NEW CHALLENGES FOR THE CEGRN

Below you find the text of the paper in the form as it was presented at the session G6.1. The paper "New challenges for the CEGRN" presented at the Session G.1 by Prof. Alessandro Caporali was after the Session updated and in the meantime published in the journal "Technophysics" under the title "Surface kinematics in the Alpine–Carpathian–Dinaric and Balkan Region inferred from a new multi-network GPS combination solution". You can find the text of the updated paper at the journal homepages of internet in www.elsevier.com/locate/tecto.

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ABSTRACT

The Central European Geodynamic Reference Network is active since the early 1990's with a consistent and systematic activity of measurement, processing and scientific interpretation of the GPS and derived data. The project CERGOP 2 which was financed by the EU under FP5 has contributed to build the necessary cohesion and awareness of the different fields of expertise which are necessary to manage a geodetic network spanning Central Europe, and with important connections to other networks, in particular the EPN. In this second decade there are a number of challenges which will need a strong effort. The ambitious EPOS and TopoEurope projects are looking for a homogeneous and consistent dense velocity field for application to geodynamics and seismicity. The theme of the dense velocity field is present also within the IAG, in the working group 'Regional Dense Velocity Fields'. Finally, the way in

which the ETRF2000 coordinates of stations in national networks evolve relatively to the stable part of Europe is related to the details of the 3D velocities. This is relevant to INSPIRE, and the obligation of the EU Countries to follow the ETRS89 standards. CEGRN has the potential to effectively play an active role in these scientific issues, because the CEGRN campaigns are of high quality, fulfill state-of-the-art standards and extend over a very long lapse of time. Possible initiatives linked to the scientific projects mentioned above include 1) a participation in the proposed COST Action called TEGO 'Towards a European GNSS Observatory'; 2) a study of the best way to combine the CEGRN campaign solutions with the EPN network solution.

1. INTRODUCTION

The Central European GPS Geodynamic Reference Network (CEGRN) was established in 1994 in the framework of the CERGOP project (Central European Regional Geodynamics Project), supported in the period 1994 – 1998 by the EU under the contract No. CIPA-CT94-0114 within the FP4. The results of the CERGOP project proved that CEGRN could be considered as a well-established research infrastructure in Central Europe for earth sciences which can be used as a research tool in the region by a large number of users also outside the group of collaborating countries. In order to ensure a long-term functionality of the CEGRN, to maintain and further develop the CERGOP achievements and also to form an institutional background of the CERGOP-2/Environment Project, supported by the EU within the FP5 under contract EVK2-CT-2002-00140, the CEGRN Consortium was formally established in 2001 by the institutions participating in CERGOP. At present the Consortium associates 15 members of 14 countries: Austria, Bosnia Herzegovina, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Italy, Poland, Rumania, Serbia, Slovakia, Slovenia, Ukraine. They are committed to:

- **coordinated establishment, maintenance and upgrade of CEGRN GNSS sites,**
- **coordinated repeated or permanent monitoring GPS measurements,**
- **operation, maintenance and development of the CEGRN Data and Processing Centres.**

The scientific objectives of CEGRN include:

Modelling of regional intra-plate 3D velocity field at millimetre level
Combination of solutions of individual analysis centres
Combination of repeated epoch networks, coordinate and velocity estimates
Evaluation of accuracy and reliability of the obtained information
Velocity maps, regular grid velocities, deformations, geo-kinematical interpretations
Evaluation of statistical significance of derived quantities
Visualisation of products, geo-kinematical maps
Strain analysis and detection of velocity changes for dynamical investigations and special study areas with national or regional densification networks

This paper illustrates the CEGRN structure, operations and main results, and outlines new activities and outreach initiatives foreseen for the next years.

2. ORGANIZATION, CAMPAIGNS AND DATA FLOW

Table 1 summarizes the CEGRN observation campaigns at permanent (P) and epoch (E) sites since 1994.

