A VELOCITY FIELD FOR ROMANIA AND BULGARIA

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1. INTRODUCTION

Movements South of the Carpathian Mountains which deviate from those of the Eurasian Plate were detected last year. This motivates to investigate this area closer. First velocity estimations are done by using cleaned coordinate time series which are generated at the OLG (Observatory Lustbuehel Graz) analysis centre every quarter of a year. To assure high quality the results are compared with the official solutions of the IERS (International Earth Rotation and Reference Systems Service) and the EPN (EUREF Permanent Network) (Time Series Monitoring). The working steps of velocity estimation and comparison are described and first results are presented. At this moment the low density of GPS permanent stations in Romania, Bulgaria and the surrounding area complicates the interpretation of the results.

2. INVESTIGATION AREA

The velocities of the GPS permanent stations included in the investigation area are taken from two networks which are processed weekly by the OLG analysis centre. One of them is the Monitoring Oriental Network (MON). It covers the South East of Europe, a large part of Africa and the South Western part of Asia. The second OLG network is the CERGOP network (CEG), which includes GPS permanent stations in the South East of Europe.
The obtained investigation area covers Bulgaria, Romania and the surrounding area. It includes 21 GPS permanent stations, 11 of them are EPN stations, three of them are also IERS stations. Since Sofia (SOFI) is part of all networks, its velocities are compared with the official solutions. The same is done for the velocities of the stations Graz (GRAZ), Matera (MATE) and Zelenchukskaya (ZECK). These stations are outside the investigation area but included in both OLG networks, the EPN network and the one of IERS.

3. VELOCITY ESTIMATION AND COMPARISON

The process of velocity estimation consists of several steps. The OLG analysis centre processes the weekly solutions of four networks with the Bernese GPS Software 5.0 with the standards of EPN. By stacking the weekly solutions (derived from daily solutions) together "raw" time series are formed. After inspecting them, outliers and offsets are defined and eliminated to obtain a better RMS of the velocities. Outliers, most of them values of a single week differing by more than 10 mm from the neighbouring weeks, are removed.

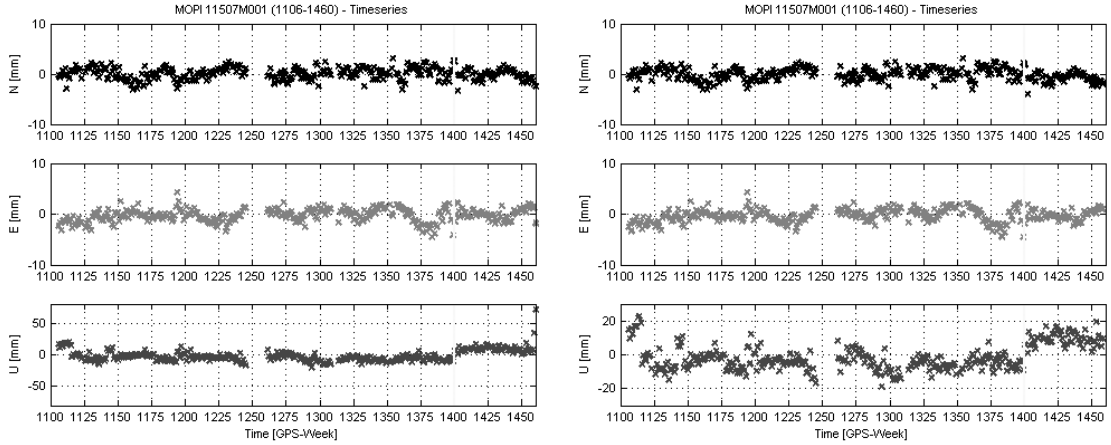

Fig. 1. Raw and cleaned Time Series of Modra-Piesok (MOPI).

Figure 1 shows an example of an outlier at the raw time series of Modra-Piesok (MOPI) (left picture). The last two values (GPS weeks 1459 and 1460) in the Up-component differ from the remaining time series by some centimetres and are therefore eliminated (cleaned time series on the right picture). The repeatability of the coordinates improves from 9.13 mm to 7.93 mm in the Up-component where the outlier occurs.

