	LEIAT502	71.0 h
2004	132-133,136-137	TRIMBLE 5700 LEICA SR520	TRM41249.00 LEIAT502	58.3 h
2005	132-133,136-137,141-142	LEICA SR520	LEIAT502 LEIAT504	75.8 h
2006	127-128,133-134	LEICA SR520	LEIAT504	48.8 h

Fig. 1 VYHL station.

In 1997 the VYHL station was included in Czech Geodynamic Network (GEODYN). Since 1997 the VYHL has been also included in the EAST SUDETEN Network established and measured by IRSM CAS Prague (Schenk et al., 1999).

3. CAMPAIGN DATA AND PROCESSING

As far as the request for at least 12 hours sessions for geodynamical purposes (Hefty, 2004) could not be met for early campaigns (1994-1996) for various reasons, it is not possible to rely on sufficient accuracy of these campaigns.

Since 1997 the observations at VYHL station were never under 24 hours, and in many cases reached times over 48 hours. It can be assumed that the coordinate and baseline time series for period 1997-2006 are representative for investovations of VYHL station positional stability. For complete information about the BUT campaigns and the instrumentation used see Table 1.

Main parameters for the Bernese data processing were: 13 degrees elevation cut-off angle, QIF ambiguity resolution strategy, estimated troposphere delay parameters for every 2 hours, and iono-free frequency combination used for final coordinate estimation. SKI-Pro solution used iono-model computed from reference station data, and standard Saastamoinen troposphere model.

Some problems were caused by necessity to process data collected with various GPS receivers/antennas. As far as the SKI-Pro software enables introduction of individual antenna phase centre corrections, in the both Bernese and SKI-Pro processing the same values stemming from BUT individual relative calibrations of all the Leica antennas used were introduced, and for other antennas the official values used in EPN processing were employed.

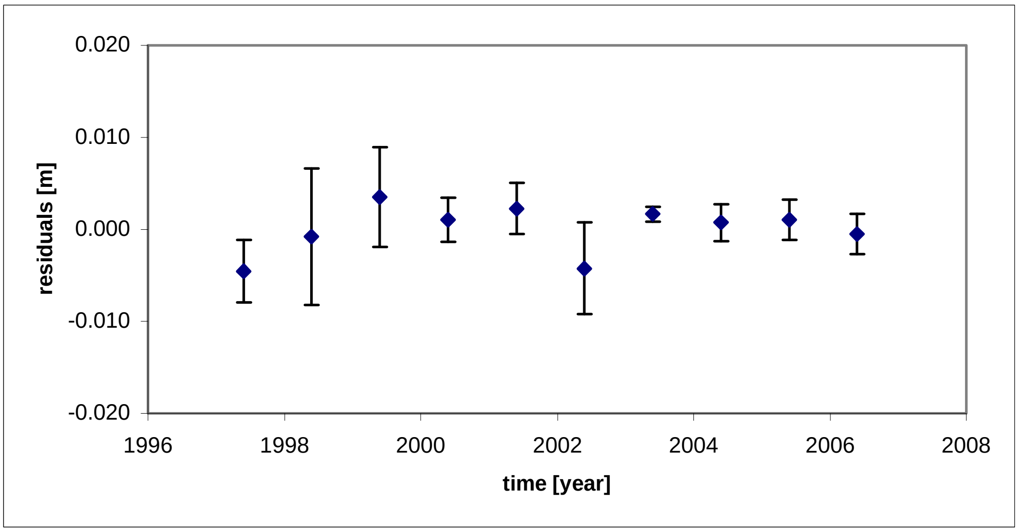

Fig. 2 VYHL - B component (2 sigma error bars).

