# The CEGRN campaigns and densification of the ETRF in Central Europe

**J. Zurutuza** (1),  A. Caporali (1), O. Khoda (2), G. Stangl (3), M. Becker (4), M. Bertocco (5), L. Gerhatova (6), M. Mojzes (6), J. Papčo (6), M. Mulic (7), Yu. Stopkhay (8), C. Nagorneac (9), A. Mihailov (9), S. Lazić (10), B. Stopar (11), M. Figurski (12), B. Droscak (13), P. Mitterschiffthaler (3), Artur Malczewski (14), E. Parseliunas (15), J. Reznicek (16), J. Nagi (16), J. Kaplon (17), S. Wajda (18), S. Berk (19), K. Medved (19), S. Dimeski (20), G. Grenerczy (21), M. Marjanović (22), J. Simek (23), P. Pihlak (24), T. Srechko (25)

(1)  University of Padova (Department of Geosciences), Padova, Italy;
(2)  Main Astronomical Observatory National Academy of Sciences of Ukraine, Kiev, Ukraine;
(3)  Space Research Institute, Austrian Academy of Sciences, Graz, Austria;
(4)  Technical University of Darmstadt, Germany;
(5)  Centro di Ateneo di Studi e Attività Spaziali "Giuseppe Colombo" - CISAS, Padova, Italy;
(6)  Slovak University of Technology, Bratislava, Slovakia;
(7)  University of Sarajevo, Bosnia and Herzegovina;
(8)  System Solutions, Kiev, Ukraine;
(9)  Institute of Geodesy, Engineering Research and Cadastre "INGEOCAD", Chisinau, Moldova;
(10)  Republic Geodetic Authority, Belgrade, Serbia;
(11) University of Ljubljana, Slovenia;
(12) Military University of Technology. Faculty of Civil Engineering and Geodesy, Centre of Applied Geomatics, Warsaw, Poland;
(13) Geodetic and Cartographic Institute, Bratislava, Slovakia;
(14) TPI NETPro Poland;
(15) Vilnius Gediminas Technical University. Department Department of Geodesy and Cadastre, Vilnius, Lituania;
(16) State Administration of Land Surveying and Cadastre, Czech Republic;
(17) Institute of Geodesy and Geoinformatics, Wroclaw University of Environmental and Life Sciences, Wrocław, Poland;
(18) ASG-EUPOS Management Center in Warsaw, Department of Geodesy, Cartography and Geographic Information Systems, Warsaw, Poland;
(19) Surveying and Mapping Authority of the Republic of Slovenia;
(20) Sector for Geodetic Works at Agency for Real Estate Cadastre, Macedonia;
(21) Satellite Geodetic Observatory, Institute of Geodesy Cartography and Remote Sensing, Hungary;
(22) CROPOS – CROatian POsitioning System;
(23) Geodetic Observatory Pecný and Department of Geodesy and Geodynamics of the Research Institute of Geodesy, Topography and Cartopraphy, Czech Republic;
(24) Maa-amet/Estonian Land Board Mustamäe, Tallinn, Estonia;
(25) Agency for Real State Cadastre. Republic of Macedonia

