# EUREF densification camapaign in Republic of Serbia

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# OUTLINE

1. Description of the campaign
2. Datum definition
3. Processing parameters
4. Results
5. Conclusions

# Description of the campaign

# Description of the campaign

- 20 EPN class A stations
- 48 stations from national permanent networks
  - 29 AGROS stations
  - 13 MAKPOS stations
  - 3 FOMI stations
  - 3 BULIPOS stations
- 19 field points
  - 6 EUREF BALKAN 98 Serbian block
  - 7 EUREF FYROM 96
  - 6 from SREF project

# Description of the campaign

## EPN stations

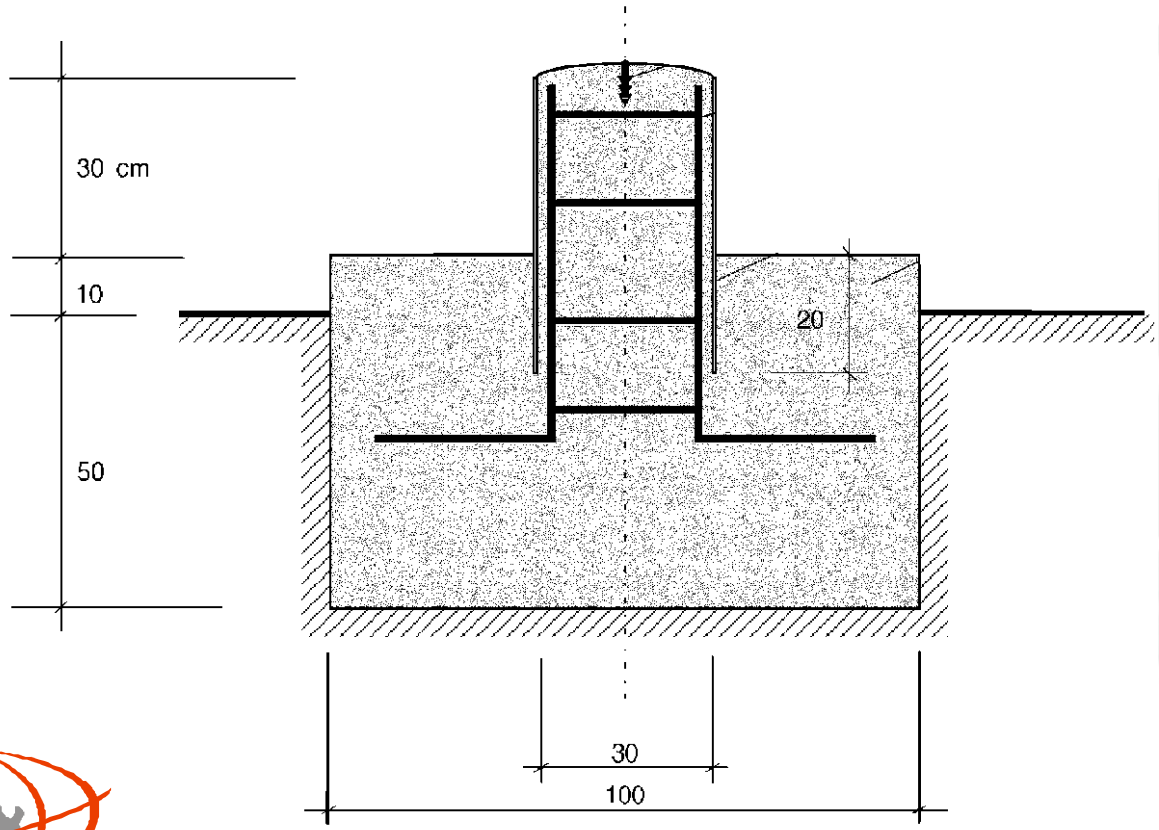
| 4-char ID | Domes No. | Full Name | Network |
|---|---|---|---|
| AUT1 | 12619M002 | Thessaloniki | EPN A fiducial station, Processed data |
| BACA | 11405M001 | Bacau | EPN A fiducial station, Processed data |
| BAIA | 11406M001 | Baia Mare | EPN A fiducial station, Processed data |
| BUCU | 11401M001 | Bucuresti | EPN A fiducial station, Processed data |
| BZRG | 12751M001 | Bolzano-Bozen | EPN A fiducial station, Processed data |
| DEVA | 11408M001 | Deva | EPN A fiducial station, Processed data |
| DUBR | 11901M001 | Dubrovnik | EPN A fiducial station, Processed data |
| GRAZ | 11001M002 | Graz-Lustbuehel | EPN A fiducial station, Processed data |
| GSR1 | 14501M001 | Ljubljana | EPN A fiducial station, Processed data |
| ISTA | 20807M001 | Istanbul | EPN A fiducial station, Processed data |
| MATE | 12734M008 | Matera | EPN A fiducial station, Processed data |
| ORID | 15601M001 | Ohrid | EPN A fiducial station, Processed data |
| OROS | 11207M001 | Oroshaza | EPN A fiducial station, Processed data |
| OSJE | 11902M001 | Osijek | EPN A fiducial station, Processed data |
| PADO | 12750S001 | Padova | EPN A fiducial station, Processed data |
| PENC | 11206M006 | Penc | EPN A fiducial station, Processed data |
| SOFI | 11101M002 | Sofija | EPN A, Processed data |
| SRJV | 11801S001 | Sarajevo | EPN A fiducial station, Processed data |
| WTZR | 14201M010 | Bad Koetzting | EPN A, Processed data |
| ZIMM | 14001M004 | Zimmerwald | EPN A fiducial station, Processed data |

