Could recent GNSS data provide an evidence of tectonic processes within the TT zone?

Jan Cisak, Hassan Walyeldeen, Łukasz Żak
Institute of Geodesy and Cartography, Warsaw, Poland.
27 Modzelewskiego St., 02-679 Warsaw, Poland.
e-mail: jan.cisak@igik.edu.pl.

Abstract. Poland is situated on a stable Eurasian plate. The geology of the plate is not uniform. Precambrian and Paleozoic platforms are major geological structures at the territory of Poland. They are separated by the Teyseire-Tornquist zone that crosses Poland from North-West to South-East. The location of the IGiK Geodetic-Geophysical Borowa Gora Observator and the WUT Astrogeodetic Jozefoslaw Observatory with respect to the TT zone makes possible to determine eventual tectonic displacements in the region with the use of precise geodetic measurements. The time series of data from GNSS permanent stations BOGO and JOZE of both Observatories are used to check if the recent GNSS data provide an evidence of relative movement of the stations investigated.

The paper presents the results of the analysis of time series of the components of the vectors between the GNSS permanent stations of both observatories.

Keywords. BOGO-JOZE vector; GNSS; Teyseire-Tornquist zone; tectonic motion.

1 Introduction

Estimation of the tectonic motion between the Precambrian Platform of Eastern Europe and the Paleozoic Platform of Central and Western Europe is considered as one of the major tectonic problems in Europe (Grad et al., 2000). The Teyseire-Tornquist zone has crossed diagonally Poland from North-West to South-East (Fig. 1). Two permanent GNSS stations BOGO and JOZE were installed in the vicinity of T-T zone by Institute of Geodesy and Cartography (IGiK) at Borowa Gora Geodetic-Geophysical Observatory and Warsaw University of Technology (WUT) at Astrogeodetic Jozefoslaw Observatory respectively. Both stations are associated with the European Permanent GNSS Network (EPN) since 1997 – almost the beginning of the GPS era in Poland. Moreover, JOZE station also operates within the International GNSS Service (IGS). Table.1 summarize the characteristics of those stations (Krynski, 2011).

The main aim of this study is to investigate the tectonic motion of the area of Teyseire-Tornquist zone using the GNSS data provided by BOGO and JOZE stations.

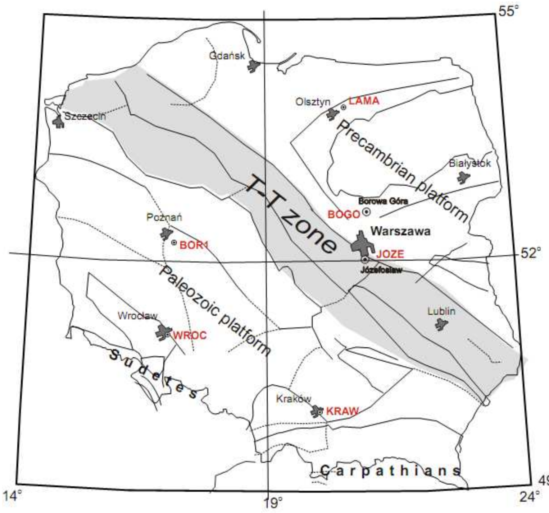

Fig. 1. The geological structure of Poland and the location of the main EPN stations

2 Data processing

Data from two eleven day intervals: 150 to 160 DOY and 250 to 260 DOY of each year from 1997 to 2010 were chosen for the processing of the BOGO-JOZE vector. Observation data for both stations with 30 sec interval as well as IGS precise ephemeris have been downloaded from BKG server. The Bernese and Pinnacle softwares were used for the data processing. Additionally, time series of the components of the BOGO-JOZE vector was calculated using published ITRF05 co-ordinates and velocities of both stations.

Table 1. Characteristics of BOGO and JOZE stations

4 char Station ID	Domes Number	Approx Latitude	Approx Longitude	Receiver	Antenna
BOGO	12207M003	52° 28' 33"	21° 02' 07"	Javad TRE_G3T DELTA	ASH701945C_M SNOW
JOZE	12204M001	52° 05' 50"	21 ° 01' 54"	TRIMBLE 4000SSI	TRM14532.00 NONE

2.1 Processing using Bernese software

An optimal processing strategy applying precise ephemeris and earth rotation parameters provided by IGS was used to process the data with the Bernese GPS software v.5.0 which is comprehensive GNSS software for the scientific purposes. Data processing started with preparing a priori coordinates for each day using the ITRF05 coordinates and velocities. The pre-processing consists of five major steps (Walyeldeen, 2009):

1. Convertion of the RINEX files to the Bernese format files.
2. Clock synchronization using the code data.
3. Creation of BOGO-JOZE baselines using single-difference observations file.
4. Detection the cycle slips using triple-differences.
5. Detection of the outliers and removing them from the observation files.

