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SK*POS* permanent stations stability monitoring

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Abstract

Tracking of the SK*POS* permanent station stability as one of the service quality characteristic was set up on the national service center on Geodetic and cartographic institute (GKU) Bratislava in 2008 year. Usage of scientific software and reliable procedure assures the quality of the outputs in comparison with usually used monitoring modules from commercial control software. This year (2010) when the SK*POS* service celebrates his fourth and of course successful anniversary, it is right time to perform better and more reliable characterization of the permanent stations especially from the stability point of view. In the article there are the new developments and experiences from four year long observation time interval presented and evaluated. Also if it is considered, that permanent station antenna behavior represents the behavior of the land where the station is placed, the result can characterized site tectonics and can help us to understand the local geodynamics better.

Introduction

All GNSS real-time service providers need to know as much information about the quality of the whole service (operation, outputs, products, etc.) as it is possible especially for satisfying themselves as well as their users and which can let them to say that their service is reliable and accurate. One of the major systematic error sources, which have direct influence on quality of all outputs, is knowledge about the permanent stations coordinates and theirs stability in time. This is why the information about the real stations behavior over the time is one of the most important interests of service providers.

That kind of interest about permanent station stability (quality), have also kept in mind SK*POS* operators (GKU Bratislava) from the beginning of the service. Thus, as a result of service improvements activity in 2008 (two years after the service starts), the precise tracking of the SK*POS* permanent station stability was set up. Till that time, only commercial control software module was used for SK*POS* permanent station stability monitoring. For the new precise monitoring of the stations behavior was used coordinate time series analysis as the best tool for describing theirs characters. Stations coordinates were computed by scientific Bernese GPS software v.5.0 (Dach et al., 2007). The processing continued with coordinate composition to time series for each station, which later underwent to the analysis using MathCAD14 mathematic software. All the procedure you can find described in (Droščák, 2008). Result of this endeavor was precise characterization of the permanent stations behavior and theirs classification according to their stability to stabile stations, stations with trend or with periodic variation. A small disadvantage of the result was, that coordinates from only two years observation interval were monitored (stations did not have more observations) which means that some of the station long period characteristics could be let undetected, or estimated values could be biased, especially on stations where were performed hardware upgrade or exchange.

This year, when the SK*POS* service is celebrating its fourth anniversary, we have decided to perform the new insight on stations stability and to perform better evaluation of station characteristics like it was done in past (2008). Especially the new approach of coordinates referencing introduction and the observed data from 4 years long time interval force us to await more realistic outputs of stations behavior characteristics. This can help us to better determinate and evaluate the stability of all stations in detail.

Basic information about SK*POS*

SK*POS* as a Slovakian GNSS real-time positioning service enables to its users determinate theirs position or determinate position of objects or phenomenon of their interests in real-time or in post processing mode on difference quality levels from sub meters to millimeters in ETRS89 reference system. The network infrastructure consists of 26 GNSS permanent stations equipped with Trimble NetR5 or NetR8 receivers and Zephyr Geodetic Model 2 antennas. The stations are equally distributed around whole Slovak republic (see fig. 1). SK*POS* is an integral part of EUPOS and follows all its standards and documents (*EUPOS* ISC, 2009).

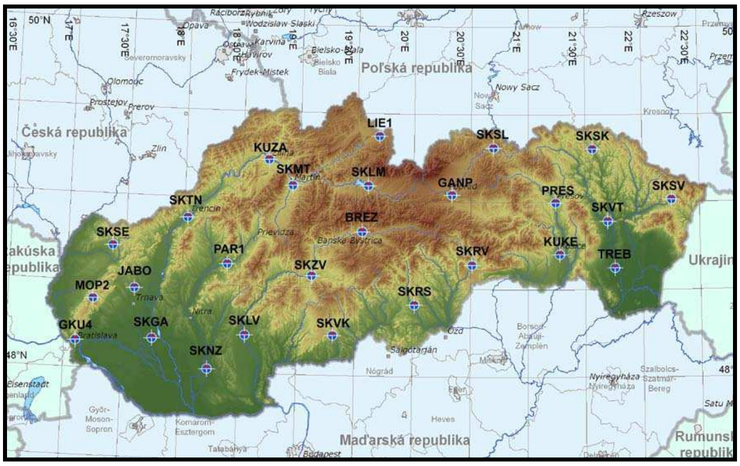


Fig. 1 SK*POS* network (status November 2010).

