COMPARING VELOCITY ESTIMATIONS FROM PERMANENT TIME SERIES AND CEGRN EPOCH CAMPAIGNS

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1. INTRODUCTION

Site velocities are the basic input for geokinematics and reference systems. One of the main goals of the CERGOP project is to densify the IGS and EPN field of permanent GNSS stations in Central Europe by epoch and permanent sites. The network CEGRN started to be observed in 1994 and covers now about 100 sites between the Baltic and the Mediterranean Sea (http://www.sgo.fomi.hu/index_eng.html). A traditional solution of the velocity field was already published in 2007 (Caporali et al., 2008a) and 2008 (Caporali et al., 2008b). In the meantime a new campaign CEGRN07, the change of analysis models and a new realization of the global reference system ITRS happened. Therefore it was decided in 2007 to reprocess all campaigns to the newest standards. Finished in 2008 this article is intended to compare the results to the international standards at identical sites. Because all sites of CEGRN are processed as epoch sites the question was if and how the results would fit into the velocity field derived by permanent stations.

2. VELOCITY COMPARISONS

The compared velocities are taken from four different sources:
(1) CEGRN reprocessed: The nine campaigns between 1994 and 2007 have been reprocessed using ITRF2005 orbits, coordinates and velocities, absolute phase calibration corrections, and an improved troposphere modelling (Drescher, Becker, 2007, [3]). A handful of permanent stations have been added to fill gaps and to strengthen the reference. The results from six analysis centres have been united to a common solution and for each site with more than two periods velocities have been estimated. The solution is referenced to ITRF2005 by selecting up to 10 sites by the minimum constrained approach. The Bernese Software 5.0 is used. The preliminary lateral velocities are shown in figure 1.
(2) CERGOP permanent: Since 1999 the CEGRN sites which deliver permanent data, plus about 20 other permanent sites (mostly from EPN) are analysed by OLG AC on a weekly basis (Haslinger, Stangl, 2006, [4]). The network uses ITRF2005 (in fact IGS05) coordinates and velocities since end of 2006. It therefore contains mixed results from relative and absolute phase calibration corrections.

For removing jumps in the time series of coordinates EPN and own offsets are applied. Velocities are estimated for all sites older than 26 weeks (half a year). The lateral velocities are shown in figure 2.

<u>(3) EPN Time Series Product</u>: (http://www.epncb.oma.be/_trackingnetwork=>Station coordinates and http://www.epncb.oma.be/_dataproducts/timeseries=>Cleaned time series), The former Time Series Project, now a product of EPN is using the weekly EPN solutions since 1996 for getting time series. Also not reprocessed jumps are handled by CATREF, but almost always keeping the velocity values constant. For the comparison the 'CLEANED TIME SERIES' have been used. From former computations offsets have been estimated where a jump in the coordinates were recognized.

<u>(4) EUREF Pseudo-Campaigns</u>: These campaigns have been created artificially by selecting the EPN weekly solutions at the time of each CEGRN campaign. The reason behind was to demonstrate what happened if the CEGRN campaigns had not been reprocessed. From those campaigns velocities have been estimated using the Bernese Software 5.0.