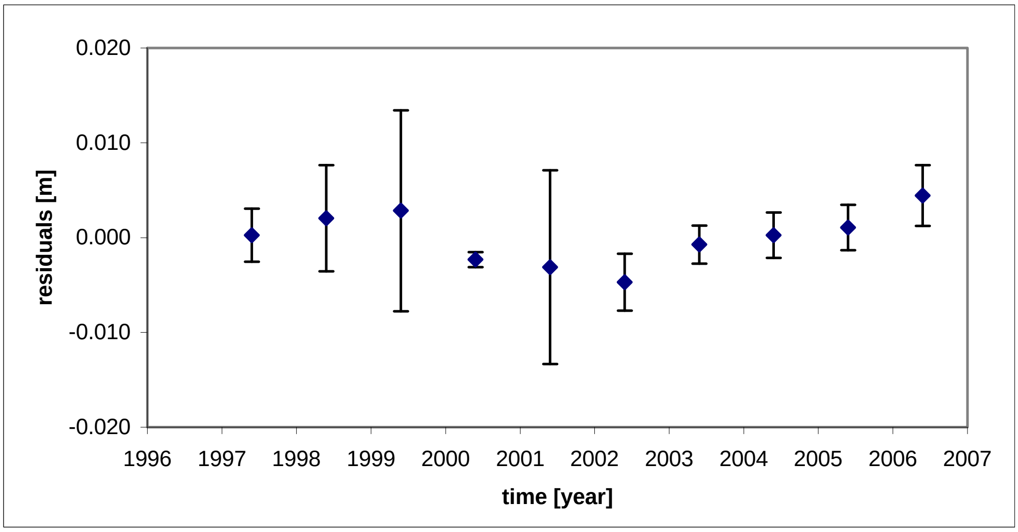

Fig. 3 VYHL - L component (2 sigma error bars).

4. EVALUATION OF VYHL STATION HORIZONTAL STABILITY

The VYHL station horizontal stability was considered in two ways. Firstly the ETRS89 positions of VYHL in each campaign were evaluated, and secondly the baseline slope distances time series were analysed.

ETRS89 coordinates were computed from respective ITRF positions using the procedure described in (Boucher and Altamimi, 2007), in two variants. In first variant the reference stations in distances about 100 km (GOPE, WROC, TUBO) were used, and in second variant the reference stations in distances about 300 - 400 km (BOR1, GRAZ, WTZR) were used. The reference stations coordinates were fixed (heavily constrained) on values of respective EPN weekly solutions.

In Figurek 2 and 3 the time series of VYHL ETRS 89 coordinate components B, L with 2 sigma (95% confidence) error bars are shown. The coordinate residuals were computed in respect to IGS stations BOR1, GRAZ, WTZR. It is clear that no significant shift in horizontal direction is detected on given confidence level. Differences in error bar sizes are caused by different amounts of data in single campaigns, by differences in instrumentation and by different atmospheric conditions prevailing in particular campaigns.

Figure 4a shows the 2D horizontal ETRF89 position evolution of the VYHL station in relation to EPN stations in distances about 100 km (GOPE, WROC, TUBO), and Fig. 4b shows the similar evolution relative to the surrounding IGS Network stations in distances about 300 – 400 km (BOR1, GRAZ, WTZR). In both the figures the ETRF89 coordinates computed with Bernese software together with 2 sigma error bars are displayed. No significant systematic shifts are apparent from the graphs, the