# Outline

1. Introduction
2. CEGRN 2015 «former» Campaign
3. Increased CEGRN Network
4. Conclusions (future plans)

# CEGRN Motivation and Goals (extract from the EUREF CEGRN MoU signed in Chisinau, 2011)
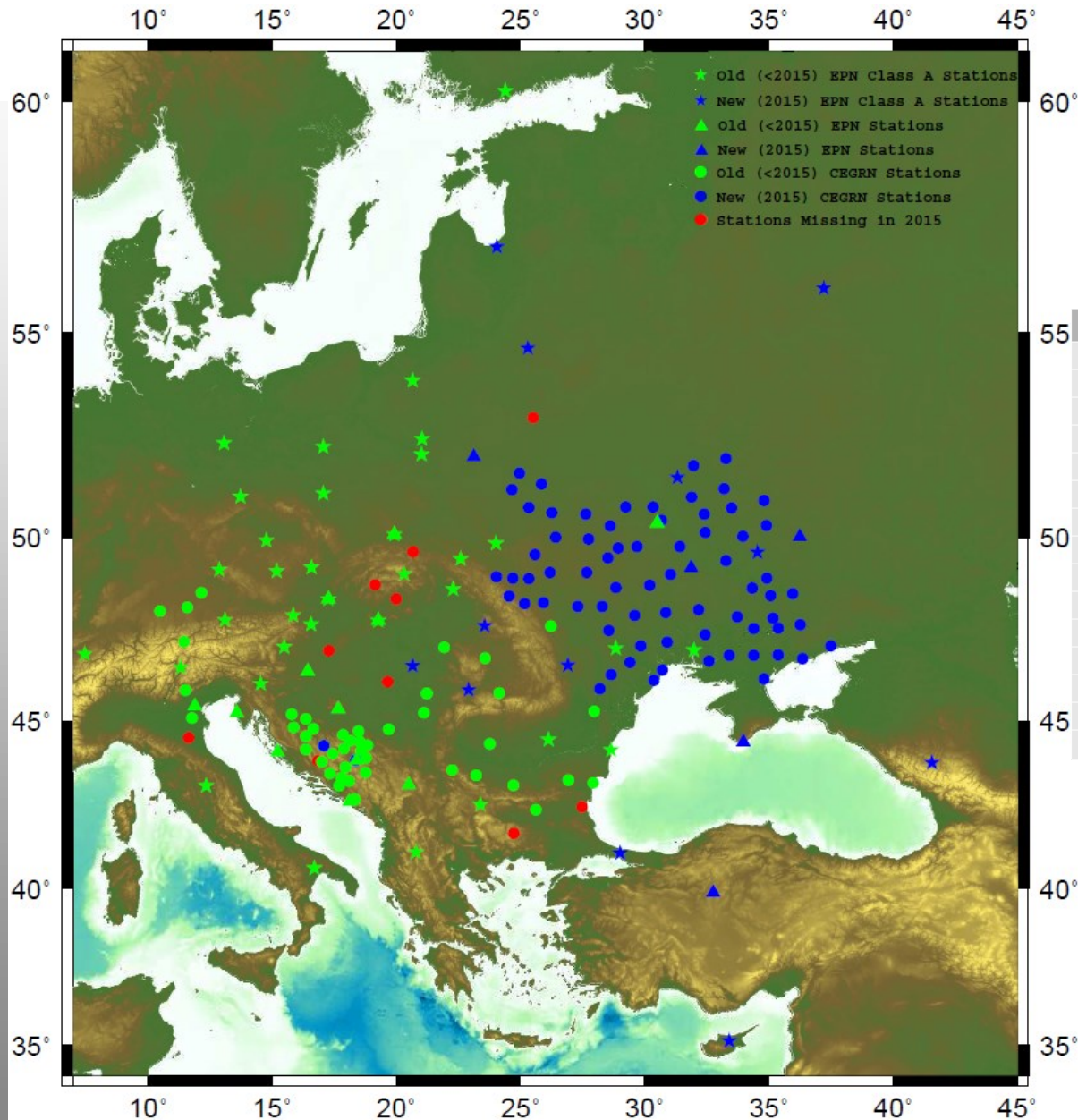
## 3. Objectives

The objective of this Memorandum of Understanding is, in general, to create the conditions to facilitate the data exchange and to promote the increase in the co-operation between the two parties, for the benefit of both, and in particular, to facilitate the densification of the European GNSS network for reference frame definition and geokinematical applications.

It is expected that a closer co-operation between EUREF and CEGRN will increase the level of support to the IAG Dense Velocity Field Project, and the availability of a combined solution with respect to a denser network.

Moreover, the co-operation will contribute to:

✓ provide better and more consistent data for geokinematics, by the optimization of guidelines for approval of networks with position and velocities and the improvement of offset treatment in time series;

✓ stimulate reprocessing of old EPN data, taking into account the foreseen realization of CEGRN 2011 and the completion of the reprocessing of the EPN;

✓ involve more nations into the INSPIRE initiative, in particular with the CRS (Coordinate Reference Systems) Implementing Rules.