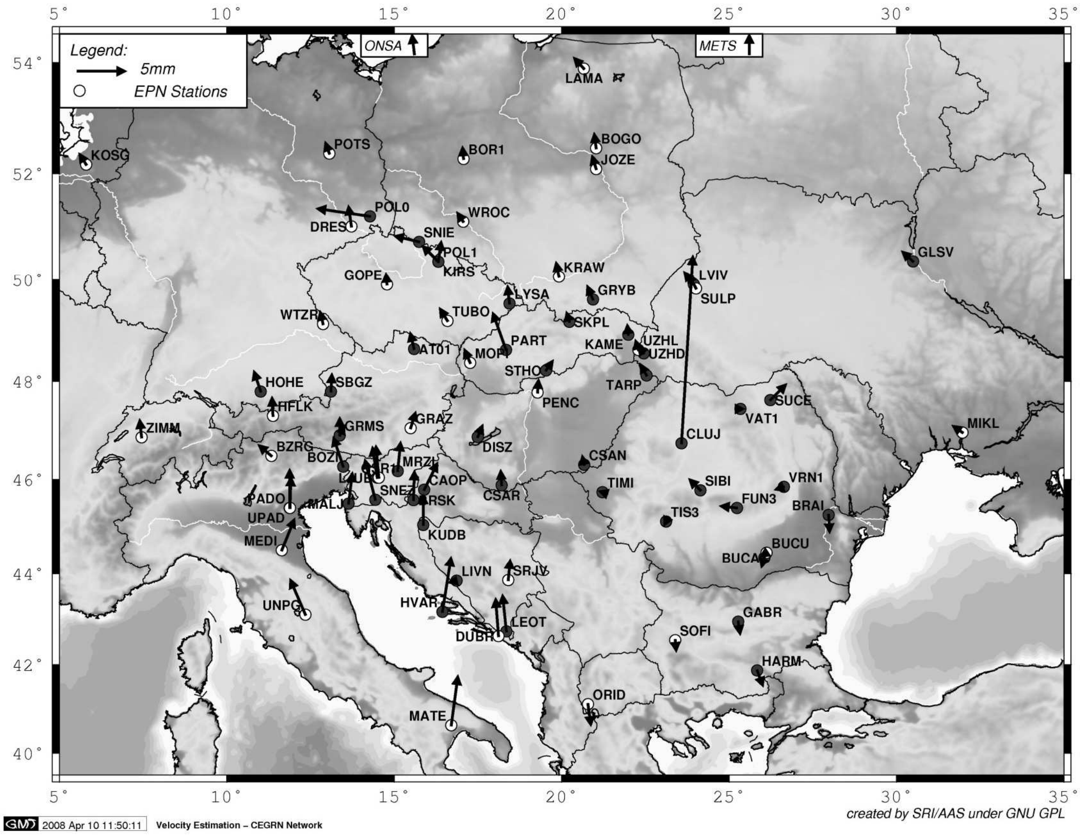

Fig. 1. Preliminary lateral velocities from CEGRN reprocessing.