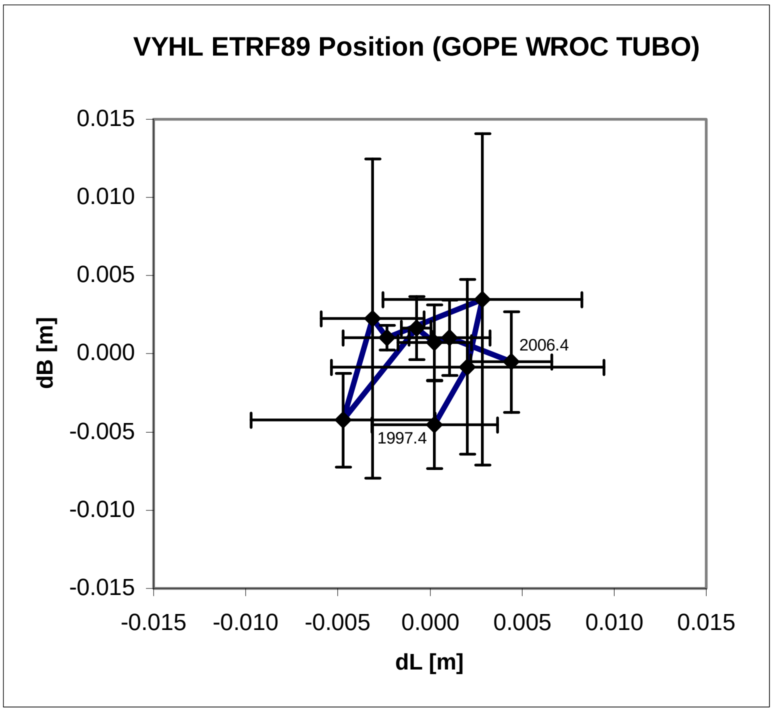

Fig. 4a VYHL – ETRF89 position evolution (2 sigma error bars).

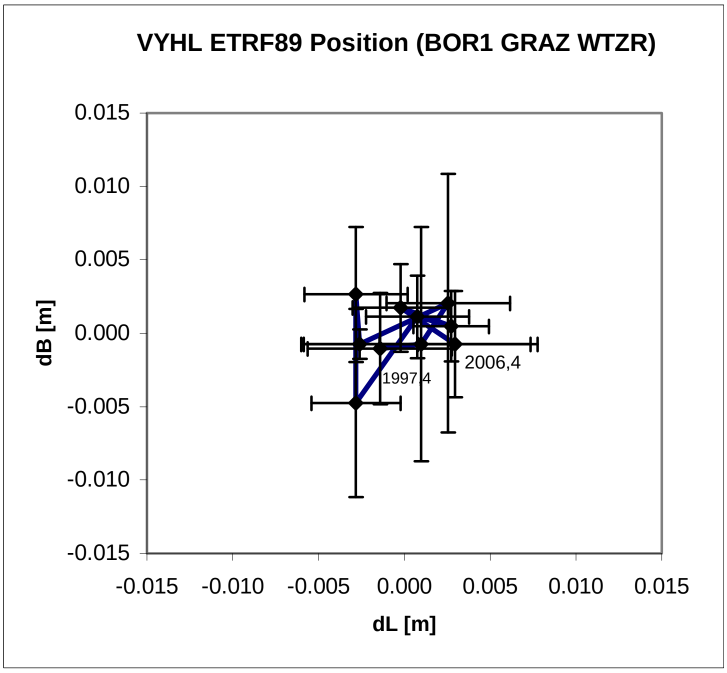

Fig. 4b VYHL - ETRF89 position evolution (2 sigma error bars).

computed positions in both cases oscillate in 1 cm interval for each component over all the data period. Positional dispersion in both cases is comparable. The confidence regions are somewhat smaller for the second case.

Figure 5 illustrates the comparison of Bernese and SKI-Pro VYHL ETRF89 L-component residuals time series evaluated in relation to IGS stations BOR1, GRAZ, WTZR. It can be seen from the example that the Bernese results have somewhat better consistence, but the differences Bernese – SKI-Pro are within several millimeters for baselines up to 300-400 km.

