



Donostia - San Sebastian
May 25th - 27th, 2016



ETRS89 Densification: The CEGRN Campaign

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Outline

1. Introduction
2. CEGRN 2015 Campaign
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CEGRN Consortium

The CEGRN Consortium (*Central European GPS Geodynamic Reference Network Consortium*) serves the operation, maintenance and development of the CEGRN network, coordinates the measurements, data processing, and collaboration in different research topics. The Consortium also serves as the institutional background of the CERGOP-2/Environment Project, supported by the EU 5th Framework Programme under contract EVK2-CT-2002-00140.

A first campaign took place in 1996. Since 1997, each two years, a weekly campaign has been observed, normally in June.

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.

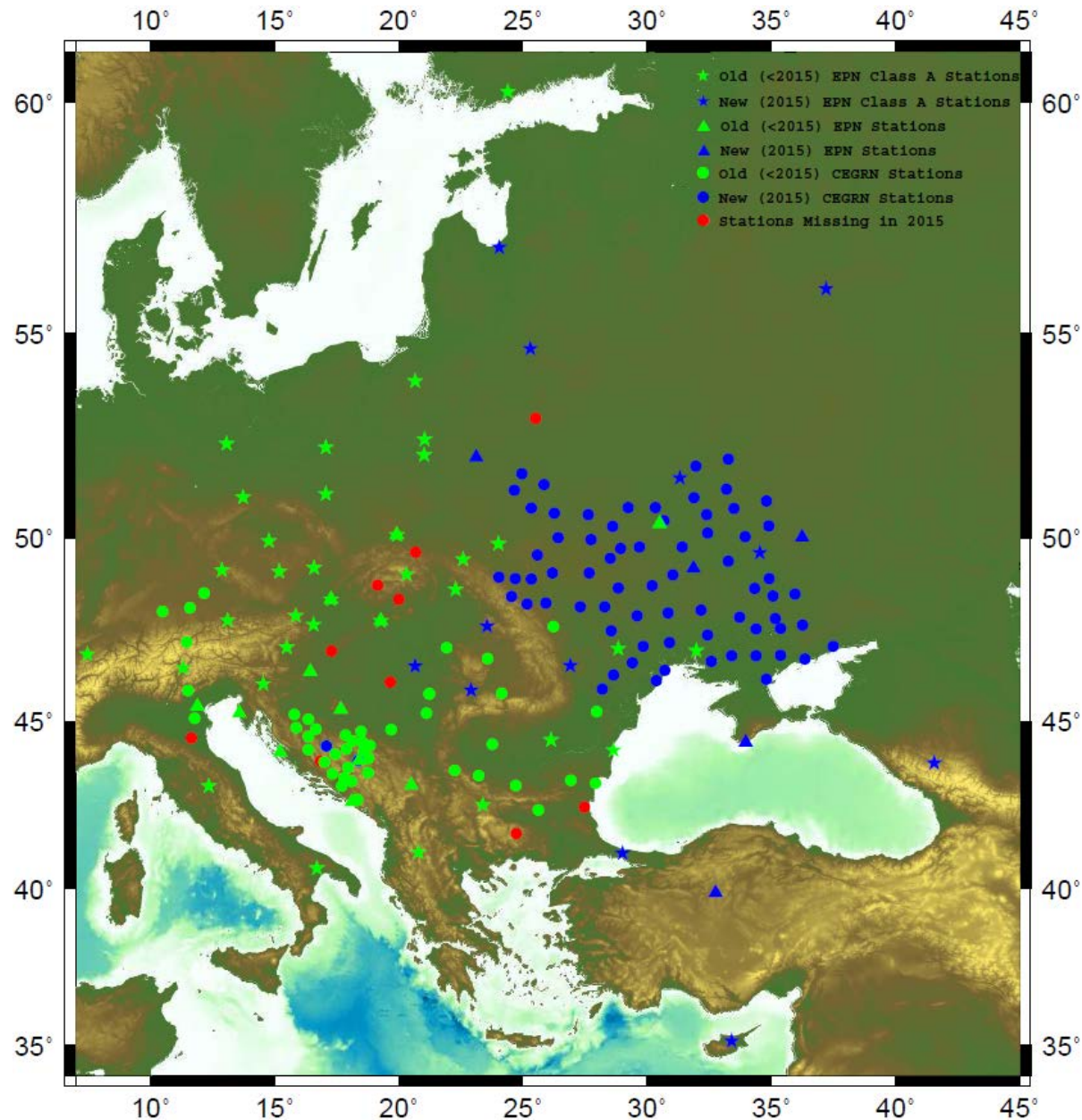
CEGRN campaigns

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)