Table 1: CEGRN Campaigns

Campaigns	Period	Country	Sites
CEGRN'94	2-6 May 1994	10	30
CEGRN'95	29 May-3 June 1995	11	36+5
CEGRN'96	10-15 June 1996	11	35+6
CEGRN'97	4-10 June 1997	12	35+10
CEGRN'99	14-19 June 1999	13 (extended network)	57 (19P+38E)
CEGRN'01	18-23 June 2001	13 (extended network)	51 (28P+23E)
CEGRN'03	16-21 June 2003	13 (extended network)	51 (28P+23E)
CEGRN'05	20-25 June 2005	14 (extended network)	97
CEGRN'06	12-18 June 2006	Only CGPS	47
CEGRN'07	18-23 June 2007	19 (extended network)	81
CEGRN’09	22-27 June 2009	19 (extended network)	85
CEGRN’11	20-26 June 2011	tbd	tbd

The CEGRN network has connections and overlaps with some major European networks such as the EUREF EPN (European Permanent Network) or the Austrian Reference Network ARE (Figure 1). This ensures a proper alignment and scale with the ITRS realizations for both position and velocity.

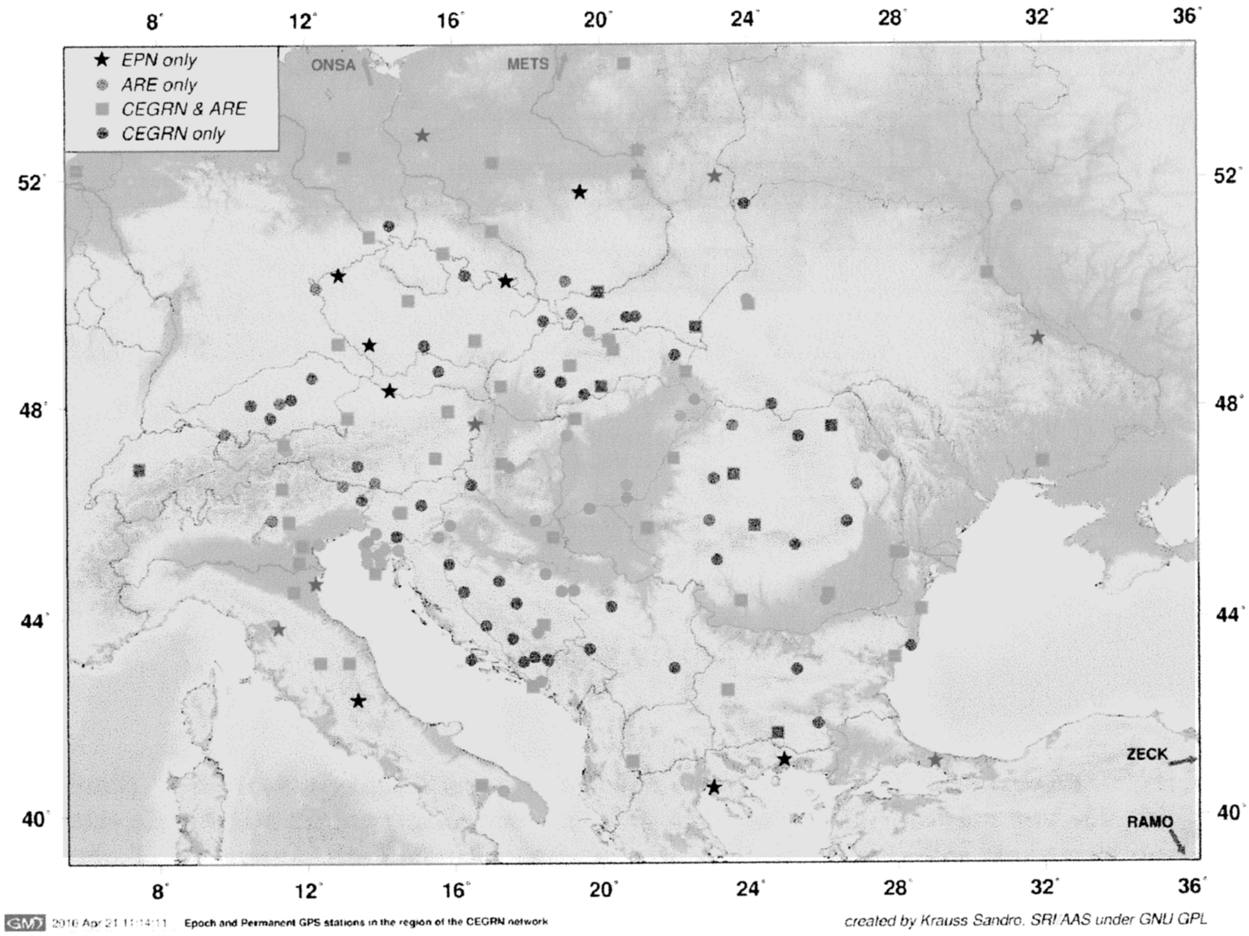

Figure 1. The CEGRN sites and their relation to major European geodetic networks.

The data are collected at the CEGRN Data Center hosted by the Space Research Institute of the Austrian Academy of Sciences in Graz. Seven CEGRN Analysis Centers access the data and process the RINEX files according to the latest standards (EPN Guidelines): Antenna models, Tide corrections, Orbits and Earth Orientation Parameters (EOP's), elevation cutoff, reference coordinates and constraints (Figure 2).

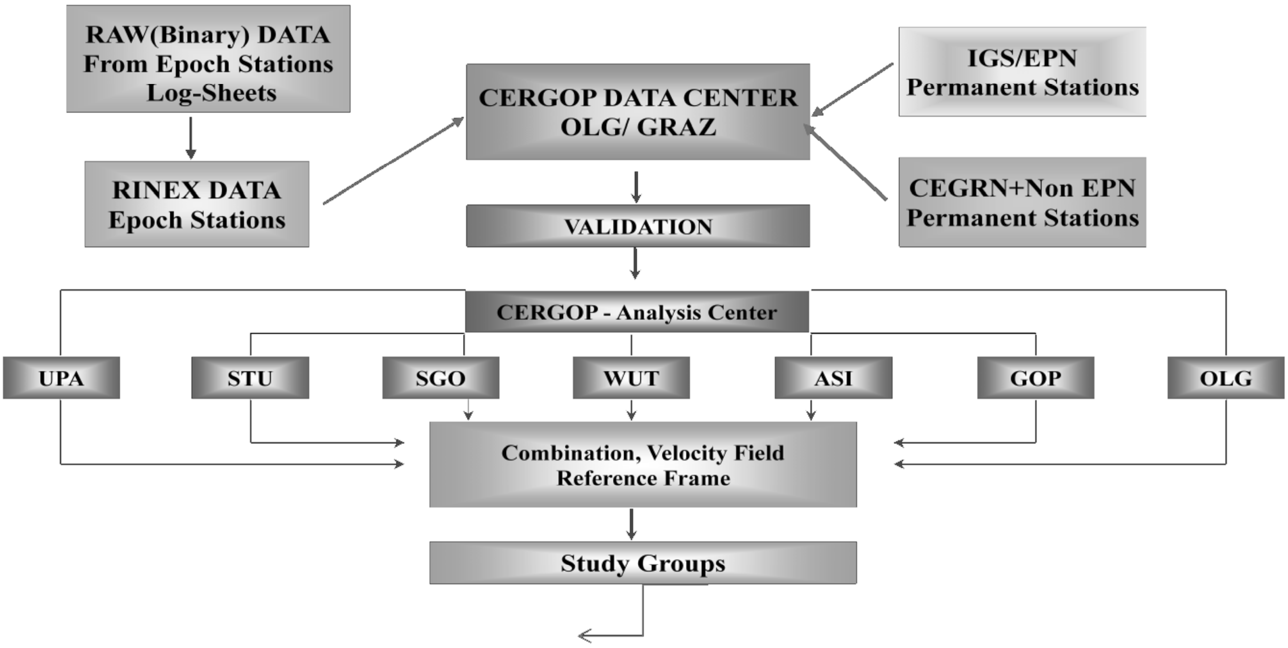

Figure 2. The data flow structure within CEGRN.