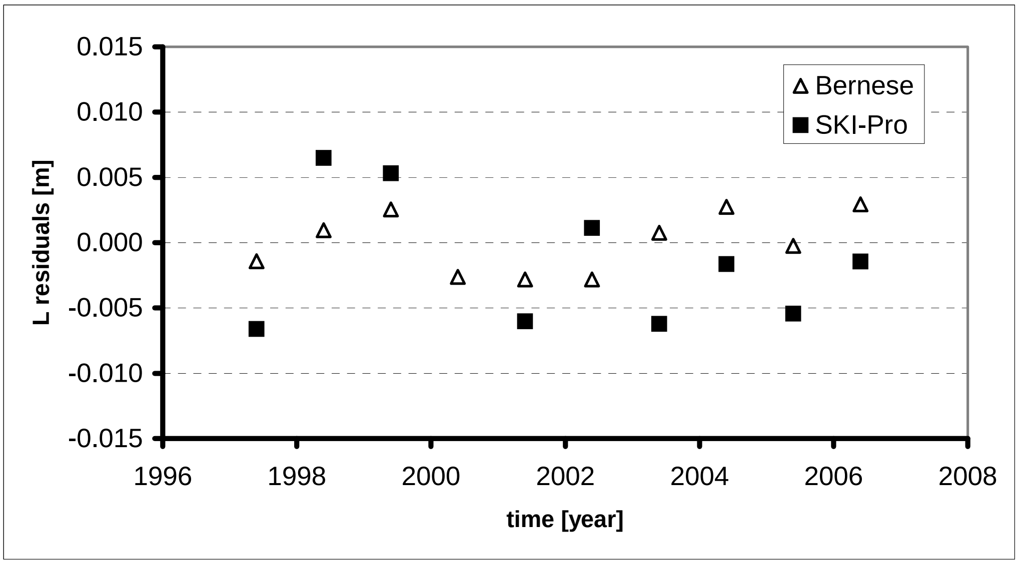

Fig. 5 VYHL L component residuals - Bernese and SKI-Pro solutions.

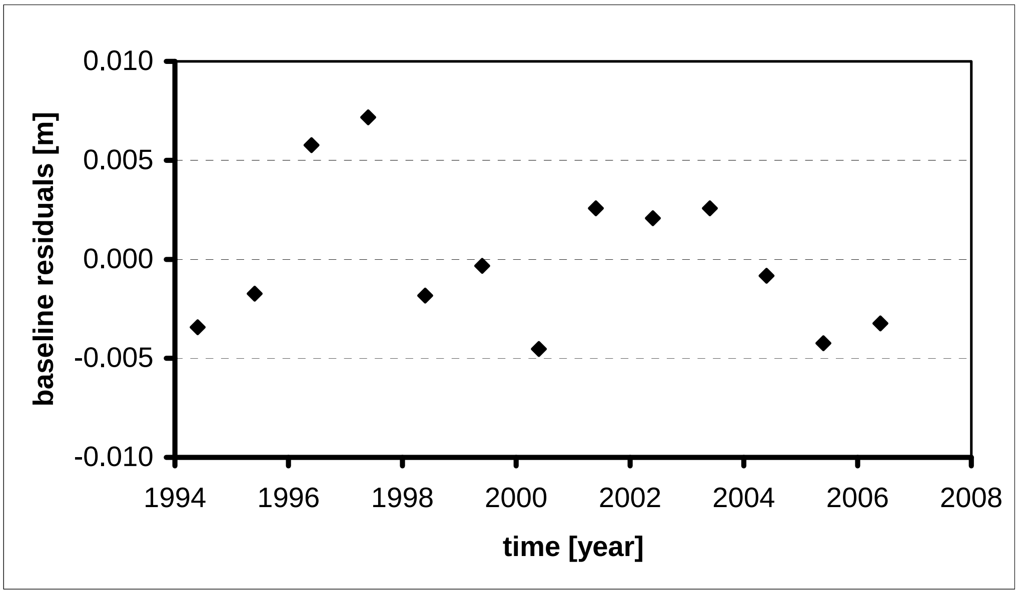

Fig. 6 Baseline VYHL - VLAS time series.

For the second way the evaluation of the baseline slope distances time series from VYHL to each station used were analysed. In first step the baselines within local Sněžník Network were assessed. The example of VYHL – VLAS baseline is shown in Figure 6. All the baselines were processed with SKI-Pro software here, as far as the baseline lengths did not exceed 15 km, and differences between Bernese and SKI-Pro results were negligible.

In next step the baselines from VYHL to surrounding permanent GPS stations were evaluated. In Figure 7 the graph illustrating the example of VYHL – GOPE baseline slope distance time evolution is displayed. It again does not indicate any significant trend within 2 sigma confidence regions, comparable to the previous step. Other baselines behave in similar way.

On ground of the baseline time series from VYHL to 6 surrounding permanent GPS stations the baseline accuracy dependence upon the baseline length was evaluated. Included is also the analysis after exclusion of time series residual trends.

The graph in Figure 8 displays the standard deviations for diferent baseline lengths from 100 km up to 360 km. It shows that the average standard deviation for 100 km baseline length were about 2.5 mm, with 0.1 mm/100 km increment.