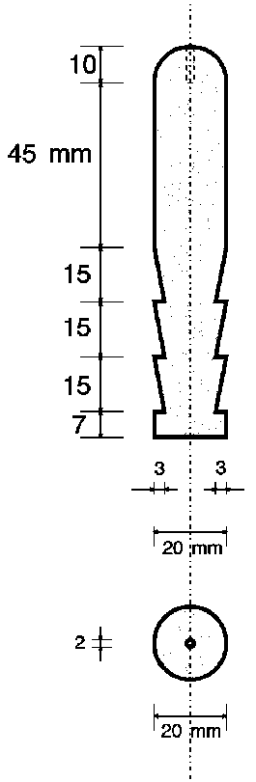
# Description of the campaign



# Description of the campaign

## Monument type for points from SREF project



# Description of the campaign

## Monument type for EUREF points

# Description of the campaign

## GNSS equipment

- Trimble 5700, TRM41249.00 TZGD (mainly for AGROS stations)

Other equipment models used for the campaign

Receivers

- Trimble NETR5, Trimble NETRS, Trimble 4000 series, LEICA GRX1200GGPRO, LEICA SR530

Antennas

- TRM39105.00 NONE, TRM55971.00 NONE, TRM29659.00 NONE, LEIAT504GG LEIS, TRM33429.00+GP NONE

# Description of the campaign

## Observation period

5 GPS weeks (1595-1599)

Observation period for the filed points was 5 days during the GPS week 1597

# Description of the campaign

## Processing

- processing is done in October 2010 by Republic Geodetic Authority
- following the “Guidelines for EPN Analysis Centers”
- Bernese GPS Software, version 5.0, update February 18, 2010

# Datum definition

## Fiducial points

| 4-char ID | Domes No. | Full Name | Network |
|---|---|---|---|
| AUT1 | 12619M002 | Thessaloniki | EPN A fiducial station, Processed data |
| BACA | 11405M001 | Bacau | EPN A fiducial station, Processed data |
| BAIA | 11406M001 | Baia Mare | EPN A fiducial station, Processed data |
| BUCU | 11401M001 | Bucuresti | EPN A fiducial station, Processed data |
| BZRG | 12751M001 | Bolzano-Bozen | EPN A fiducial station, Processed data |
| DEVA | 11408M001 | Deva | EPN A fiducial station, Processed data |
| DUBR | 11901M001 | Dubrovnik | EPN A fiducial station, Processed data |
| GRAZ | 11001M002 | Graz-Lustbuehel | EPN A fiducial station, Processed data |
| GSR1 | 14501M001 | Ljubljana | EPN A fiducial station, Processed data |
| ISTA | 20807M001 | Istanbul | EPN A fiducial station, Processed data |
| MATE | 12734M008 | Matera | EPN A fiducial station, Processed data |
| ORID | 15601M001 | Ohrid | EPN A fiducial station, Processed data |
| OROS | 11207M001 | Oroshaza | EPN A fiducial station, Processed data |
| OSJE | 11902M001 | Osijek | EPN A fiducial station, Processed data |
| PADO | 12750S001 | Padova | EPN A fiducial station, Processed data |
| PENC | 11206M006 | Penc | EPN A fiducial station, Processed data |
| SRJV | 11801S001 | Sarajevo | EPN A fiducial station, Processed data |
| ZIMM | 14001M004 | Zimmerwald | EPN A fiducial station, Processed data |

# Datum definition

## Datum definition (ITRF2005)

- ITRF2005 epoch 2010.631
- Based on EPN cumulative solution EPN_A_ITRF2005_C1600

# Datum definition

## Datum definition type

- Minimum constraint solution on fiducial stations
- Minimum constraint condition is no net translation

# Processing parameters

- IGS final precise orbits, Earth rotation parameters, and satellite clock information
- CODE Ionosphere maps and Differential code biases for satellites and receivers
- absolute antenna model for antenna phase centre variations based on IGS05 model was used for processing
- converted epn_05_1604.atx to Bernese format
- individual antenna calibrations for 5 EPN fiducial stations listed in file above