Eventually, the normal equations are stacked, constraints are imposed on position and velocities of datum-defining stations and a solution is derived for position and velocities of the network. To overcome the inconsistencies due to the use of different standards during the years, the available data have been reprocessed according to the IGS05.ATX antenna model and using consistent orbits, EOP's, elevation cutoff and constraints (minimum constraints). The aspects of a transition to the new ITRF2008 and the transition to the IGS08 reference frame of GNSS with its associated absolute antenna calibrations in IGS08.ATX will be studied in detail after the 2011 campaign (Becker et al., 2010). The horizontal and vertical velocities obtained up to now are shown in Figure 3 and 4, respectively. The horizontal part clearly shows that the southern part of Eurasia is actively deforming as a result of the interaction of the African plate, the Arabian plate and the intervening minor plates which might be identified in the collision zone. The vertical part shows that subsidence is dominating in Central Europe. As for the horizontal velocities, there are a few sites which deviate from the general pattern. In most cases they reflect known local instabilities. The overall picture which is derived from these data (Caporali et al., 2008, 2009) fits very well into the large scale European geokinematics which is implied by the similar processing of the EPN data. The CEGRN data provide additional detail in specific Central European areas (e.g. Hefty et al., 2009ab, 2010; Hipmanová L., 2009) in geodetically consistent and rigorous manner, and therefore we can speak on the one hand of densification of the European network, and on the other hand argue about a combination of the EPN and CEGRN normal equations, so that the combined results more exactly represent the current status. Additional data are expected to bring more detail in the next future. For example five more BULiPOS reference permanent stations (BURG, STAR, SCHUM, LOVE, MONT) in Bulgaria are expected to join the CEGRN network (Milev et al., 2010, 2011).

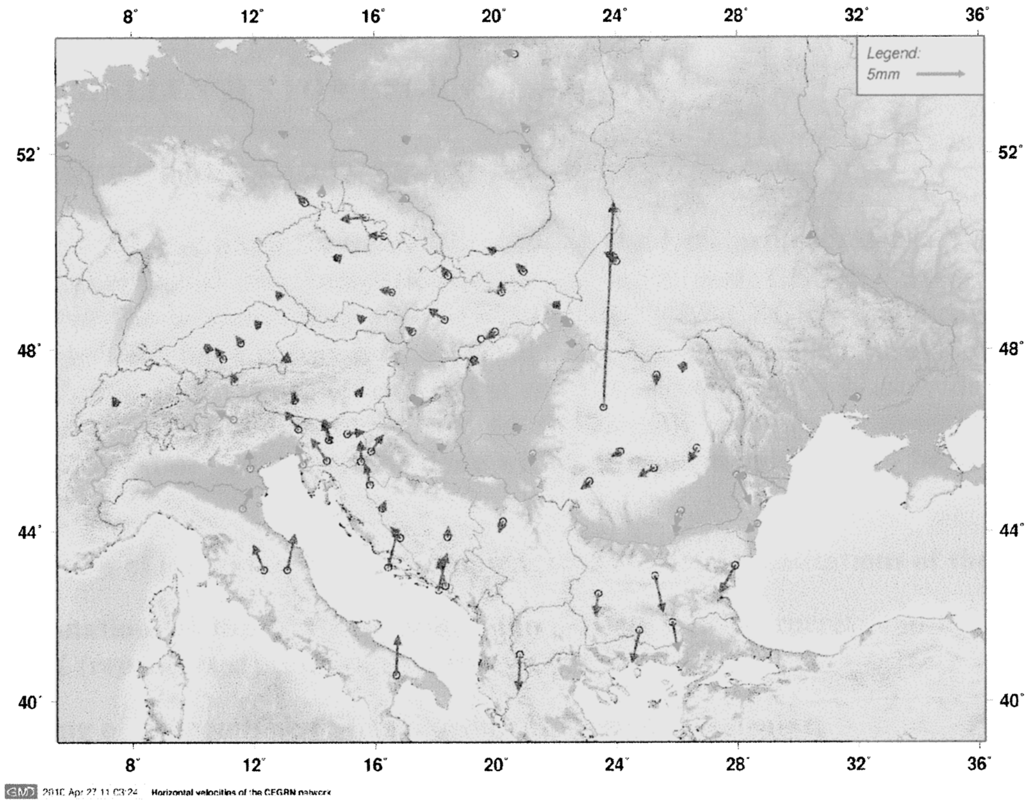

Figure 3. Horizontal velocities of CEGRN sites relative to Eurasia, resulting from the CEGRN campaigns.