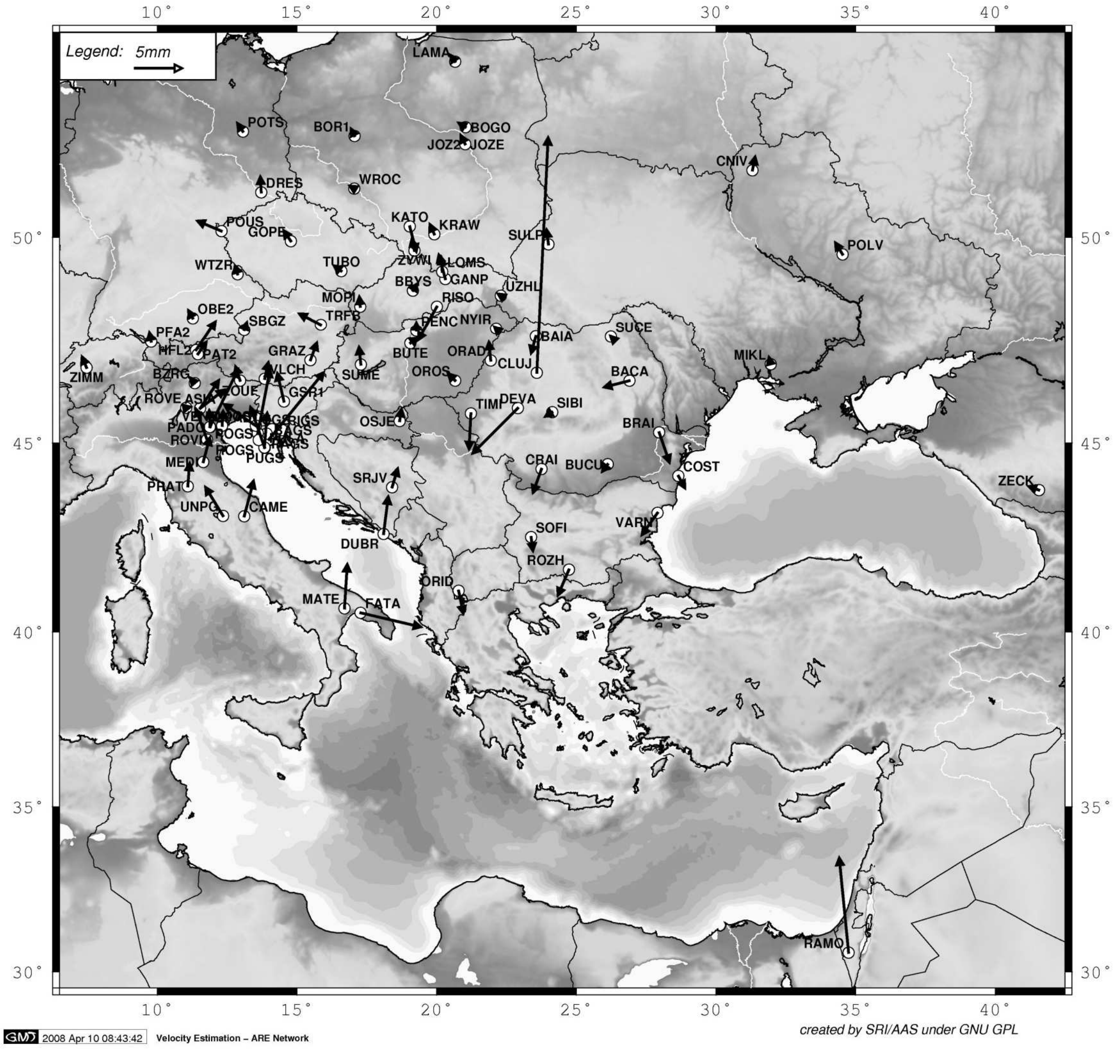

Fig. 2. Lateral velocities from CERGOP and other permanent sites.

3. VELOCITY DIFFERENCES

3.1 General Differences

As already stated all velocity sources except (1) are not reprocessed and refer to different reference systems and analysis models. Additionally all four velocity results are based on different data with respect to the amount of observations. The question is how these factors influence the results which should be biased in some way.

The first question is the one of mixing the reference frames. Because the weekly solutions of (2), (3) and (4) are in different frames (ITRF94, ITRF96, ITRF97, ITRF2000, ITRF2005/IGS05) a transformation into a common frame is mandatory for a comparison. This was done implicitly by using coordinates and velocities of special sites derived from ITRF2005. With a minimum constrained solution stacking normal equations together the weekly solutions are transformed to ITRF2005. The remaining biases (orbits, biases between transformation points, different sets of transformation points according to age) did not show up in the comparison.

Probably they are very small and behave either random or they are consumed in the transformation parameters as long wave effects. No systematic effect was found which is correlated with the age of the time series. One reason may also be that the transformation points have been carefully selected because of their stable and long time series. A side effect was also reduced by choosing a geometrical distribution which should be as good as possible.

A second effect is much stronger and cannot be neglected. ITRF2005 uses relative calibration values which differ from the absolute ones by up to 20 mm in height. Depending on the fraction of the time series before November 2006 and on the antenna type of each station the influence on the coordinates and velocities can become quite big in (2), (3) and (4). Both time series from permanent stations handled discontinuities, either by applying offsets or allowing coordinates to change, but both assume that the velocities before and after the discontinuity remained the same. This is reasonable, because changing the models should not change the behaviour of stations in nature. For (4) it is not possible in most cases to recognize discontinuities below a certain level, e.g. 10 mm. The tendency is to smooth out the offset which distorts the velocity. In the worst case (20 mm, 50% before November 2006) the height velocity changes by 10 mm/year.

A third effect concerning campaigns was compensated since the beginning of CEGRN. As can be seen from several time series seasonal changes in the coordinates can reach amplitudes up to 10 mm. The main source is the atmosphere and related effects (e.g. groundwater). Because CEGRN campaigns were performed always around beginning of June periodic effects cancel out almost completely. For permanent stations, even they are only 1-2 years old, the effects are also negligible (<0.2 mm/year).