The post processing was performed at double-difference processing level. The Dry Niell and Wet Niell map function for the dry and the wet part, respectively, were implemented to eliminate the tropospheric effects (Dach et al., 2007). The phase ambiguities have been resolved using the Quasi-Ionosphere Free (QIF) ambiguity strategy with the Global Ionosphere Models provided by IGS and Centre for Orbit Determination in Europe (CODE). The percentage of the fixed ambiguities was within the range of 70-80%. Finally, the BOGO-JOZE baseline was adjusted considering coordinate of BOGO station as fixed in the ITRF05. Figure 6 shows the component of the BOGO-JOZE vector obtained from each daily session. The X component seems stable; its changes do not extend 1 cm while in case of Y and Z components their changes are slightly bigger – about 4 cm. The calculated RMS does not extend 4 mm. It reflects the variations of daily solutions with respect to the mean of each eleven-day solution. It indicates the internal precision of the daily solution (Sjöberg et al., 2004). Figure 7 presents the RMS in X, Y, Z geocentric coordinates.

2.2 Processing using Pinnacle software

The Pinnacle software is a commercial software, which offers a possibility to introduce users own models, type of solution and precise ephemeris. For calculating the BOGO-JOZE vector of length about 40 km the wide-lane combination of L1-L2 without elimination of atmosphere effects was used. The 10° elevation mask angle has been applied. The precise ephemerides provided by IGS were used. The processing was preceded by the determination of a priori coordinates for each day using the ITRF05 coordinates and velocities. The components of the BOGO-JOZE vector were calculated from each session (Fig. 4). The trend of change in Figure 4 does not provide any evidence of relative movement of the BOGO-JOZE vector. Figure 5 shows the calculated RMS in X, Y, Z geocentric coordinates which reflect the variations of daily solutions with respect to the mean of each eleven-day solutions. They show large noise in the estimated vector coordinates (at cm level) and that is not acceptable for this study.

3 Result and analysis

The estimated variations of coordinates of the BOGO-JOZE vector using Bernese and Pinnacle softwares as well as the results of reprocessing the EPN provided by the Military University of Technology (MUT) are presented in Figure 6. The estimated temporal velocities using the mentioned four approaches are listed in Table 2. Furthermore, the length of the BOGO-JOZE vector has been calculated using four different approaches (Bernese, Pinnacle, MUT and ITRF05) as in Figure 7.

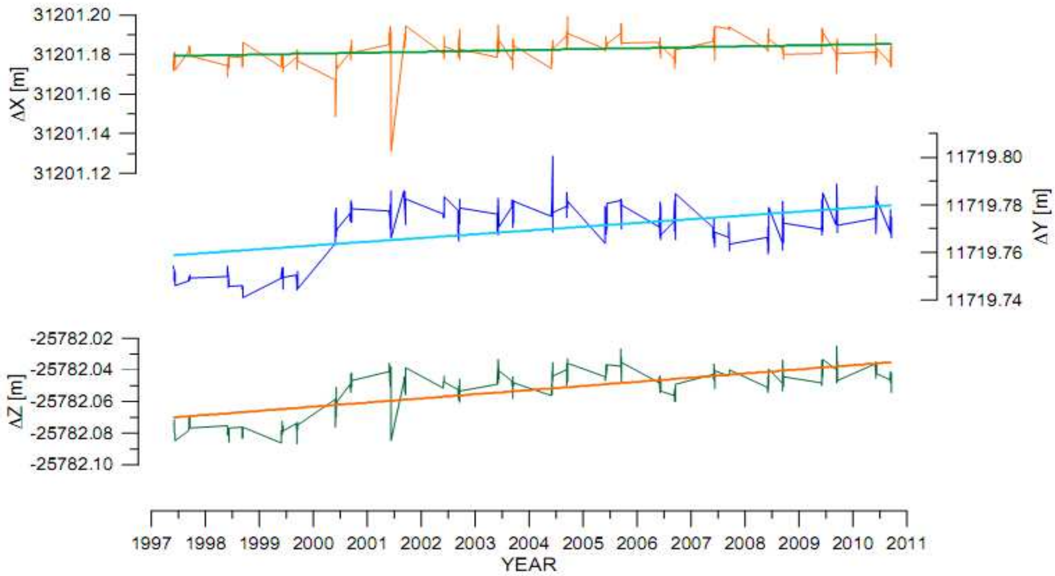

Fig. 2. Temporal changes of the BOGO-JOZE vector obtained using the Bernese software (daily solutions)