# Processing parameters

## Preprocessing

- single differences and marking of observations before cycle slip detection:
- elevation mask 3°, minimum time interval for continuous observation 361 seconds and max gap 181 seconds
- identification of data without cycle slips and in remaining data find if possible repair cycle slips at L3 linear combination

# Processing parameters

Receiver clock synchronization

- single point positioning for each station, using orbit and clock information
- code observation files

Elevation angel cutoff

- 3 degrees, elevation dependent weighting
- 10 degrees for QIF ambiguity resolution

Data sampling

- 30 seconds, QIF ambiguity resolution
- 180 seconds, for Final processing

# Processing parameters

## Modeling troposphere

- Saastamoinen model in single point positioning
- Niell model for zenith path delay and mapping function
- Dry Neill as a-priori troposphere model for zenith path delay in solving ambiguity float double differences solution

## Modeling ionosphere

- Ionosphere free $L_3$ linear combination nearly complitly eliminates ionospheric refraction effects
- In QIF ambiguity resolution strategy the L1+L2 observable used then CODE ionosphere models were introduced to improve QIF ambiguity resolution

## Handling of ambiguities

- ambiguity resolution is done baseline by baseline
- the quasi-ionosphere-free resolution strategy was used to resolve L1 and L2 ambiguities
- cut-off angel used was 10°

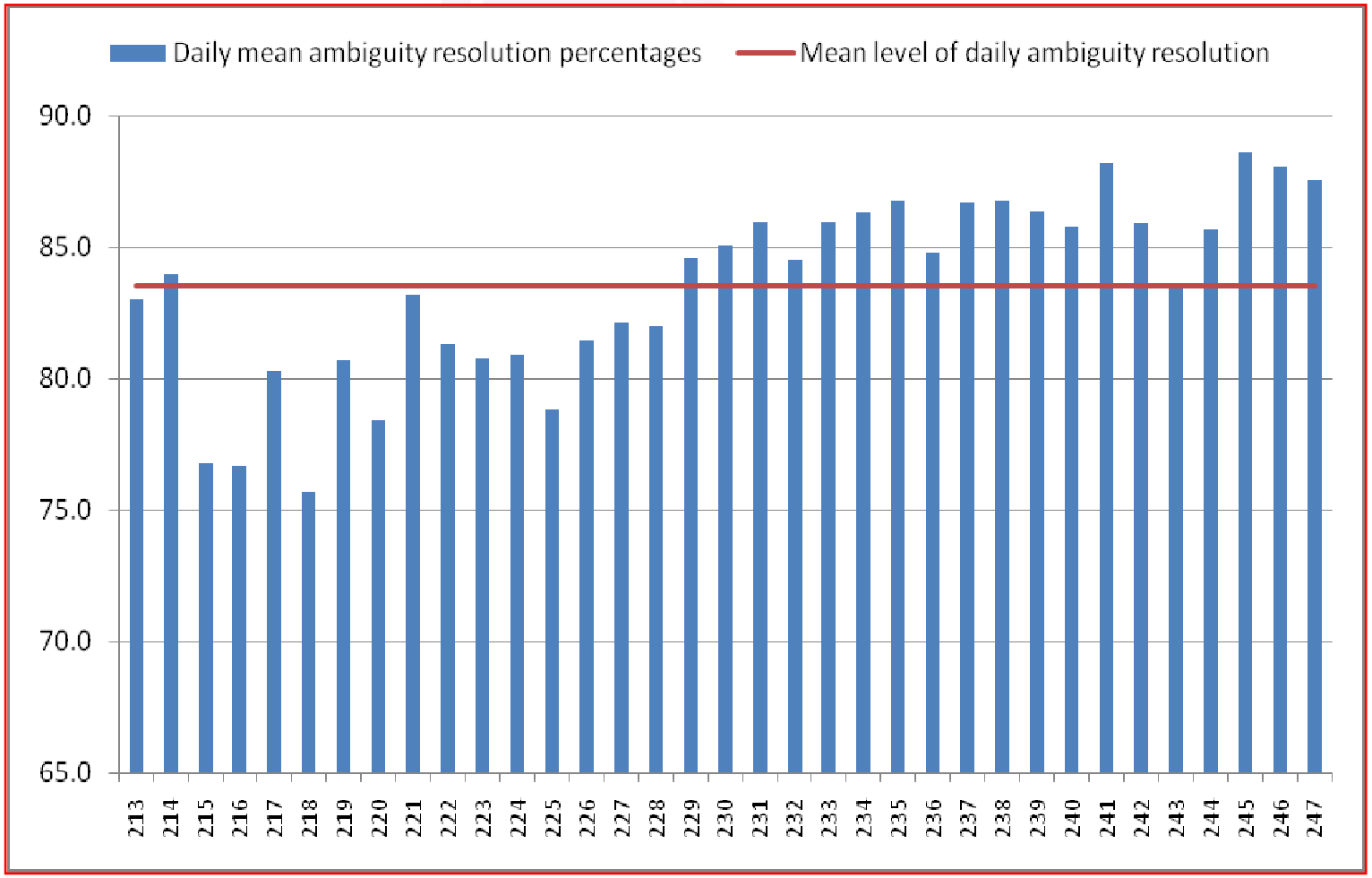
# Processing parameters

Planetary Ephemeris
– DE200

Ocean loading
– Model computed by H.G.Sherneck Onsala Space Observatory
– FES2004 model without correction for the centre of mass motion of the Earth for each station