Two kinds of monuments are used for the SK*POS* stations, monuments on roofs of the buildings (fig. 2a) or monuments as deep drilled pillars (fig. 2b). The brass module with thread and aluminum rod is used for assured the force centering antenna stabilization to the both kind of monuments.

a) Roof of the building b) Pillar

Fig. 2 Examples of SK*POS* station monuments.

SK*POS* control software is situated on National service center on GKU in Bratislava. For running the service Trimble GPS net software + additional Trimble modules are used. Right now, switch to the new Trimble VRS3Net software is preparing.

Monitoring of the SK*POS* permanent station stability on GKU

GKU Bratislava as SK*POS* operator performs two kinds of permanent station stability monitoring:

a.) Approximate monitoring with commercial control software,
b.) Precise monitoring with scientific software.

Approximate monitoring is performed on routine basis by Trimble Coordinate monitor module as a part of service control software. Module uses real time data and broadcast ephemeris. Adjustment is based on Kalman filter principle as free network solution referenced to one selected point. Disadvantage of this module is its lower precision, results relativity to selected reference point and no information about this reference point. Outputs (differences) from the module are represented by some graphics on the map or as a time series residuals concerning to reference station coordinates (fig. 3).

For precise station stability monitoring is used also on routine basis scientific Bernese GPS software version 5.0 (BSW50) and mathematic software MathCAD14, where the BSW50 serves for all GNSS observation data processing and referencing and MathCAD14 software for coordinate time series creation and analysis.

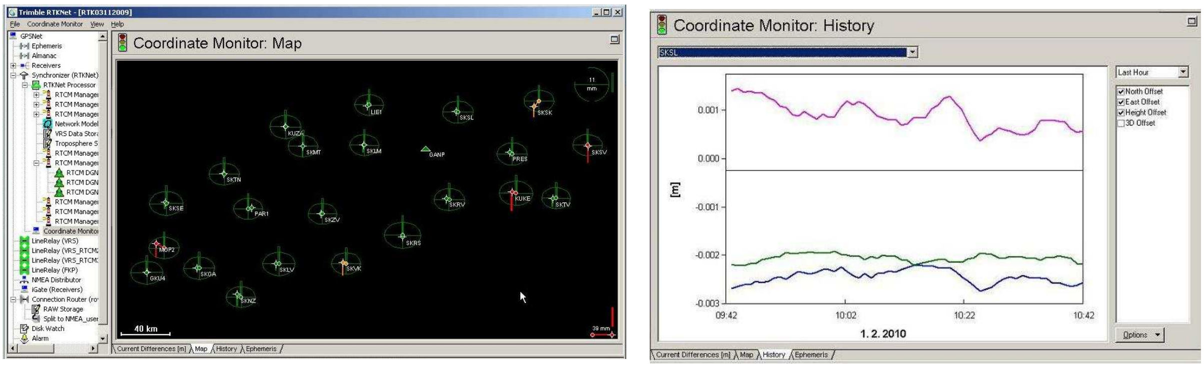


Fig. 3 Outputs from the Trimble coordinate monitor module.