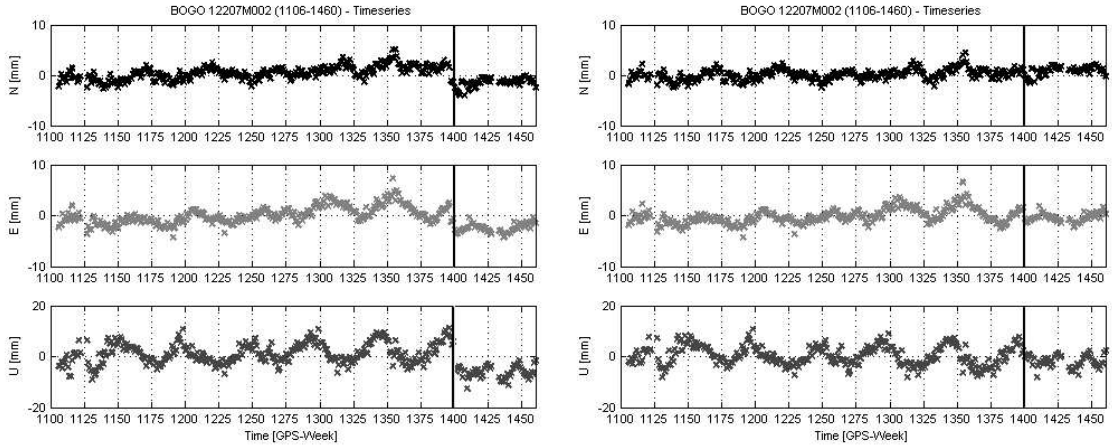

Fig. 2. Raw and cleaned Time Series of Borowa Gora (BOGO).

Offsets are estimated if several consecutive weeks differ from the former ones. Looking at Figure 2 the raw time series (left picture) of Borowa Gora (BOGO) show a jump at GPS week 1400 (marked with a vertical line), resulting from a change of the analysis models.

After cleaning the time series (right picture) the repeatability of the coordinates improves from 1.49 mm to 1.11 mm in N, from 1.88 mm to 1.43 mm in E and from 4.68 mm to 3.76 mm in the Up-component.
After checking and cleaning the time series the velocities are estimated in a Cartesian Coordinate System (X, Y and Z) absolute and relative with respect to the Eurasian Tectonic Plate and relative in a Horizontal Coordinate System (N, E and U). The repeatability of the coordinates and the age of the stations are checked. The minimum number of solutions for reliable velocities is one year, the longer, the better.
The velocities are checked by comparing them with the official solutions of the IERS and the Time Series Project from the EPN. The absolute velocities VX, VY, VZ in ITRF2005 (International Terrestrial Reference Frame 2005) are taken for comparison.