# Results

## Daily mean ambiguity resolution percentages

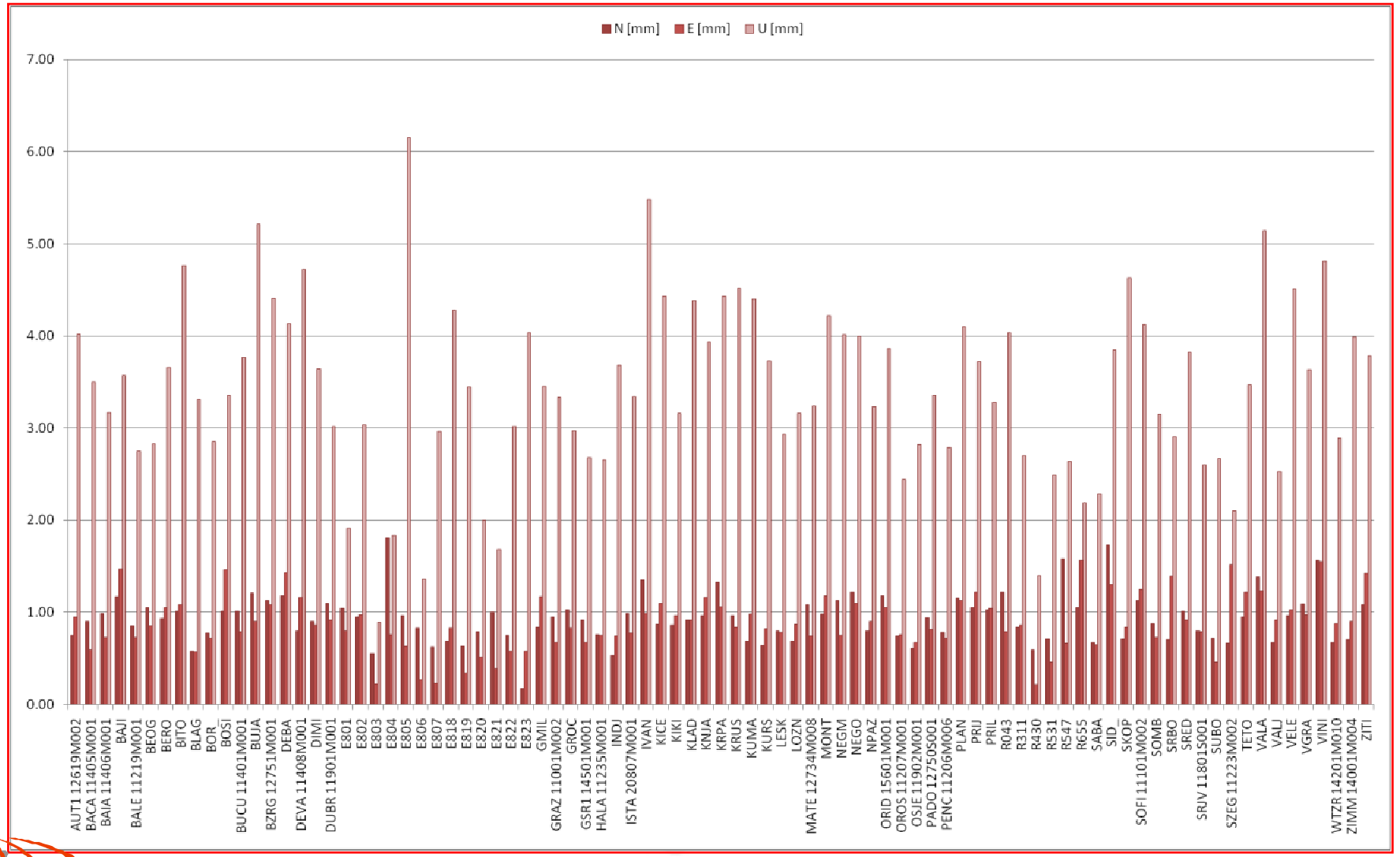


# Results

## Repeatabilities

Daily network solutions minimal constrained on fiducial stations are used for checking daily repeatability of coordinates for all stations in EUREF Serbia 2010.