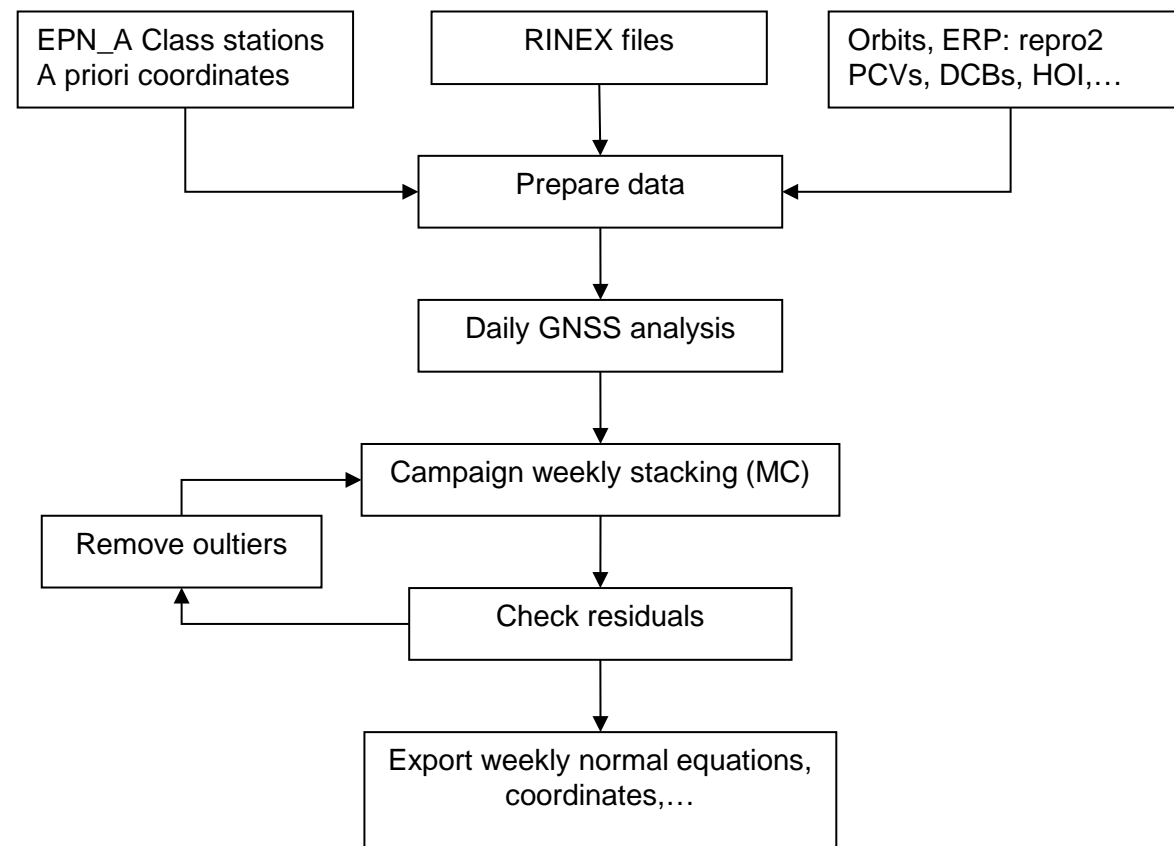
CEGRN 2015 stations

Country	Total	EPN	CEGRN	SAPOS	Country	Total	EPN	CEGRN	SAPOS
AUT	4	3	1		LTU	1	1		
BIH	26	1	25		MDA	7	1	6	
BUL	6	1	5		MKD	1	1		
CHE	1	1			POL	9	9		
CRO	5	5			ROM	12	5	7	
CYP	1	1			RUS	2	2		
CZE	3	3			SLO	1	1		
FIN	1	1			SRB	8	1	7	
GER	6	3		3	SVK	4	3	1	
HUN	4	4			TUR	2	2		
ITA	6	4	2		UKR	72	9	63	
LAT	1	1							
					Total	183	63	117	3

CEGRN 2015 Network



Processing of a weekly campaign (EUREF guidelines)



CEGRN 2015 Solution