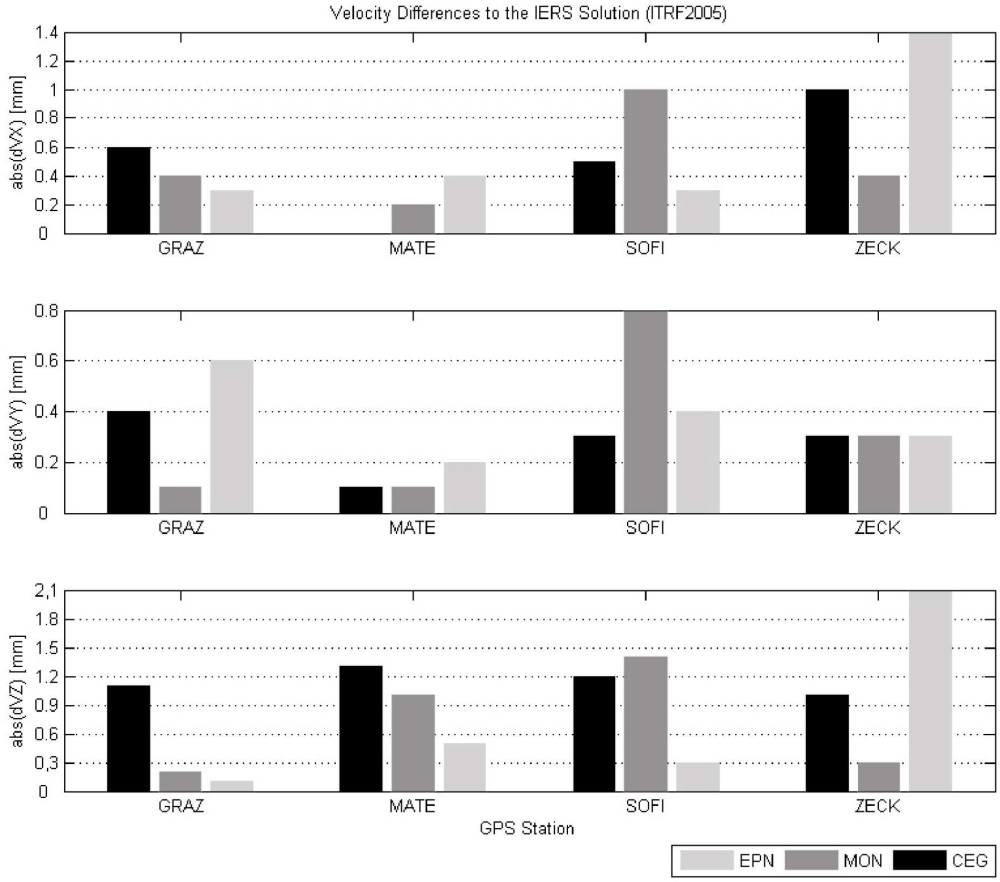

Fig. 3. Velocity Differences to the IERS Solution (ITRF2005).

The bar graph in Figure 3 shows the absolute value of the differences of CEG, MON and EPN to the IERS solutions. The maximum difference of the velocities estimated by the OLG are 1.3 mm.

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Finally the velocities VN, VE, VU relative with respect to the Eurasian Tectonic Plate are plotted and interpreted.