Basic principle of the GNSS data processing in BSW50 is based on ITRF2005 reference frame, absolute antenna phase center models and usage of final IGS ephemerides for both GPS+GLONASS systems. Followed adjustment and coordinate referencing uses Minimal constraint condition applied on set of EPN stations (BOR1, GANP, MOPI, TUBO, UZHL, GRAZ and GOPE). Thus the final results are daily sets of XYZ Cartesian coordinates in ITRF2005 reference frame for all processed stations. Because XYZ Cartesian coordinates in ITRF2005 are not suitable for station stability monitoring, elimination of the Eurasian plate motion by usage of ITRF2005 velocity model defined by rotation gets from (Boucher and Altamimi, 2008) is used and theirs transformation to topocentric coordinate system (neu) is performed. From resulted topocentric coordinates are then composes residual time series for each station, on which are later performed analysis. Residual time series analysis can be understood as a determination of station behavior characteristics and their decomposition to trend, seasonal or cyclic variation by usage of linear regression and harmonic analysis. Before performing of this decomposition it is important to evaluate the quality of the used upper mentioned procedure. For that purpose, the comparison of EPN stations residual time series with the time series from EPN web page can be performed (see fig. 4).

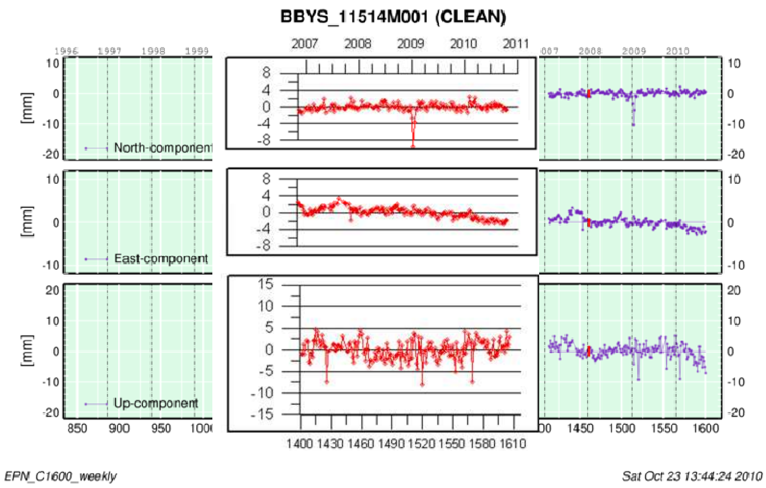


Fig. 4 Residual time series comparison of SK*POS* solution with EPN solution (source www.epncb.oma.be) on Slovakian EPN station BBYS.

Figure 4 confirms that very good coincidence with EPN solution was obtained. This information allows us to consider all created time series as correct and relevant.

Some experience and findings from time series analysis of SK*POS* stations

Time series residual analysis of all SK*POS* permanent network stations was focused to depict the real stations behavior and to determinate the mathematic characteristics of this behavior, from which could be evaluated the quality of the service. Because a lot of interesting facts were found out during analysis performance, we would like to show you some.

On the fig. 5 you can see two kinds of typical station movements of SK*POS* permanent stations – trend (fig. 5b) and yearly seasonal variation (fig. 5a).