# CEGRN 2015 "former" Network



Legend:
- ★ Old (<2015) EPN Class A Stations
- ★ New (2015) EPN Class A Stations
- ▲ Old (<2015) EPN Stations
- ▲ New (2015) EPN Stations
- ● Old (<2015) CEGRN Stations
- ● New (2015) CEGRN Stations
- ● Stations Missing in 2015

| CAMPAIGN | PERIOD | COUNTRIES | 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 (29P+28E) |
| CEGRN'01 | 17–23 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) | 94 |
| CEGRN'06 | 12–18 June, 2006 | only CGPS | 44 |
| CEGRN'07 | 18–23 June, 2007 | 14 (extended network) | 95 |
| CEGRN'09 | 22–27 June, 2009 | 14 (extended network) | 85 |
| CEGRN'11 | 20–25 June, 2011 | 14 (extended network) | 74 |
| CEGRN'13 | 16–22 June, 2013 | 14 | 96 |
| CEGRN'15 | 14–20 June, 2015 | 23 | 183 (UPA+MAO) |
| **CEGRN'17** | **11-17 June, 2017** | **proposed** | **proposed** |

# Increased CEGRN Network

During 2015 and 2016, several Agencies were contacted to ask about their willingness to getting involved in the CEGRN Project.

The answer was excellent, and we can summarize it in:

RINEX files:
- Albania: contributes with 6 additional stations in Albania (2003, 2005, 2007 and 2015),
- Romania: contributes with 5 additional stations in Romania starting from 2015,
- Croatia: CROPOS contributes with 33 additional stations in Croatia (starting from 2009),
- Czech Republic: CZEPOS contributes with 25 new stations (starting in 2005),
- Lithuania: contributes with 29 stations (starting from 2009),
- Macedonia: contributes with 6 stations (2015).

**SINEX files:**
- ASG (Poland): solutions from 2009 to 2015
- GKU (Slovakia): solutions from 2007 to 2015
- MAO (Ukraine): solutions from 2001 to 2015

- EUR: all available SINEX files at the CEGRN campaigns (including 2015!)