# Results


N [mm]
E [mm]
U [mm]
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
AUT1 12619M002
BACA 11405M001
BAIA 11406M001
BAJI
BALE 11219M001
BEOG
BERO
BITO
BLAG
BOR_
BOSI
BUCU 11401M001
BUJA
BZRG 12751M001
DEBA
DEVA 11408M001
DIMI
DUBR 11901M001
E801
E802
E803
E804
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E806
E807
E818
E819
E820
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E822
E823
GMIL
GRAZ 11001M002
GROC
GSR1 14501M001
HALA 11235M001
INDJ
ISTA 20807M001
IVAN
KICE
KIKI
KLAD
KNJA
KRPA
KRUS
KUMA
KURS
LESK
LOZN
MATE 12734M008
MONT
NEGM
NEGO
NPAZ
ORID 15601M001
OROS 11207M001
OSJE 11902M001
PADO 12750S001
PENC 11206M006
PLAN
PRIJ
PRIL
R043
R311
R430
R531
R547
R655
SABA
SID_
SKOP
SOFI 11101M002
SOMB
SRBO
SRED
SRJV 11801S001
SUBO
SZEG 11223M002
TETO
VALA
VALJ
VELE
VGRA
VINI
WTZR 14201M010
ZIMM 14001M004
ZITI

# Results

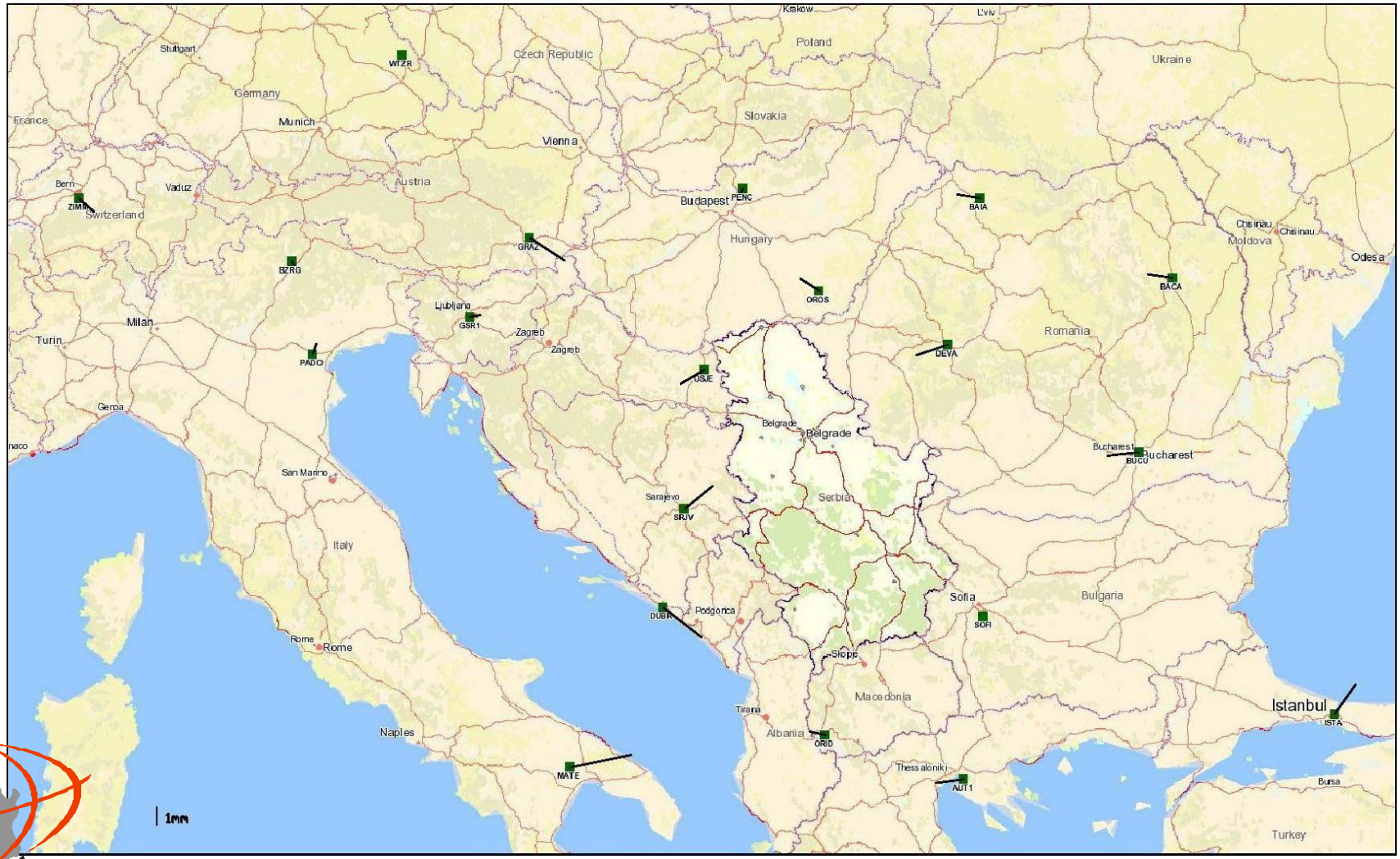
Comparison with latest EUREF densification of ITRS