3.2 Station Differences

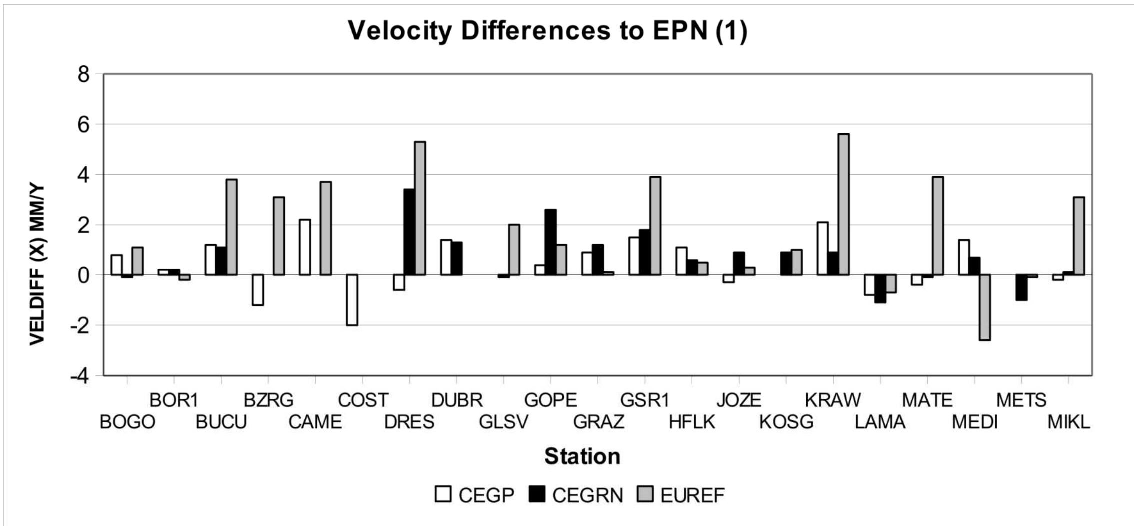

Fig. 3. Differences in Velocity Estimations, Networks – EPN, X-Component Part 1.

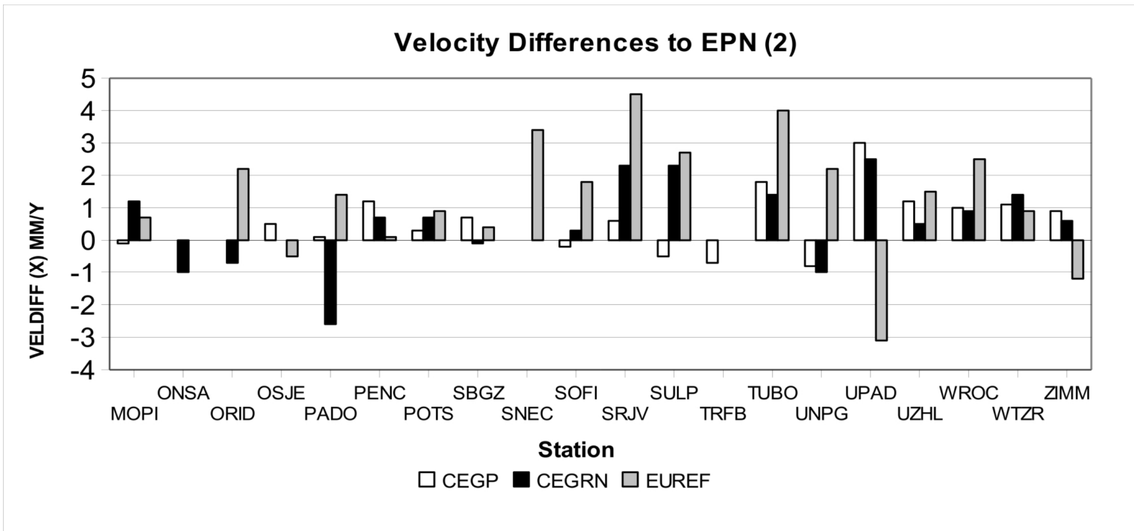

Fig. 4. Differences in Velocity Estimations, Networks – EPN, X-Component Part 2.

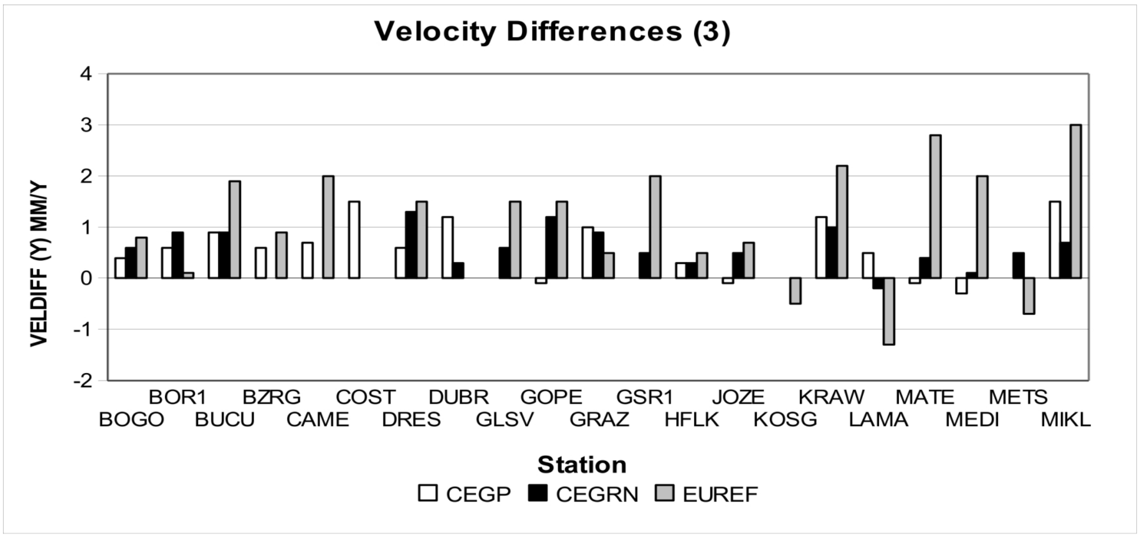

Fig. 5. Differences in Velocity Estimations, Networks – EPN, Y-Component Part 1.