a) Seasonal variation b) Trend

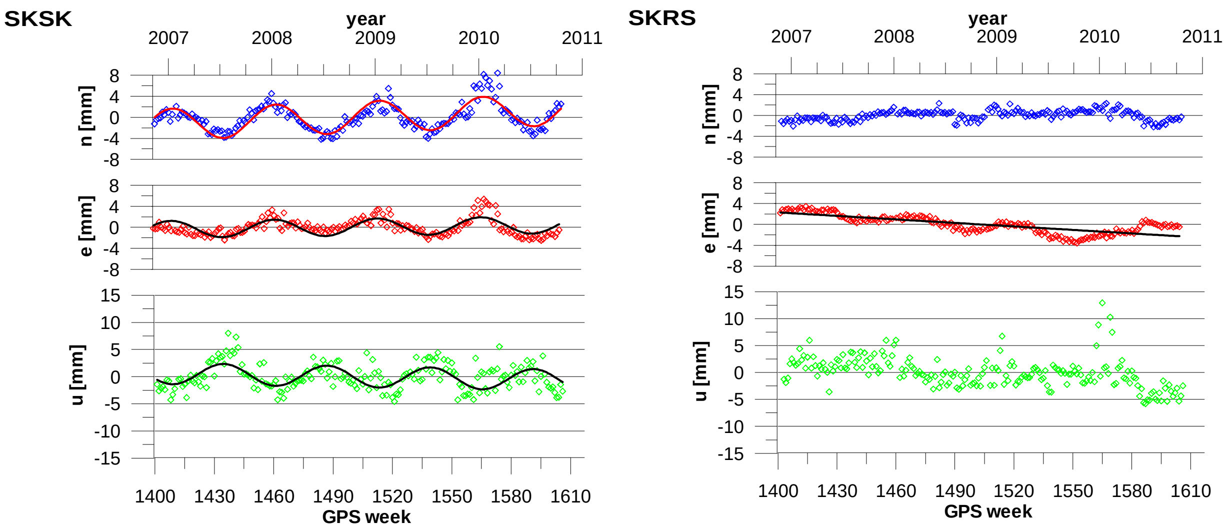
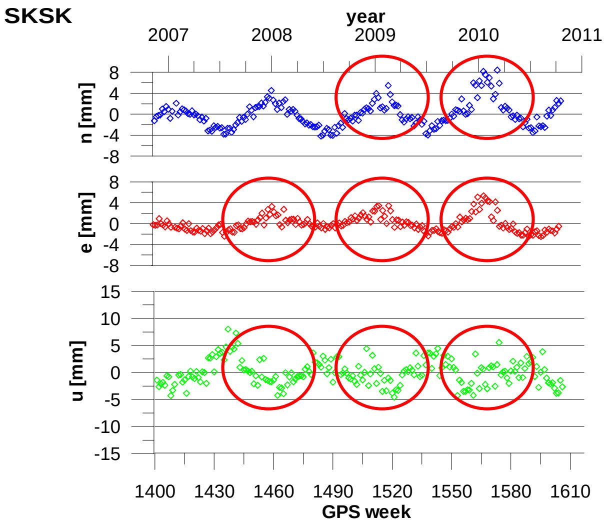


Fig.5 Typical movement character detected on SK*POS* permanent stations.

A lot of station coordinates are also affected by bad weather conditions during winter seasons caused by snow or ice antenna coverage. We call this problem as “winter” effect and the example is depicted on figure 6. Another interesting finding is behavior of the station KUZA after the March 2009. On the station there was not equipment exchange performed, but there was performed some roof reparation and the result is as follows (fig. 7).



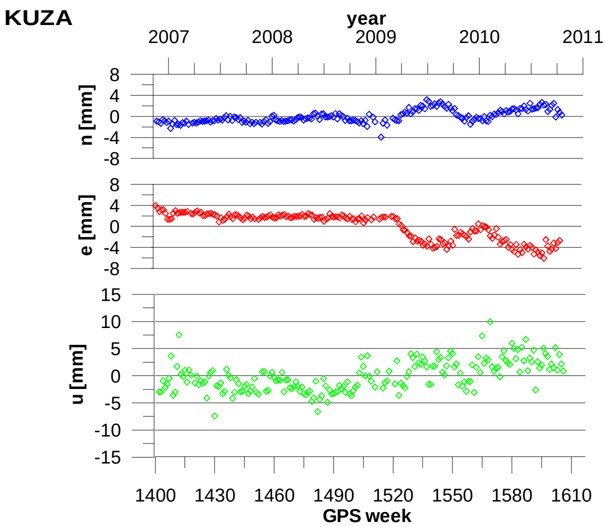


Fig. 6 “Winter” effect visible on SKSK station. **Fig. 7** Start of the periodic movement on KUZA station.

The next kinds of findings are marked simply as “jumps findings”. Typical example of jump is visible on all coordinates components of the station SKGA (fig. 8). All jumps which you can see on figure were caused by antenna reinstallation despite that force centering stabilization is used on the SK*POS* stations (fig.2). This is why it is not recommended to manipulate with stations antennas on EPN stations in any way. Different situation was detected as jump of the north component on station LIE1 (fig.9). But there was no antenna replacement or reinstallation remarked. What is very interesting, that jump occurs only on one component, so we expect that it can be a problem with antenna phase center or?

