

## ANALYSIS OF STABILITY OF PERMANENT GPS STATIONS KRAW, KATO AND ZYWI

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## ABSTRACT

GPS permanent stations KRAW, KATO and ZYWI are part of so called Active Geodetic Network which covers entire area of Upper Silesian Coal Basin (USCB) in Poland and forms precise reference frame for geodetic and geodynamic applications. Moreover the above mentioned stations belong to EUREF Permanent Network. The stations, as datum points, play important role in precise positioning and geoid determination in area of USCB. The study of the stability of these points is one of the main components in precise monitoring of ground deformation in mining areas. The analysis of stability of permanent GPS stations KRAW, KATO and ZYWI are based on the coordinate time series obtained from the EUREF weekly solutions. The relative coordinate time series of weekly solutions for the vectors KRAW - KATO, KRAW - ZYWI, KATO - ZYWI are presented. The consistency, linearity, seasonal variations and jumps in the relative coordinate time series are discussed.

**KEYWORDS:** time series analysis, GPS permanent stations, relative site velocities

## COORDINATES STABILITY ANALYSIS

Analysis of stability of permanent stations KRAW KATO and ZYWI are based on time series obtained from weekly "combined" solutions. Weekly subnet solutions of the KRAW and ZYWI stations are generated at 4 Local Analysis Centres (GOP, OLG, SUT, WUT), and solutions of the station KATO are generated at 3 LAC (GOP, OLG, WUT). Given coordinates in the ITRF2000 frame at the epoch of observation has been converted to the ETRF89 by applying transformations formula published by (Boucher and Altamimi, 2001). Analysed data are from 1203 to 1349 GPS Week for station KRAW and from 1231 to 1349 for KATO and ZYWI stations. Coordinate time series (dN, dE, dU) plotted respect to the mean  $\phi$ ,  $\lambda$ ,  $h$  coordinates of each station are shown in Fig. 1. At this figure, the KRAW station north component periodical variations are clearly visible. Fig. 2 shows the station KRAW coordinates in the north-east plane with the building where station is located in the background. Direction of the coordinates variations is in good agreement with the long axis of the building, and we suppose that the variations may be caused due to building seasonal displacement. In the further analysis in this paper the seasonal variations has been eliminated from the north component.

Time-frequency analysis of the north component shows that the signal consist of two main components of periods  $T_1 = 52.65$  GPS weeks and  $T_2 = 25.49$  weeks and amplitudes  $A_1 = 2.9$  mm and  $A_2 = 0.9$  mm respectively. It can be seen that this component may

be considered as constant in the whole analysed period (Fig. 3). North component variations has been modelled and then eliminated using function describing two signals with common period  $T$ , shifted in phase by  $\theta$ , with component amplitudes  $A$  and  $\alpha A$ , and constant offset  $B$ :

$$\varphi = B + A \sqrt{1 + 2\alpha \cos\left(\frac{2\pi}{T}t + \theta\right) + \alpha^2}$$

Function in this form better then the sum of two sinusoidal components approximate  $\varphi$  data from KRAW station. The other functions modelling periodical variations of this station are presented in (Hefty et. al., 2005). Time series of north component of KRAW station after seasonal variations removal are presented in Fig. 4. Next the relative  $d\phi$ ,  $d\lambda$ ,  $dh$  coordinates variations for KATO-KRAW, KATO-ZYWI and ZYWI-KRAW vectors are calculated. Based on vectors coordinates the relative yearly velocities are calculated assuming linear drift (Table 1). Comparing this results with the relative velocities calculated from site velocities published by EUREF (Table 2) some differences of 1 mm/yr can be seen.

## CONCLUSIONS

GPS permanent stations KRAW, KATO and ZYWI relative movement analysis are based on almost 3 years of observational data. Preliminary results shows relative velocity of 5 mm/year in the north component of KATO-KRAW and KATO-

**Table 1** Relative velocities of KRAW, KATO and ZYWI.

	$d\phi$ [mm/yr]	$d\lambda$ [mm/yr]	$dh$ [mm/yr]
KATO-KRAW	4.44	-1.33	2.02
KATO-ZYWI	4.97	-1.29	1.09
ZYWI-KRAW	-0.55	0.00	1.00

**Table 2** Relative velocities of KRAW, KATO and ZYWI stations obtained from site velocities published by EUREF.

	$d\phi$ [mm/yr]	$d\lambda$ [mm/yr]	$dh$ [mm/yr]
KATO-KRAW	5.42	-1.54	1.93
KATO-ZYWI	5.39	-1.53	0.21
ZYWI-KRAW	0.03	-0.01	1.72