The CEGRN 2015 Solution is a combination of two solutions at the NEQ level.

1. UPA — University of Padua, Italy:

- A. Former CEGRN network.
- B. 32 new stations in the Western Ukraine.
- C. 2 new sites in BIH.
- D. 6 new Moldavian sites.

2. MAO — Main Astronomical Observatory of the National Academy of Sciences of Ukraine, Kiev, Ukraine (stations located in Ukraine and in the Eastern Europe).

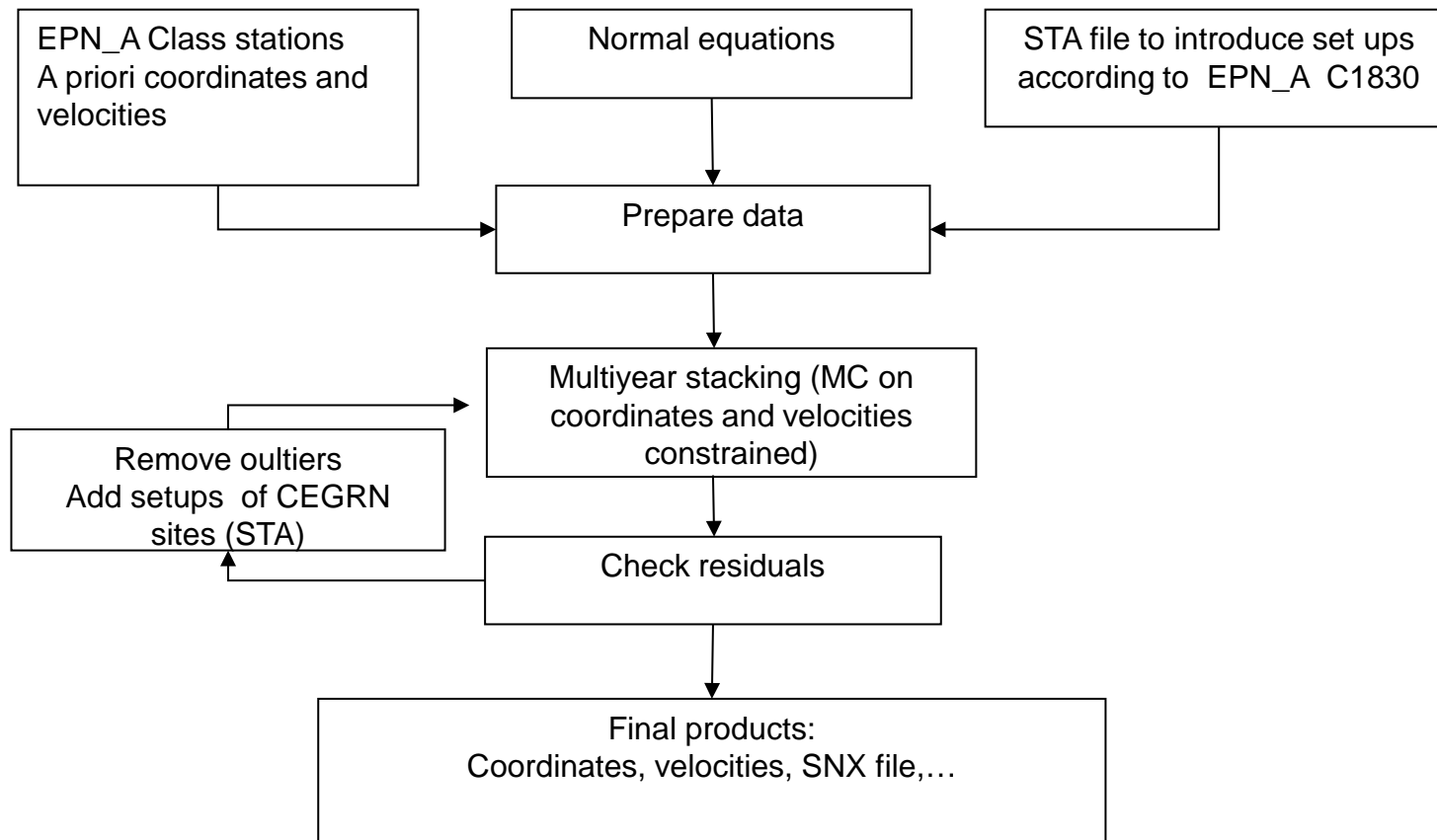
CEGRN2015 (mean repeatabilities)