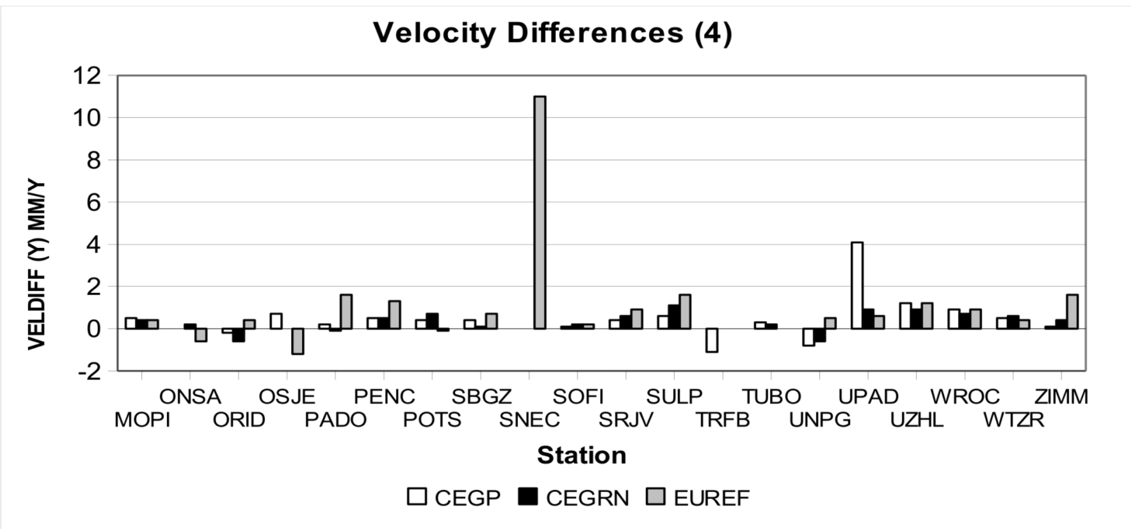

Fig. 6. Differences in Velocity Estimations, Networks – EPN, Y-Component Part 2.

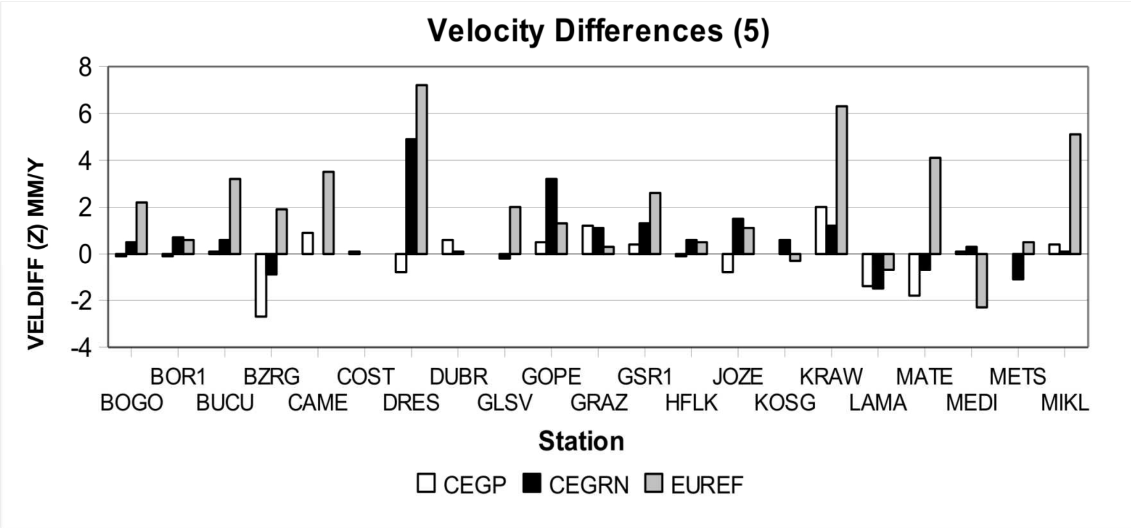

Fig. 7. Differences in Velocity Estimations, Networks – EPN, Z-Component Part 1.