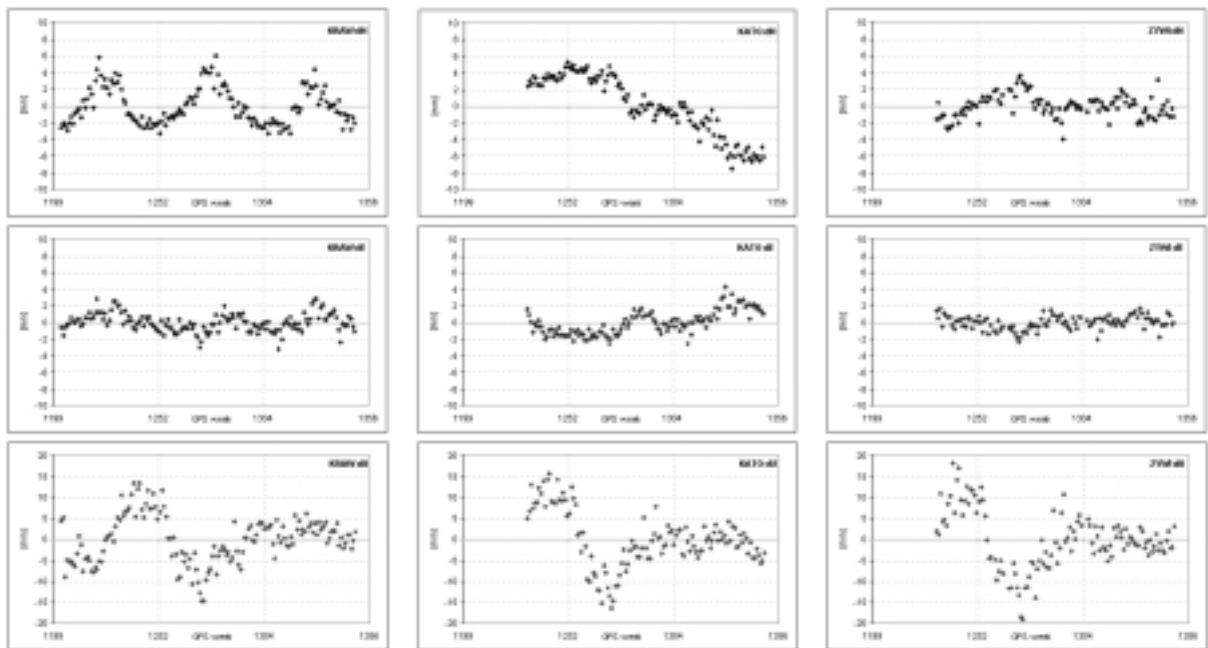
ZYWI vectors. More reliable result may be obtained after analysis of longer data period. It is noteworthy that station GANP is located on Slovak Tatra side. We assume that the study of behaviour of vector KRAW - GANP may be interesting in geodynamical aspect.

#### ACKNOWLEDGEMENT

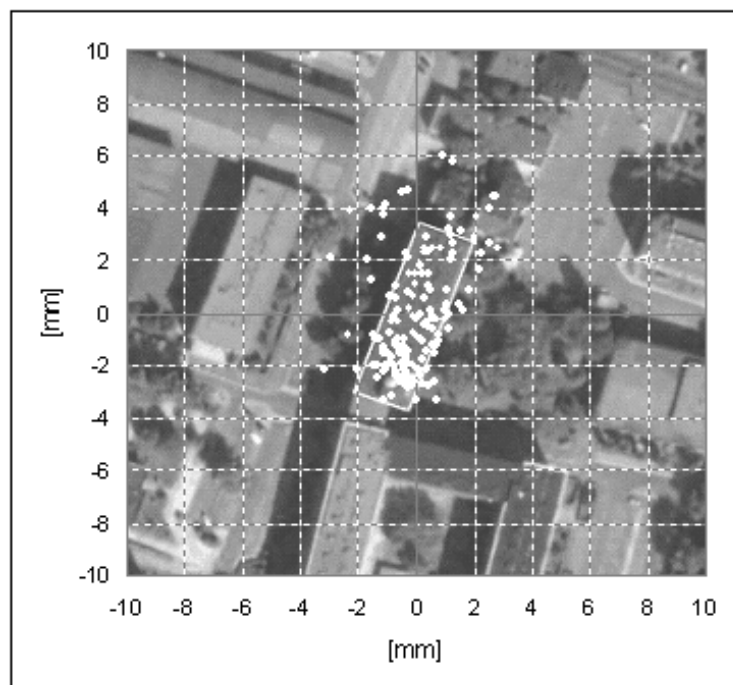
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**Fig. 1** Time series of  $\phi$ ,  $\lambda$ ,  $h$  coordinates (dN, dE, dU) of KRAW, KATO and ZYWI stations.