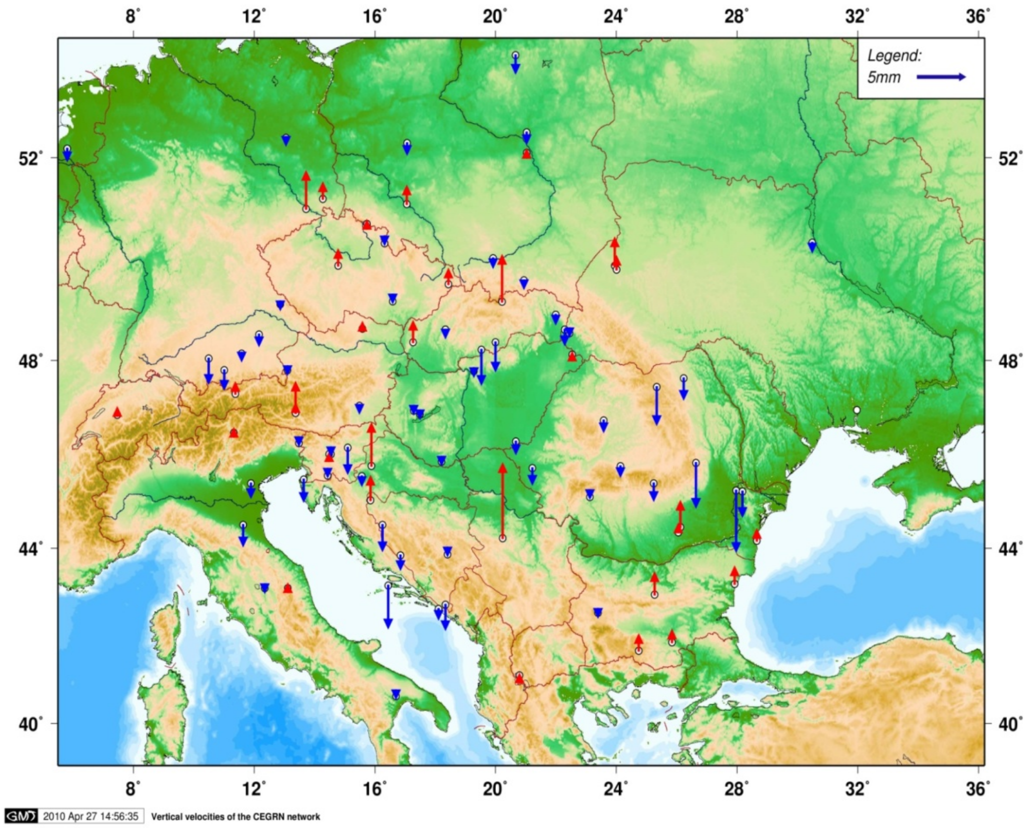

Figure 4. Vertical velocities of CEGRN sites, resulting from the CEGRN campaigns.

3. NEW CHALLENGES FOR CEGRN

3.1 EUREF CEGRN PARTNERSHIP

Recognizing on the one hand the scientific value of the IAG project 'Dense Velocity Field', and on the other hand the compatibility of the EPN and CEGRN normal equations, negotiations have been undertaken on a partnership EUREF-CEGRN finalized to generate a specific velocity field for Central Europe. A new solution is intended to use those CEGRN stations, epoch and permanent, which are not comprised in the EPN to provide more detail. The stations common to both networks would additionally provide the necessary alignment and scale. A first list of activities to be done within this partnership could be summarized as follows:

- **Validation of individual CEGRN campaigns as EPOCH realizations of the ETRF2000**
- **Combination of the 9 CEGRN campaign SINEX with corresponding EPN weekly SINEX (reprocessed). Time span: 1996 - 2011**
- **Stacking of the combined SINEX using Minimum Constraints**
- **Add to the stack EPN_A_ITRF2005.SNX as a datum**
- **Test different software: CATREF, BERNESE**
- **Include OLG's ARE SINEX files, after reprocessing**
- **Deliver result to IAG SP 'Dense Velocity Field'**

The benefits which can be expected from this partnership can be summarized as follows:

- **Test and optimize the guidelines for approval of networks with positions and velocities**
- **Test the consistency and subjectivity of the offsets in coordinate time series**
- **Involve more countries into the 'ETRS89' standards and, hence, to contribute to the adoption of the INSPIRE Directive**
- **Provide better and more consistent data for geokinematics**
- **Exploit the potential of reprocessed data sets**

The agreement is expected to be signed on the occasion of the 2011 EURF Symposium in Chisinau, (Moldavia).

3.2 PARTICIPATION IN EU SPONSORED ACTIVITIES AND PROJECTS

The need for a complex long-term global monitoring of the Earth system has led to a number of initiatives and programs which resulted in initiating and creating several global observing systems (e.g. GOOS, GTOS, GCOS) as well as regional research programmes and initiatives. The number of the global systems has been growing especially over the last 10 – 15 years. In all global observing systems most attention is paid to space-based observations, but of a special importance are also *in situ* observations made at the surface of the Earth, in its atmosphere and oceans. In recent years a move can be seen towards the integration of *in situ* geological and geophysical observations with satellite observations.

There exist at present at least two scientific initiatives where an active involvement of CEGRN as a regional research infrastructure for earth sciences can be foreseen.

One of them is the European Plate Observing System (EPOS) which was included into ESFRI and is supported under the 7. FP. EPOS is intended to be the European counterpart of the Plate Boundary Observatory (PBO) in the US. It is a multinational initiative that aims at integration of observational data in a wide range of space and time and relevant modeling facilities to obtain a better understanding of earthquakes, volcanoes, surface dynamics and tectonics. The vision of EPOS is to integrate real time observations from permanent national and regional geophysical networks with the observations from *in situ* experiments and temporary monitoring experiments through a cyber-infrastructure for data mining and assimilation and facilities for data integration, archiving and exchange.

The second is TopoEurope, supported by the European Science Foundation. TopoEurope concentrates on Quaternary research, where the knowledge of present deformation inferred from regional scale geodesy plays an important role.

In perspective, it is worth mentioning the TEGO – Towards a European GNSS Observatory- proposed Cost Action. TEGO intends to coordinate ongoing national or local projects that estimate site positions, velocities and strain fields with the aim to estimate homogeneously and precisely the 3D field resulting from deformation across the active seismogenic zones in Europe.

The proposed breakdown in Work Packages is as follows:

WG1: Quality criteria and coordination of the deployment of permanent GNSS stations.
WG2: Standardization of data and processing centers.
WG3: Combination of network solutions.
WG4: Mapping velocities into strain rate.
WG5: Outreach and Coordination with other Programs.

The decision on preliminary acceptance is expected by May 6. 2011. If approved, the mechanism underlying a COST action offers the possibility to pay for travel expenses and the organization of meetings, summer school and publications. TEGO could therefore help in bringing together European communities sharing common interests in reference frames, geodesy and geokinematics.

Other potential cooperations could be established within the European Earth monitoring programme and projects GMES (Global Monitoring for Environment and Security) and EUMETNET Programmes for meteorological monitoring. Participation in more financially supported projects is of vital importance for a more successful contribution of CERGOP investigations to the monitoring of the environment.

4. CONCLUSIONS

By virtue of its regular campaigns and structured organization, CEGRN blends permanent and epoch Stations to provide intraplate velocities at the < 0.5 mm/yr level, for those stations which have been measured for a sufficiently long time. To make these results truly useful for geokinematics, a connection with European wide networks such as the EPN is needed, as well as an integration of the geodetic knowledge with other resources and cooperative projects, particularly in the geophysical and seismological fields. These requirements are clearly identified in the planning of the CEGRN activities in the near future.

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