# CEGRN Increased Network
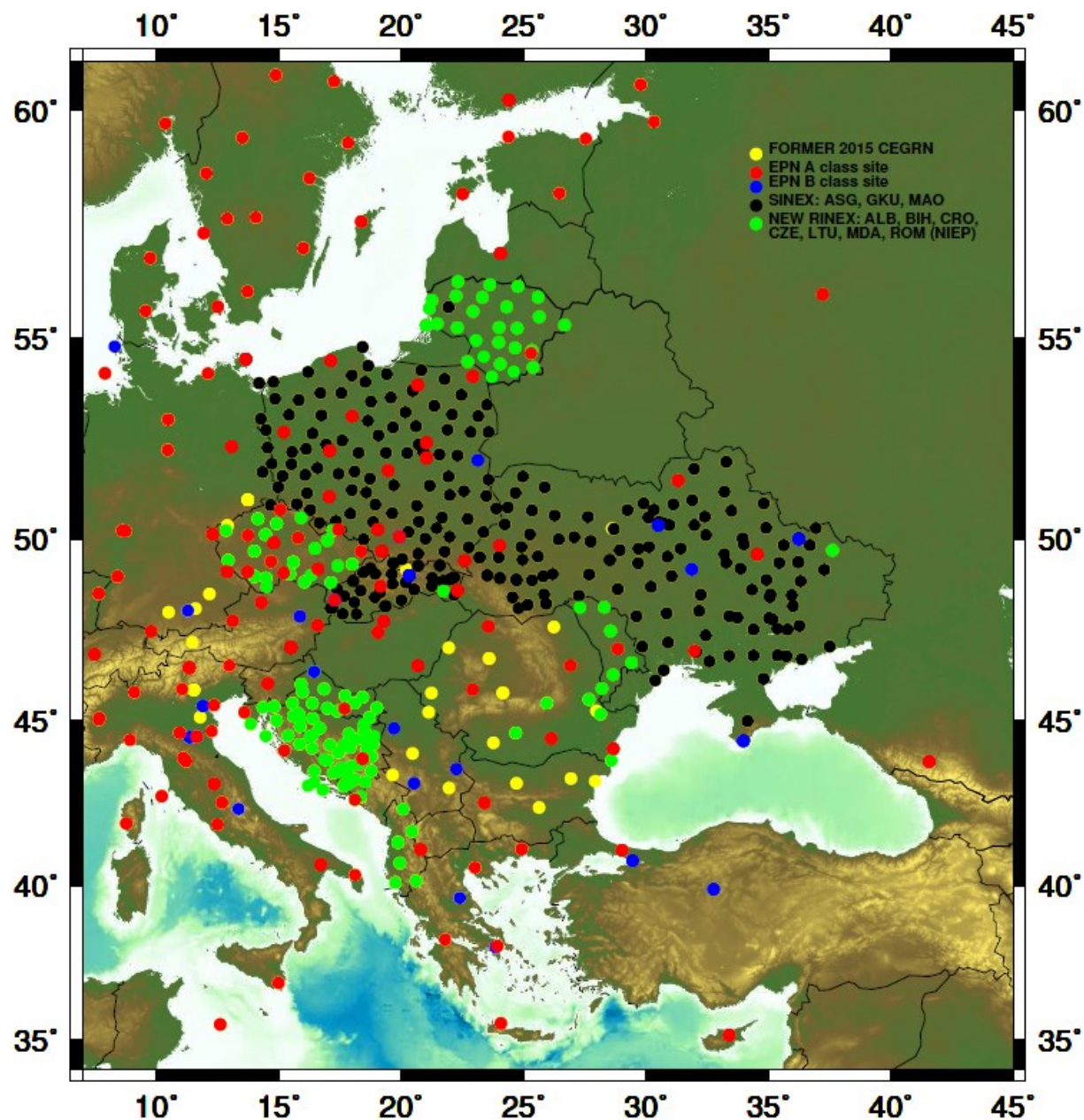
# Increased CEGRN Network

The processing strategy of the campaigns is the same as in the validated solution, but because new RINEX/SINEX files are also available, a slight change was introduced:

A) RINEX level:
- Compute the new RINEX files using EPN A class sites to align the solutions (solution UP1),
- Stack this solution with the former one (called UP0) to get the UPA${WWWW}7.NQ0 combined solution,

B) SINEX level:
- Convert all SINEX (ASG, GKU, MAO and EUR) into BSW52 NQ0 format (SNX2NQ0),
- Stack the NQ0 files to a weekly CEG${WWWW}7.NQ0 file:

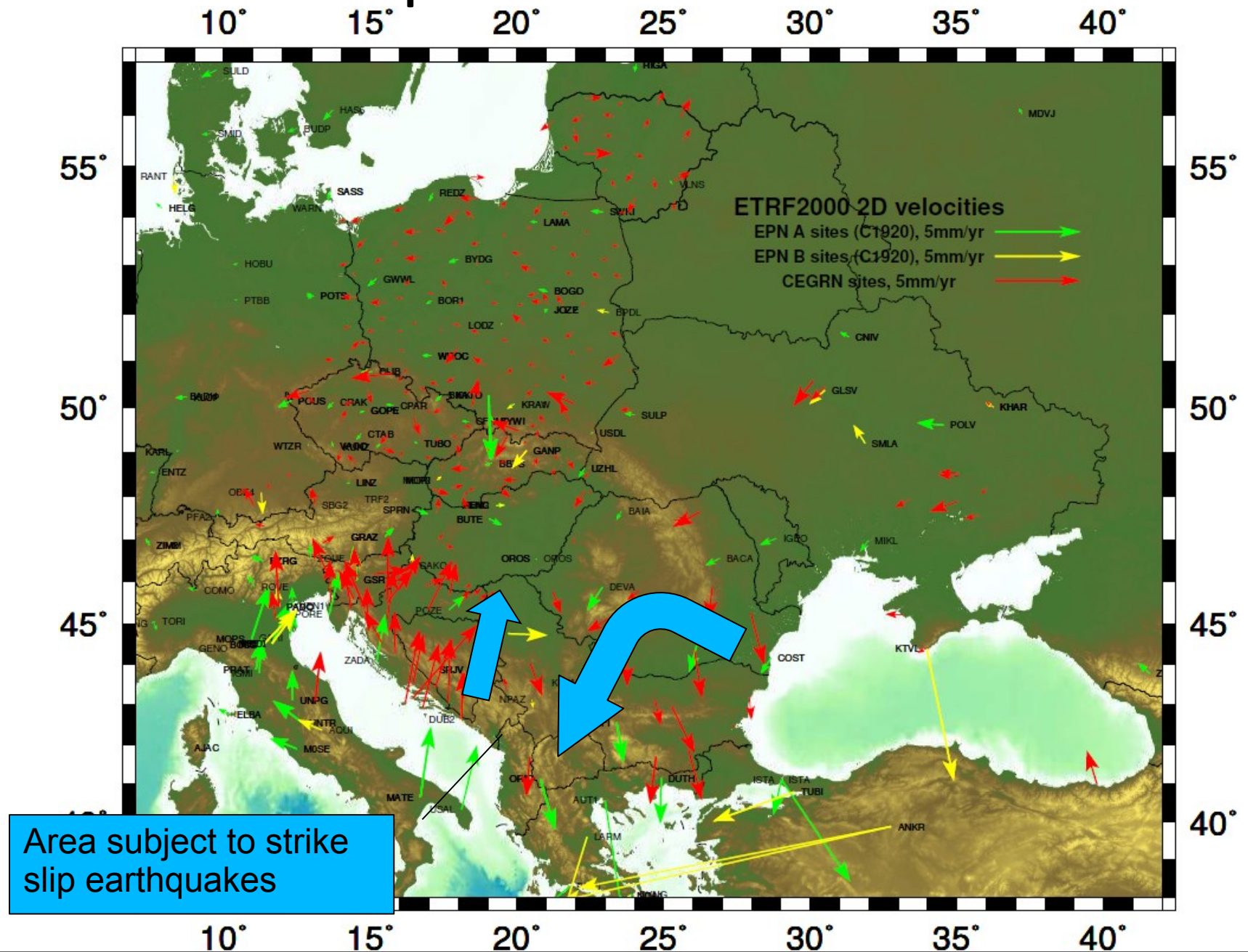UPA${WWWW}7.NQ0 + ASG${WWWW}7.NQ0 + GKU${WWWW}7.NQ0 + MAO${WWWW}7.NQ0