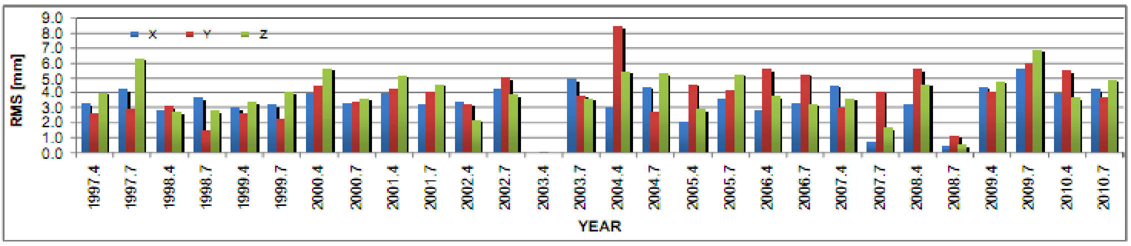

Fig. 3. RMS of components of the BOGO-JOZE vector obtained with the Bernese software

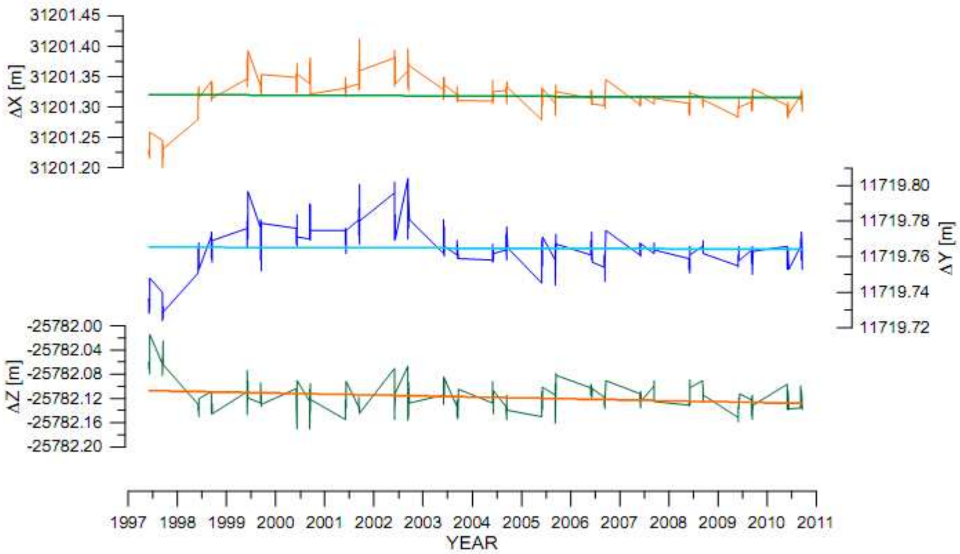

Fig. 4. Temporal changes of the BOGO-JOZE vector obtained using the Pinnacle software (daily solutions)

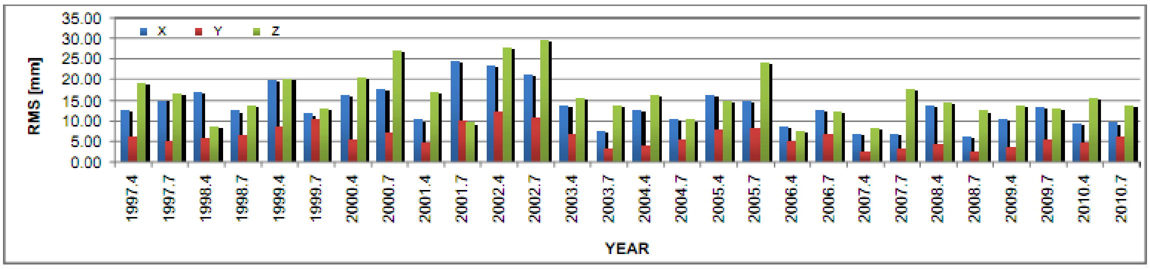

Fig. 5. RMS of components of the BOGO-JOZE vector obtained using the Pinnacle solutions