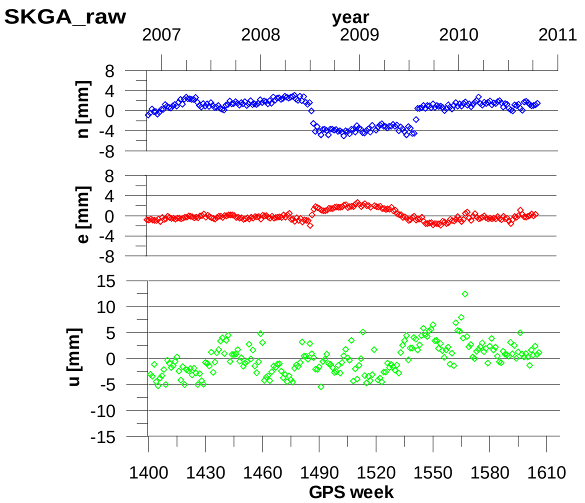


Fig. 8 Jumps visible on SKGA station due to antenna reinstallation.

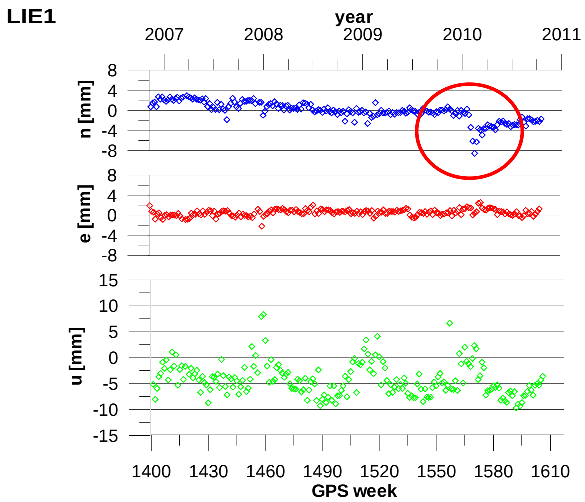


Fig. 9 Unknown reason of jump detected on LIE1 station.

One more very interesting findings represent the up component variation on two pillar stations LIE1 and GANP (fig. 10). As it is mentioned, both stations used pillar monumentation so theirs variation is mysterious. This problem is not solved till now and is still under investigation.