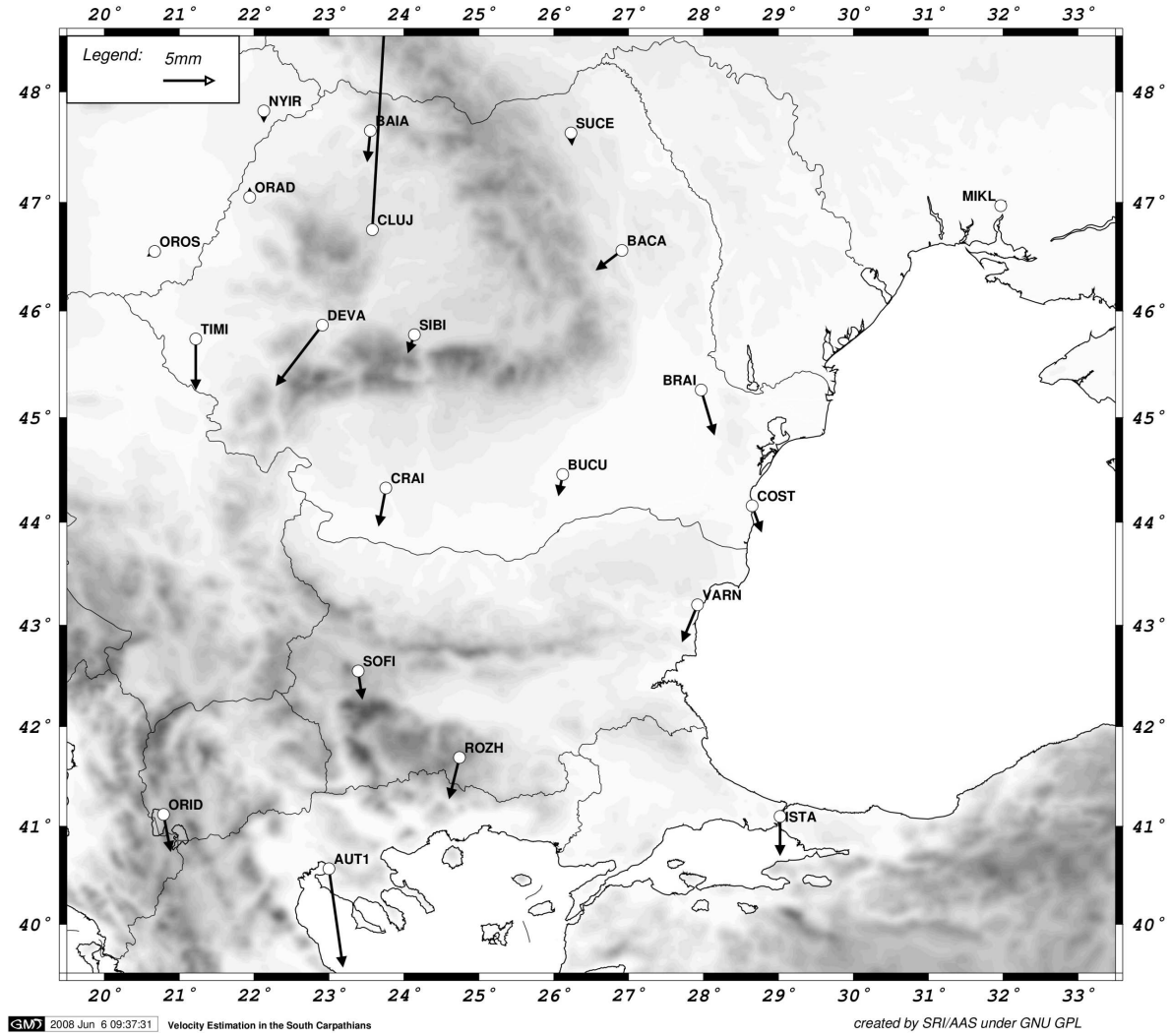

Fig. 4. Velocity Estimation in the South Carpathians.

It can be shown in Figure 4 that the velocities of some stations are not fitting to those of the surrounding area, especially Cluj (CLUJ) and Deva (DEVA). CLUJ is already known to be located on a sliding slope (Haslinger et al., 2006). It is assumed that DEVA also is situated on a sliding area. The velocities of Timisoara (TIMI) are ignored in this case because of the short number of weeks (11) the station is part of the CEG network. The different features of the velocities in the Carpathian Mountains and those at the South of them are clearly seen and are significant. The Carpathian Mountains seem to be very stable whereas the GPS stations in Bulgaria and the South of Romania generally show a southward direction, probably a rotation. More interpretation can be done by including the data of more GPS stations in Bulgaria and Greece which have started in 2008.

5. CONCLUSIONS

Quality control is an important working step to have confidential velocities, thereby a lot of effort has to be spent for data pre-processing. For comparison with official solutions more GPS stations are required. This was complicated by merging two completely different networks processed by the OLG using identical sites. Additionally more official solutions would be preferred.
Looking at the velocities in Romania and Bulgaria different movements between the Carpathian Mountains and the region in the South of them can be shown. The problem is the small number of GPS stations in this area presently. The OLG analysis centre has already included a lot of additional stations from the HEMUS net in Bulgaria and Greece into the MON to get more information about the movements in about one year.

6. REFERENCES

EPN Project for time series monitoring: "Coordinates/velocities computed by the EPN Project for time series monitoring" and "Official coordinates/velocities issued by the IERS": http://www.epncb.oma.be/_trackingnetwork/coordinates/index.php

Haslinger C., Stangl G., (2006), The time series of the permanent CERGOP stations – first velocity estimation of the non-EPN sites, Proceedings of the EGU G6 Symposium "Geodetic and Geodynamic Programmes of the CEI (Central European Initiative)", Reports on Geodesy No,1(76),2006,23-28