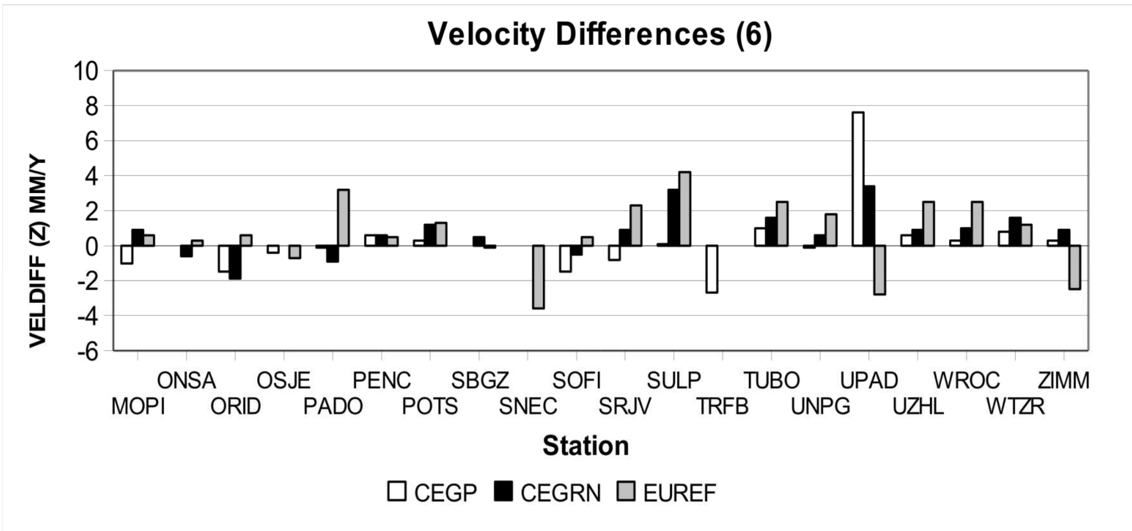

Fig. 8. Differences in Velocity Estimations, Networks – EPN, Z-Component Part 2.

As can be seen from figure 3-8 most of the velocity differences between EPN and the other estimations are small, below 2 mm/year. It can also be seen that the EUREF estimation (4) is the estimation with the largest outliers. Station SNEC (Czech Republic) is an exception because EPN uses the whole year of it while EUREF uses only the June. Because SNEC behaves very bad in wintertime the EPN estimation is wrong and the EUREF one is correct (CEGRN and CEGP have not yet estimated it because of the short inclusion). The CEGRN solution has major differences at DRES and GOPE in the Up component (X+Z), because major offsets have been neglected. Smaller differences above 2 mm/year appear also at PADO, SRJV and SULP, this cannot be explained presently. The largest difference of the permanent CERGOP network is at UPAD which was included only for one year. Smaller deviations above 2 mm/year are also recognized at CAME and KRAW.

4. CONCLUSIONS

As could be demonstrated by the EUREF pseudo-campaign reprocessing campaigns improve the velocity estimation considerably. Therefore it was reasonable to reprocess the CEGRN campaigns. Reprocessing of campaigns is much less time consuming than the reprocessing of permanent station networks. Taking all CEGRN campaigns together the amount of data is only two months. On the other side campaigns are vulnerable not detecting discontinuities. Large discontinuities appear as outliers which reduce the time span considerably by removing them. From this study it seems that offsets below 30 mm remain in the velocity estimation of campaigns, leading to biased results. Theoretically discontinuities should be handled in campaigns like in permanent networks, by piecewise estimation of coordinates and constraining the velocities to the same values. However, several points would be lost for estimation because at least three campaigns per piece are required. This is frequently not the case. Therefore it would be more practical to apply known offsets (e.g. because of wrong calibration values, permanent time series). Second, the increase of the number of campaigns helps also to check for discontinuities. As can be shown from the CEGRN campaigns the precision is approximately the same since 1994 when reprocessed. Due to financial aspects since 1997 the campaigns are only bi-annual than yearly. Returning to yearly campaigns would speed up the estimation of a dense velocity field within Central Europe. Nevertheless the velocities from the reprocessed CEGRN campaigns are consistent with those of permanent networks and can be included into a future European Velocity Field.

5. REFERENCES

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