   + EUR${WWWW}7.NQ0 → CEG${WWWW}7.NQ0
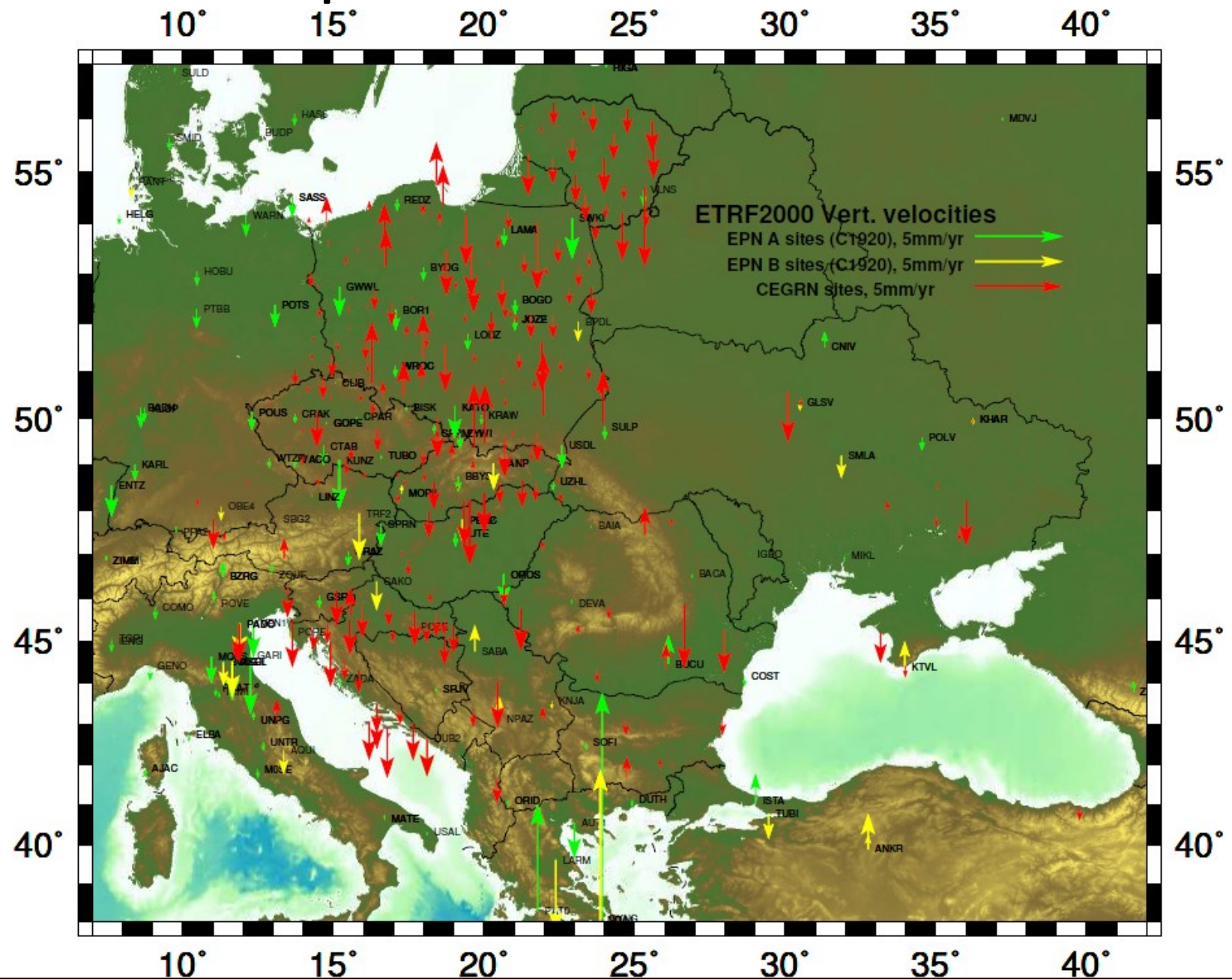ASG, GKU, UPA and MAO are repro2 compliant