**Fig. 2** Scatter plot of north-east components of KRAW station.

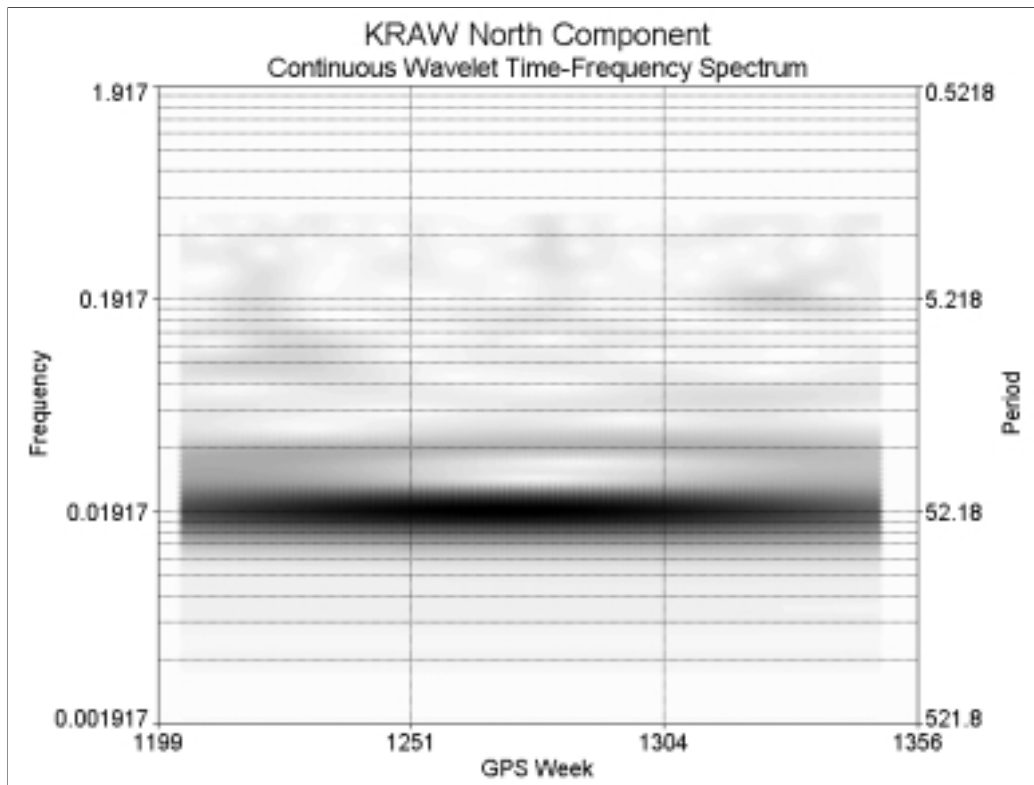


Fig. 3 Time-frequency spectrum of KRAW north component.

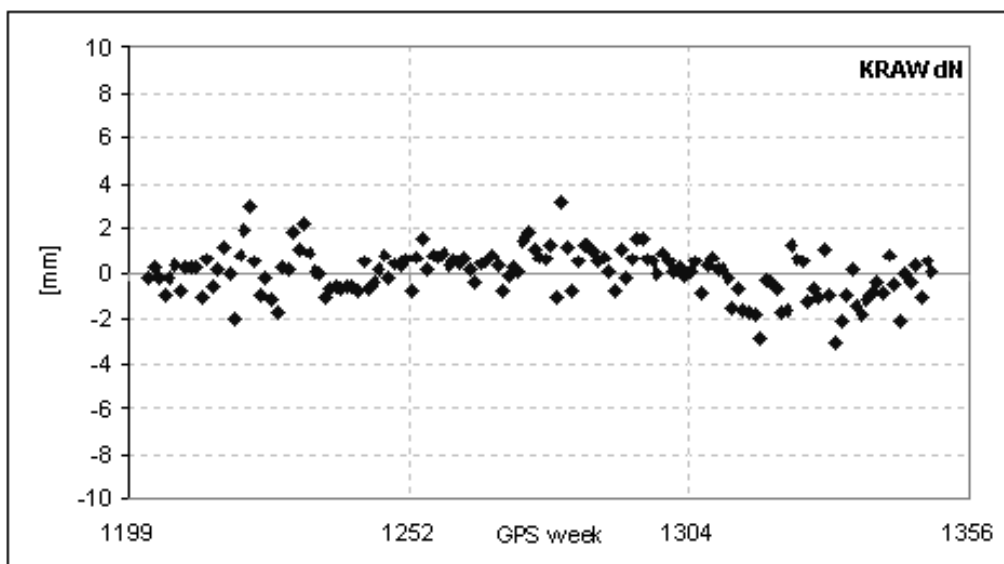


Fig. 4 Time series of KRAW station north component after seasonal variations removal.