Comparison of ITRF2005/2010.631 coordinates vs. coordinates from EUREF solution EPN_A_ITRF2005_C1600

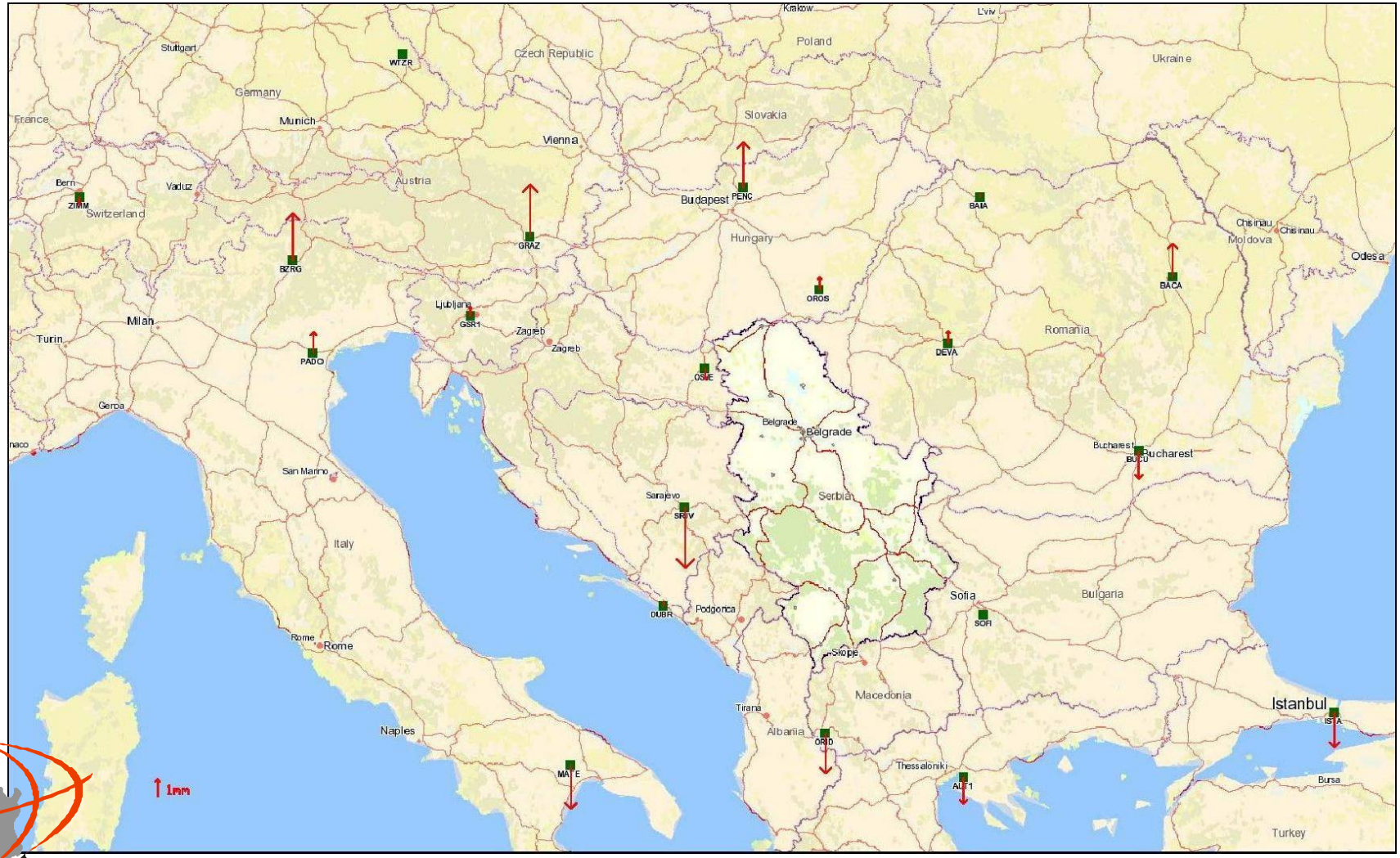
# Results

| Station | N [mm] | E [mm] | U [mm] |
|---|---|---|---|
| AUT1 12619M002 | -0,2 | -1,6 | -1,5 |
| BACA 11405M001 | 0,2 | -1,4 | 1,9 |
| BAIA 11406M001 | 0,2 | -1,3 | 0,1 |
| BUCU 11401M001 | -0,2 | -1,8 | -1,6 |
| BZRG 12751M001 | -0,2 | 0,1 | 2,7 |
| DEVA 11408M001 | -0,6 | -1,8 | 0,7 |
| DUBR 11901M001 | -1,7 | 2,2 | 0,2 |
| GRAZ 11001M002 | -1,3 | 2,0 | 3,0 |
| GSR1 14501M001 | 0,1 | 0,6 | 0,5 |
| ISTA 20807M001 | 1,7 | 1,2 | -2,0 |
| MATE 12734M008 | 0,7 | 3,5 | -2,5 |
| ORID 15601M001 | 0,2 | -0,9 | -2,3 |
| OROS 11207M001 | 0,7 | -1,1 | 0,7 |
| OSJE 11902M001 | -0,8 | -1,4 | -0,6 |
| PADO 12750S001 | 0,6 | 0,2 | 1,2 |
| PENC 11206M006 | -0,2 | -0,1 | 2,6 |
| SRJV 11801S001 | 1,3 | 1,6 | -3,5 |
| ZIMM 14001M004 | -0,8 | 0,9 | -0,4 |
| **RMS / COMPONENT** | **0,9** | **1,6** | **1,9** |

# Results


Krakow
L'viv
Stuttgart
WTZR
Czech Republic
Poland
Ukraine
Germany
France
Munich
Slovakia
Vienna
Bern
ZIMM
Vaduz
Austria
Switzerland
Budapest
PENC
BAIA
Chisinau
Chisinau
Moldova
Hungary
GRAZ
Odesa
BZRG
BACA
OROS
Ljubljana
GSR1
Milan
Turin
Zagreb
Zagreb
Romania
PADO
DEVA
OSIJ
Genoa
Belgrade
Belgrade
Bucharest
BUCU
Bucharest
San Marino
Sarajevo
SRJV
Serbia
Italy
Sofia
Bulgaria
Podgorica
DUBR
SOFI
Rome
Rome
Skopje
Macedonia
Istanbul
ISTA
Tirana
Albania
ORID
Naples
MATE
Thessaloniki
AUT1
Bursa
Turkey
1mm

# Results


Krakow
Lviv
Stuttgart
WTZR
Czech Republic
Poland
Ukraine
Germany
France
Munich
Slovakia
Vienna
Bern
ZIMM
Vaduz
Austria
Budapest
PENC
BAIA
Switzerland
GRAZ
Hungary