Repeatability (mm)

Computed Sites	N	E	U	
134	0.92	1.02	3.55	CEGRN 2015 (UPA)
123	1.12	1.13	4.38	CEGRN 2015 (MAO)

- ✓ IERS 2010 conventions adopted
- ✓ GLONASS is included
- ✓ Cutoff angle: 3°
- ✓ Guidelines for densification strictly implemented
- ✓ Class A EPN sites for datum definition

Stacking of weekly campaign (EUREF guidelines)



Former CEGRN repeatabilities

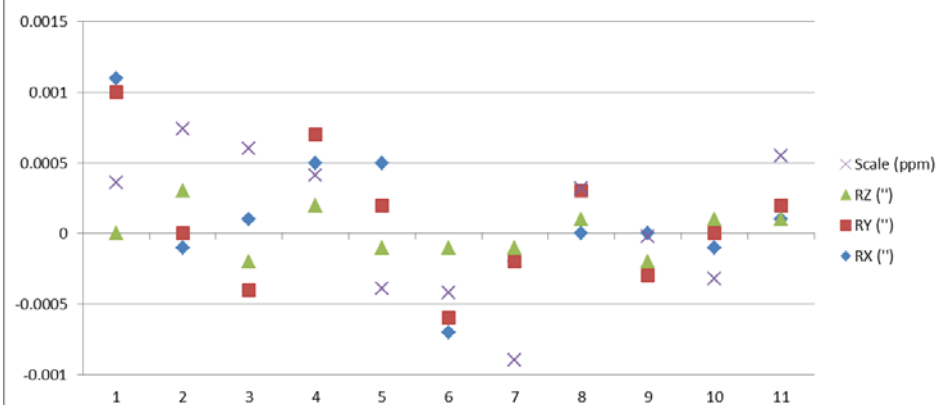
- ✓ REPRO2 implies consistent quality across 17 years.
- ✓ GLONASS was included.
- ✓ Guidelines for densification strictly implemented.
- ✓ Class A EPN sites for datum definition; solution numbers of EPN_A and B sites implemented.
- ✓ TWG validated this Network (for CRDs and VELs): [EUREF2015 resolutions \(resolution 2\)](#)
- ✓ Repeatabilities at the same level as CEGRN 2015

Computed Sites	Repeatability (mm)			
	N	E	U	
50	1.54	1.16	3.82	CEGRN 1996
44	1.34	1.01	3.40	CEGRN 1997
62	1.46	0.97	3.73	CEGRN 1999
57	1.16	0.83	3.77	CEGRN 2001
77	1.20	0.93	3.19	CEGRN 2003
105	1.14	0.91	3.74	CEGRN 2005
95	1.37	1.23	4.06	CEGRN 2007
85	1.18	0.98	3.83	CEGRN 2009
60	0.82	0.90	3.24	CEGRN 2011
101	1.02	1.15	3.90	CEGRN 2013
134	0.92	1.02	3.55	CEGRN 2015 (UPA)
123	1.12	1.13	4.38	CEGRN 2015 (MAO)