5. CONCLUSIONS

Positional stability of the VYHL station of the Sněžník Network was considered in two ways – from ETRF89 coordinates time series analysis, and from baseline slope distances time series analysis with respect to surrounding GPS stations. In each way the

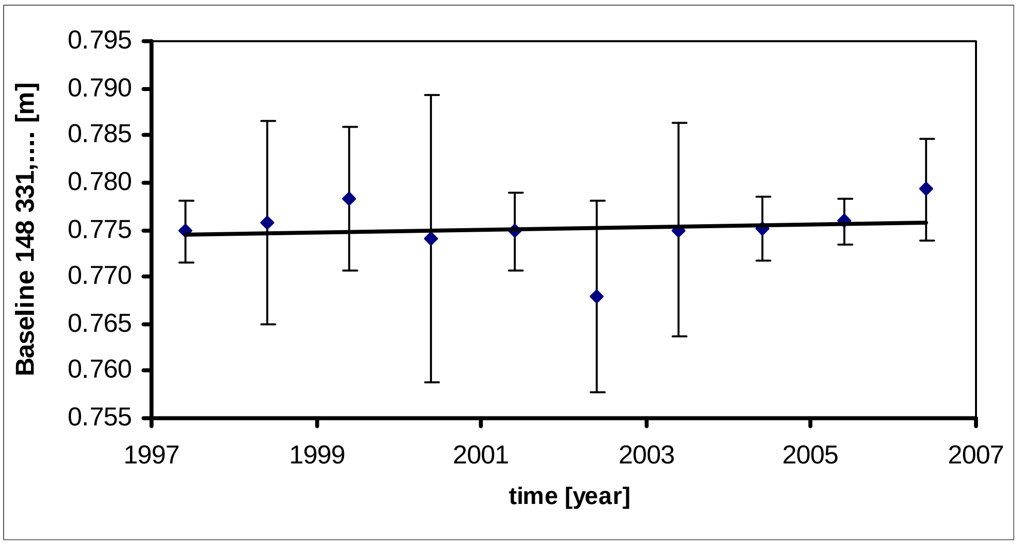

Fig. 7 Baseline VYHL-GOPE time series (2 sigma error bars).

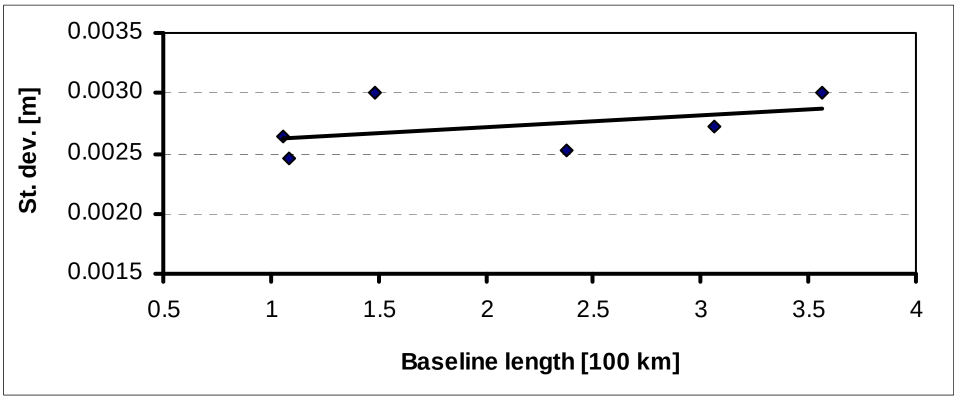

Fig. 8 Average baseline standard deviations.

analysis had been conducted on three levels of reference frames concerning the stations used– local, EPN, and IGS. For the analyses only the GPS observation data collected mostly with Leica receivers within BUT Brno campaigns over time span of 13 years had been used.

Athough the particular campaigns differed in data amount and instrumentation, the resulting time series indicate no significant movement of VYHL station in horizontal direction (at 95% confidence level). Differences between Bernese and SKI-Pro processing results were on millimetre level for baselines up to 400 km, which corresponds well with (Fotiou et al., 2006). ITRS velocity estimates for VYHL (v_N = 0,0138 m/y, v_E = 0,0198 m/y) agree very well with velocities of surrounding IGS and EPN stations.

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