Chisinau
Chisinau
Moldova
Odesa
BZRG
BACA
OROS
Ljubljana
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DEVA
OSME
Genoa
Belgrade
Belgrade
Bucharest
BUCU
Bucharest
San Marino
Sarajevo
SRJV
Serbia
Italy
Sofia
Bulgaria
Podgorica
DUBR
SOFI
Rome
Rome
Skopje
Macedonia
Tirana
Istanbul
ISTA
Albania
ORID
Naples
Thessaloniki
Bursa
MATE
ALIT1
1mm
Turkey

# Results

## Alternative combined solution

- An alternative solution for the campaign was produced
- The difference from the final solution is in the datum definition type
- The campaign solutions on weekly basis are combined with weekly EPN solutions downloaded from ftp server BKG

# Results

## Transformation to ETRS89

- The transformation of the ITRF2005/2010.631 to ETRF2000/2010.631 is done by EPN tool on the web site http://www.epncb.oma.be/_dataproducts/coord_trans/

# Results

## Comparison with previous ETRS89 densification

| Station | 6 par estimated | | | 3(t) par estimated | | | PLAIN | | |
|---|---|---|---|---|---|---|---|---|---|
| | N [mm] | E [mm] | U [mm] | N [mm] | E [mm] | U [mm] | N [mm] | E [mm] | U [mm] |
| E818 | -13.4 | 5.0 | -2.2 | -14.2 | 3.5 | -5.0 | -24.6 | -0.2 | -52.7 |
| E819 | -5.1 | 9.4 | -12.9 | -5.1 | 8.8 | -13.3 | -14.7 | 4.5 | -61.1 |
| E820 | -3.2 | -2.2 | 8.9 | -4.0 | -2.5 | 6.7 | -13.1 | -6.2 | -41.3 |
| E821 | -2.1 | -1.0 | 1.4 | -2.2 | -0.1 | 1.3 | -10.4 | -4.3 | -46.8 |
| E822 | 18.7 | 3.4 | 16.8 | 19.5 | 3.7 | 19.3 | 10.6 | -1.3 | -28.6 |
| E823 | 4.8 | -15.2 | -11.2 | 5.6 | -13.9 | -8.2 | -2.2 | -18.9 | -56.3 |
| **RMS / COMPONENT** | **10.9** | **8.5** | **11.5** | **11.5** | **7.8** | **11.7** | **15.6** | **9.3** | **53.7** |