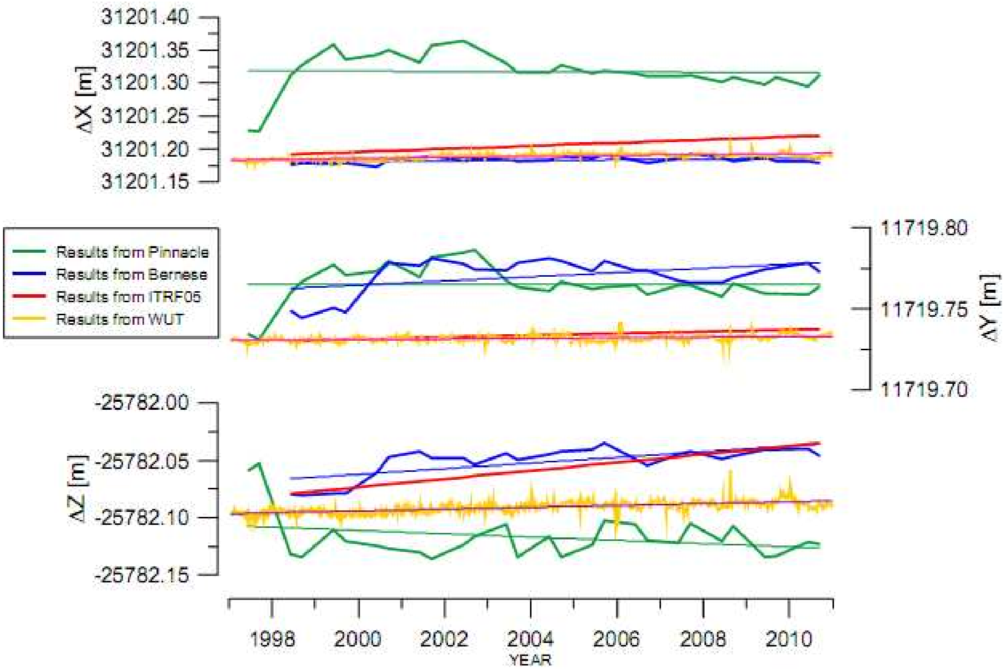

Fig. 6. Time series of coordinate's difference of the BOGO-JOZE vector obtained using four different approaches

(green: Pinnacle, blue: Bernese, red: ITRF05, and yellow: MUT solution)

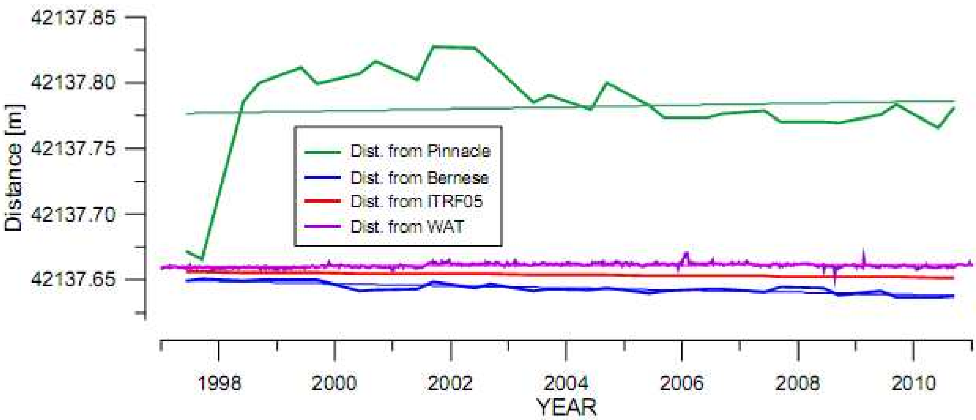

Fig. 7. Time series of the length of the BOGO-JOZE vector obtained using four different approaches

(green: Pinnacle, blue: Bernese, red: ITRF05 and magenta: MUT solution)

Table 2. The velocities of the BOGO-JOZE vector coordinates generated by four different approaches

solution	V_x [mm]	V_y [mm]	V_z [mm]
Pinnacle	-0.2±1	0.0±0.2	-1.4±0.4
Bernese	0.4±0.02	1.3±0.09	2.5±0.1
ITRF05	2.3	0.6	3.6
WUT	0.8±0.1	0.2±0.1	0.8±0.05

4 Conclusions

High-precision GPS data of DOY 150-160 and 250-260 of each year from 1997 to 2010 of the BOGO-JOZE baseline were processed in order to investigate the T-T zone tectonic activity. From the obtained results the following conclusions can be drawn:

- The investigation performed on the time series of the BOGO-JOZE vector components does not provide the evidence of tectonic processes within the TT zone.
- Large noise affected the solutions obtained with commercial software makes them of a little use for studying geodynamic phenomena in the areas of stable geological structure.
- Taking into consideration present accuracy of GNSS data, the detection of such phenomena using the solutions obtained with the Bernese software requires longer time span of data; in addition it requires data provided by other observation techniques.

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