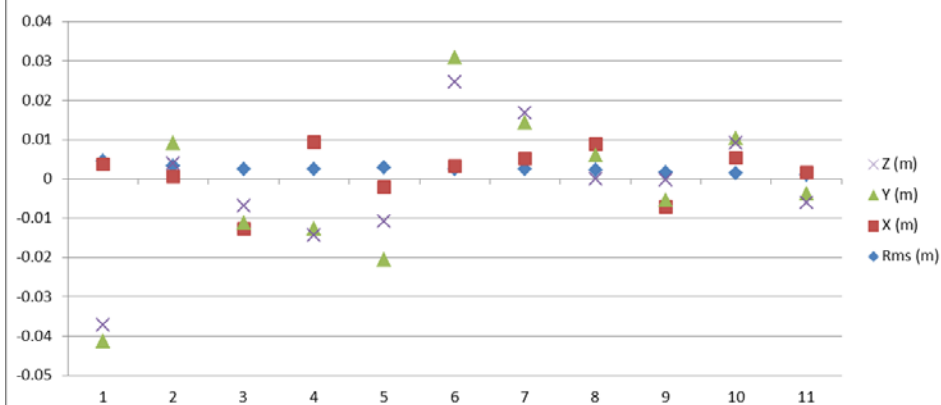
Cumulative results (combined vs individual)

Sol (Yr)	Rms (m)	X (m)	Y (m)	Z (m)	RX (")	RY (")	RZ (")	Scale (ppm)
1996	0.00461	-0.0009	-0.045	0.0043	0.0011	-0.0001	-0.001	0.00036
1997	0.00323	-0.0027	0.0085	-0.0051	-0.0001	0.0001	0.0003	0.00044
1999	0.00253	-0.0153	0.0015	0.0043	0.0001	-0.0005	0.0002	0.0008
2001	0.00254	0.0067	-0.0219	-0.0017	0.0005	0.0002	-0.0005	0.00021
2003	0.00286	-0.0049	-0.0186	0.0099	0.0005	-0.0003	-0.0003	-0.00029
2005	0.00245	0.0008	0.0276	-0.0062	-0.0007	0.0001	0.0005	-0.00032
2007	0.00252	0.0027	0.009	0.0026	-0.0002	0	0.0001	-0.0008
2009	0.00225	0.0066	-0.0028	-0.0061	0	0.0003	-0.0002	0.00022
2011	0.00162	-0.0087	0.0016	0.0052	0	-0.0003	0.0001	0.00018
2013	0.00145	0.0039	0.0049	-0.0012	-0.0001	0.0001	0.0001	-0.00042
2015	0.00103	0.0007	-0.0055	-0.0022	0.0001	0.0001	-0.0001	0.00045