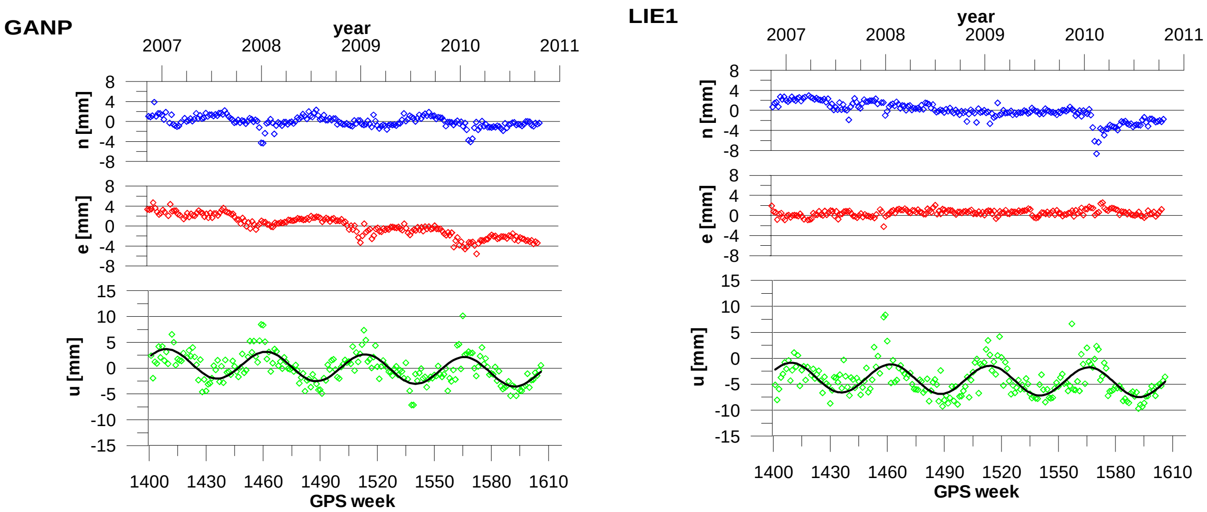


Fig. 10 Up component seasonal variation on pillar stations GANP and LIE1.

Contribution to local geodynamics by precise station stability monitoring

If we stand the assumption that permanent station antenna behavior represents the behavior of the land where the station is placed, the result can characterized the tectonics and can help us to better understand the local geodynamics. For that purpose can be used especially the information about the determined trend values from precise SK*POS* station monitoring with success. As result, we can depict crust movements of Slovakia as a velocity vectors field for horizontal plane (see fig.11).

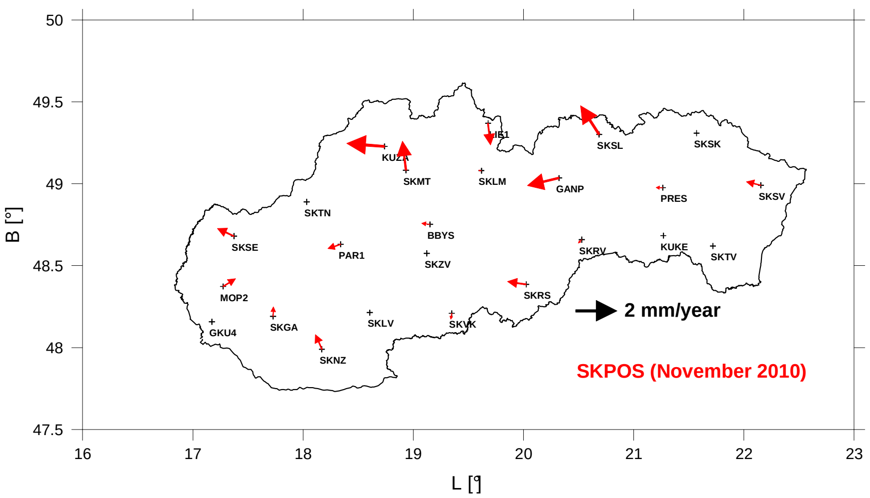


Fig. 11 Horizontal vector velocity field of SK*POS* permanent stations determined from precise station stability monitoring.

Conclusion

Precise monitoring of SK*POS* permanent stations stability is performed on routine basis on GKU for two years from 2008 year, but monitored time interval includes four years of stations operation. All of achieved results and estimated "errors" reached only few millimeters, which confirm that declared precision of SK*POS* service is guaranteed and manifest the strength and potential of GNSS technology in field of station behavior detection on millimeter level. In addition we can say that most of the SKPOS permanent stations could play an important role in contribution to geodynamics research in Slovakia for future.

References

Boucher C. - Altamimi Z.: Memo: *Specifications for reference frame fixing in the analysis of a EUERF GPS campaign. Version 7: 24-10-2008.*

Dach, R. – Hugentobler, U. – Fridez, P. Meindl, M. etc. (2007): *Bernese GPS software version 5.0*. Astronomical institute, University of Bern.

Droščák, B. (2008): *SKPOS permanent stations from time series point of view*. In CD conference proceedings of International Conference 70 years of FCE SUT, 4-5.December 2008, Bratislava. (in Slovak)

EUPOS ISC (2009): *Terms of Reference, technical standards and guidelines of the European position determination system (EUPOS)*. International EUPOS steering Committee, Berlin 2009.

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