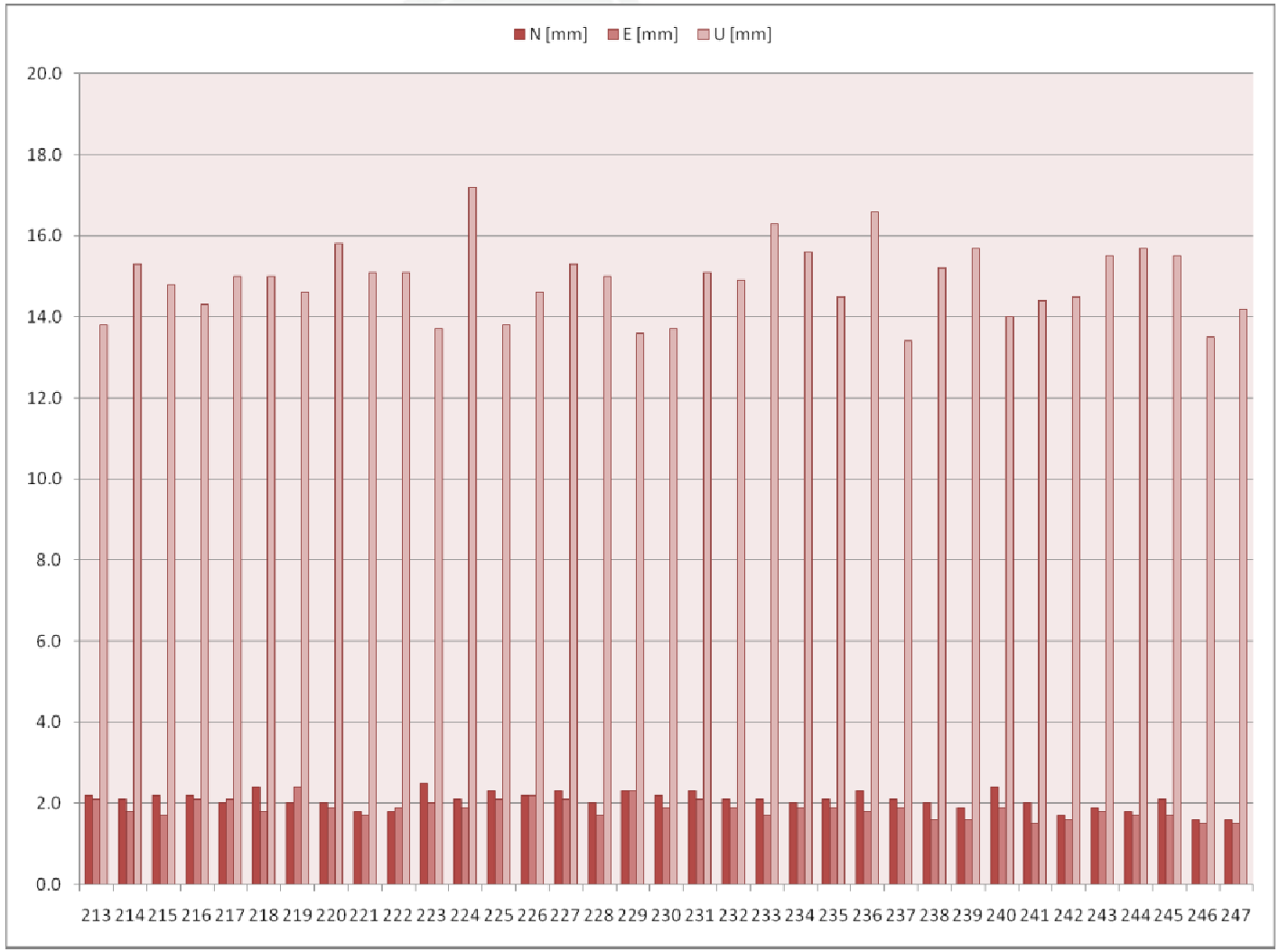
# Results

## Elevation cut – off test

- RGA is producing a test solution with cut-off angle 25°
- Comparison to the final 3° solution
- Big differences between these two solutions at stations with antenna Trimble Zephyr (TRM39105.00 NONE)

# Results

## Elevation cut – off test



# Conclusions

- The internal quality of the solution is around 1 to 2 mm in and N and E and around 3 to 5 in U
- The coordinate recoveries of fiducial stations indicate that ITRF2005 for EUREF Serbia 2010 is realized to around 2mm in all three components
- Comparison with EUREF Balkan 98 campaign based on ITRF96 is at 20mm level compared in ETRF2000, except a shift in height of 4-5cm

# Conclusions

- Results from elevation cut off test show different level of accuracy depending on antenna type used and site dependent effects. The stations with non geodetic antennas have lower level of accuracy.
- All stations with the antenna Trimble Zephyr (TRM39105.00 NONE) which is not a geodetic antenna were excluded from validation at the EUREF Technical working group meeting. The stations excluded from validation are BOSI, GMIL, INDJ, PLAN, SID_ and SRBO.

# Thank you for your attention