# Cumulative results (combined vs individual), Helmert
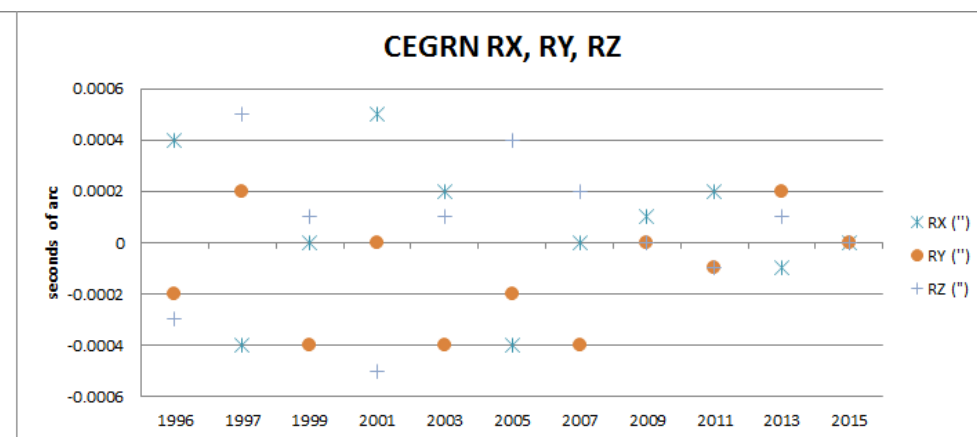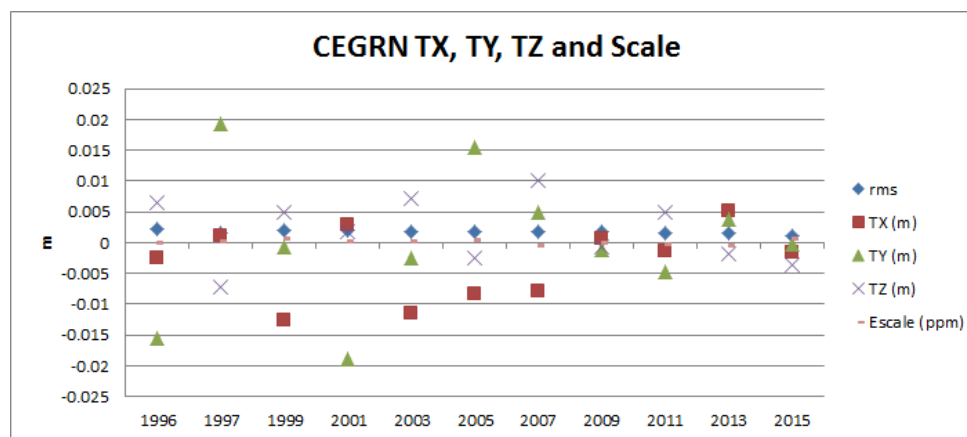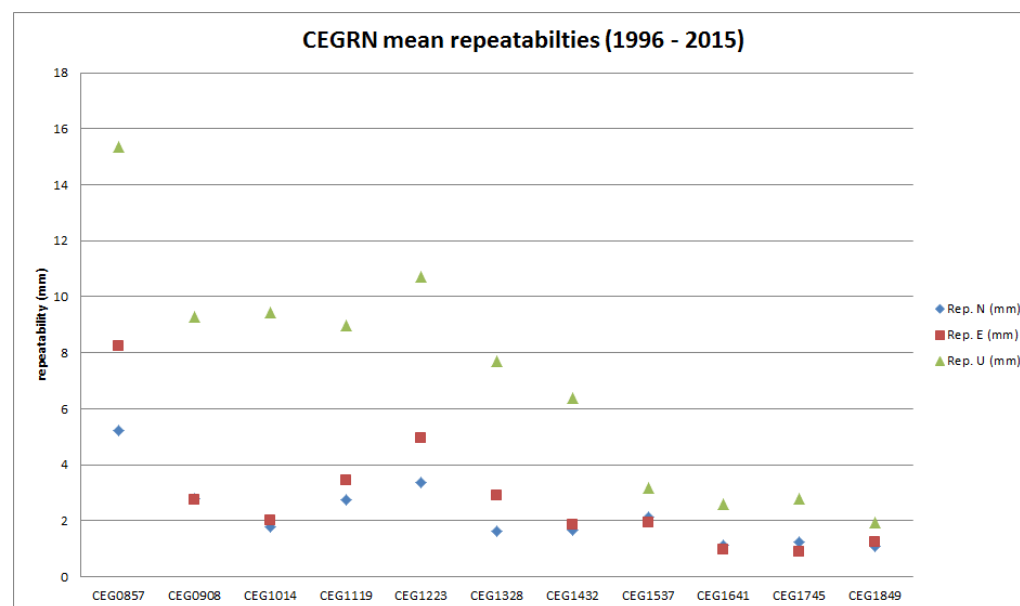
# Computed 2D Velocities

# Computed Vertical Velocities

# Conclusions

✓ We have completed 12 CEGRN campaigns bringing data spanning 1996-2015.
✓ Weekly solutions combined to corresponding EPN solutions and additional networks: ASG, GKU and MAO
✓ Coordinates and velocities computed imposing:
  ✓ Positions: MC on EPN Class A sites
  ✓ Velocities:
    ✓ Tight constraints for **A class sites** velocities;
    ✓ Others solved (no sigmas) only for a time span greater than 2 years (2 solutions) or using heavy constraint for 2 years data span. A priori velocities for these sites: Euler Pole, ITRF2008.
✓ Helmert parameters monitored epochwise relative to cumulative solution
✓ Collaboration with several Central European NMA's has increased considerably
✓ We look forward a reliable and accurate maintenance of the network for geodetic and geokinematic applications.

Many thanks to our colleagues of all the Agencies providing data.

All the results will be freely downloaded from the ftp/website (on progress)

Thank you for your attention