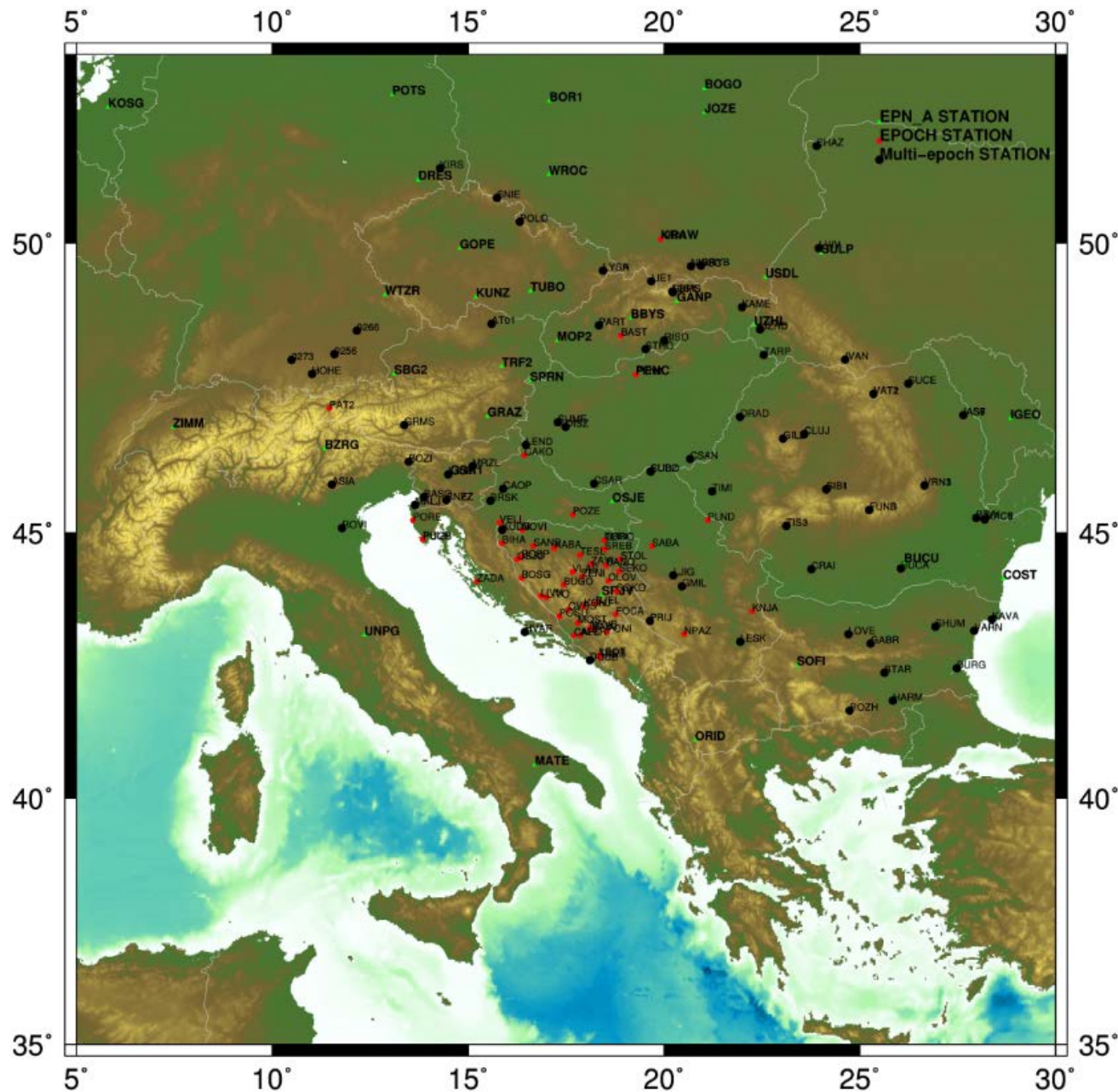
Combined vs Individual solutions: rotations and scale



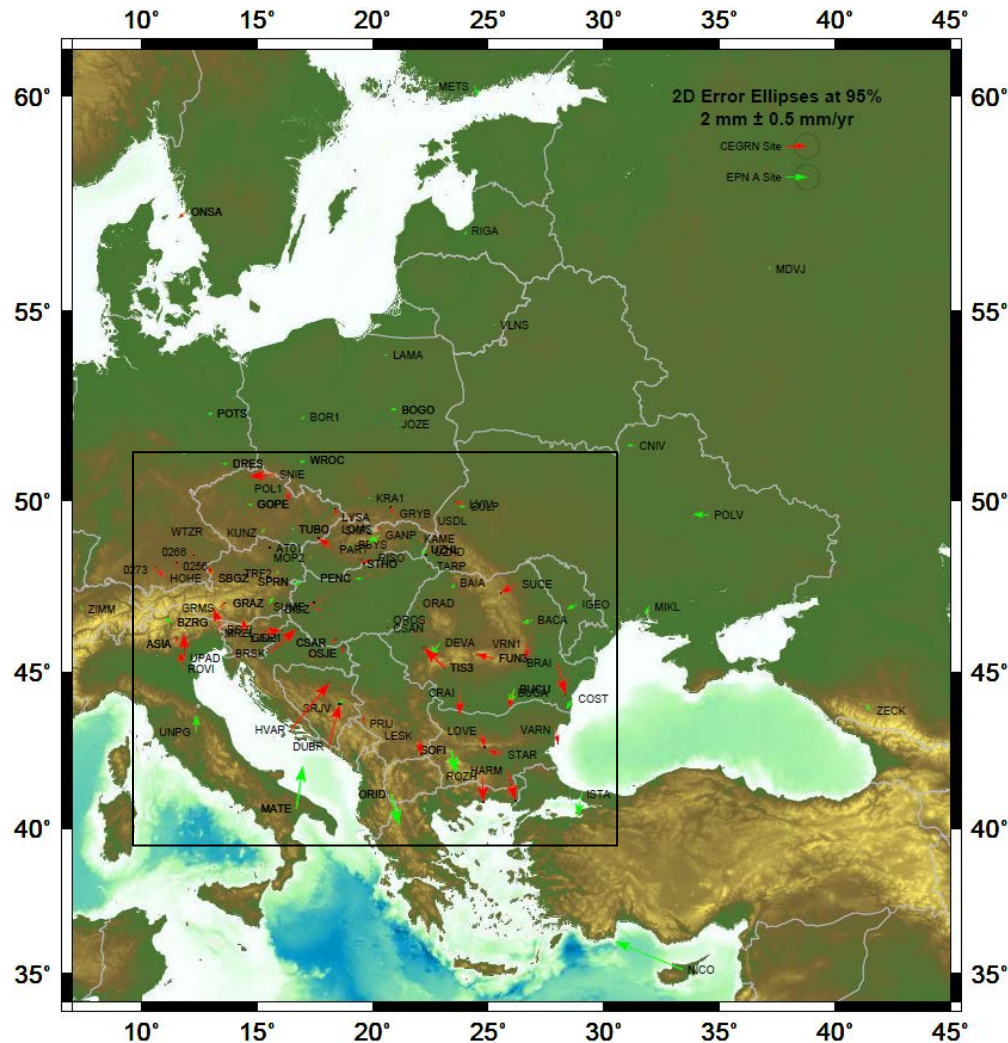
Combined vs Individual solutions: rms and translations



Former (validated) CEGRN Network



Horizontal Velocities (ETRF2000) of CEGRN A class sites



Enlarged "Class A" sites



Map of Europe showing the distribution of EPN and CEGRN sites. The map includes latitude and longitude coordinates (10° to 45° N, 10° to 45° E). Sites are marked with red and blue dots, and a legend in the bottom right corner indicates the site types and their corresponding colors.

Legend:

- +3 mm/yr EPN A sites (Red line)
- 3 mm/yr EPN A sites (Blue line)
- +3 mm/yr CEGRN sites (Red line)
- 3 mm/yr CEGRN sites (Blue line)

Conclusions

- ✓ We have completed 12 CEGRN campaigns bringing data spanning 1996–2015.
- ✓ DOMES numbers and IGS log files are required for a number of CEGRN sites.
- ✓ Increasing data in 2015 thanks to Ukraine, Moldova, and Serbia contributed new sites.
- ✓ The velocities of old CEGRN sites become more reliable and more accurate velocities from the Ukrainian, Moldovian, and Serbian sites are expected in the near future.
- ✓ Likewise for Bosnia and Herzegovina, for example, that contributed with considerable number of stations in 2013.
- ✓ For CEGRN 2015: grateful for successful cooperation with the Main Astronomical Observatory of the National Academy of Sciences of Ukraine (Kiev, Ukraine).
- ✓ We acknowledge to the System Solutions (Kiev, Ukraine), the Institute of Geodesy, Engineering Research and Cadastre "INGEOCAD" (Chisinau, Moldova), and Republic Geodetic Authority (Belgrade, Serbia) for providing data for new GNSS stations.

Thank you for your attention!