



INTEGRATION OF THE ASG-EUPOS NETWORK WITH FIRST ORDER NATIONAL GEODETIC NETWORKS – FINAL RESULTS OF THE SRC SOLUTION

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The main goal of measurement campaigns in 2008 i 2010/2011 was the integration of the ASG-EUPOS network with the existing fundamental national networks.

Additional goals performed during campaigns:

- ☐ test of the ASG-EUPOS system (2008)
- ☐ fixing ground eccentric points for the ASG-EUPOS stations
- ☐ re-measurements of EUREF-POL, POLREF and EUVN networks points
- ☐ measurement of selected points of fundamental horizontal network
- ☐ analysis of the location of points of basic network

PROCESSING NUMBER OF POINTS

☐ **2008 GPS Campaign – 286 points**

- 135 EPN/IGS, ASG-EUPOS, SAPOS, LITPOS, SKPOS and CZEPOS stations
- 151 main field points (POLREF, EUVN, EUREF-POL)

☐ **2010/2011 GNSS Campaign – 538 points**

- 147 EPN/IGS, ASG-EUPOS, SAPOS, LITPOS, SKPOS and CZEPOS stations
- 391 main field points (POLREF, EUVN, I-class and eccentric points A-class of the ASG-EUPOS stations)

☐ **Joint solution – 692 points**



PROCESSING PROCESSING PARAMETERS



Bernese GPS Software ver. 5.0

According to the EPN standards.

- ITRF 2005 for epoch of campaign
- Final IGS orbits
- IGS ERP
- QIF method of ambiguity determination
- variants for elevation cut off :
 - 5 degrees
 - 10 degrees
- observation interval 30 sec
- troposphere corrections – NMF
- Phase centre variation absolute model – EPN_05.ATX



PROCESSING COMPUTATION VARIANTS



❑ 2008 CAMPAIGN

- GPS data for diurnal sessions for elevation cut off variants: 5, 10, 15 degrees
- GPS data for 24-hour sessions (from 12:00 GMT till 12:00 GMT) for elevation cut off 10 degrees

❑ 2010/2011 CAMPAIGN AND JOINT SOLUTION

- GPS data for 24-hour sessions (from 12:00 GMT till 12:00 GMT) for elevation cut off 5 and 10 degrees
- GPS and GLONASS data for 24-hour sessions (from 12:00 GMT till 12:00 GMT) for elevation cut off 5 and 10 degrees
- joint solution of GPS data for 2008 and 2010/2011 campaigns for 24-hour sessions (from 12:00 GMT till 12:00 GMT) for elevation cut off 5 and 10 degrees

PROCESSED BASELINES FOR CAMPAIGN 2008

POLSKA

0 50 100
[km]

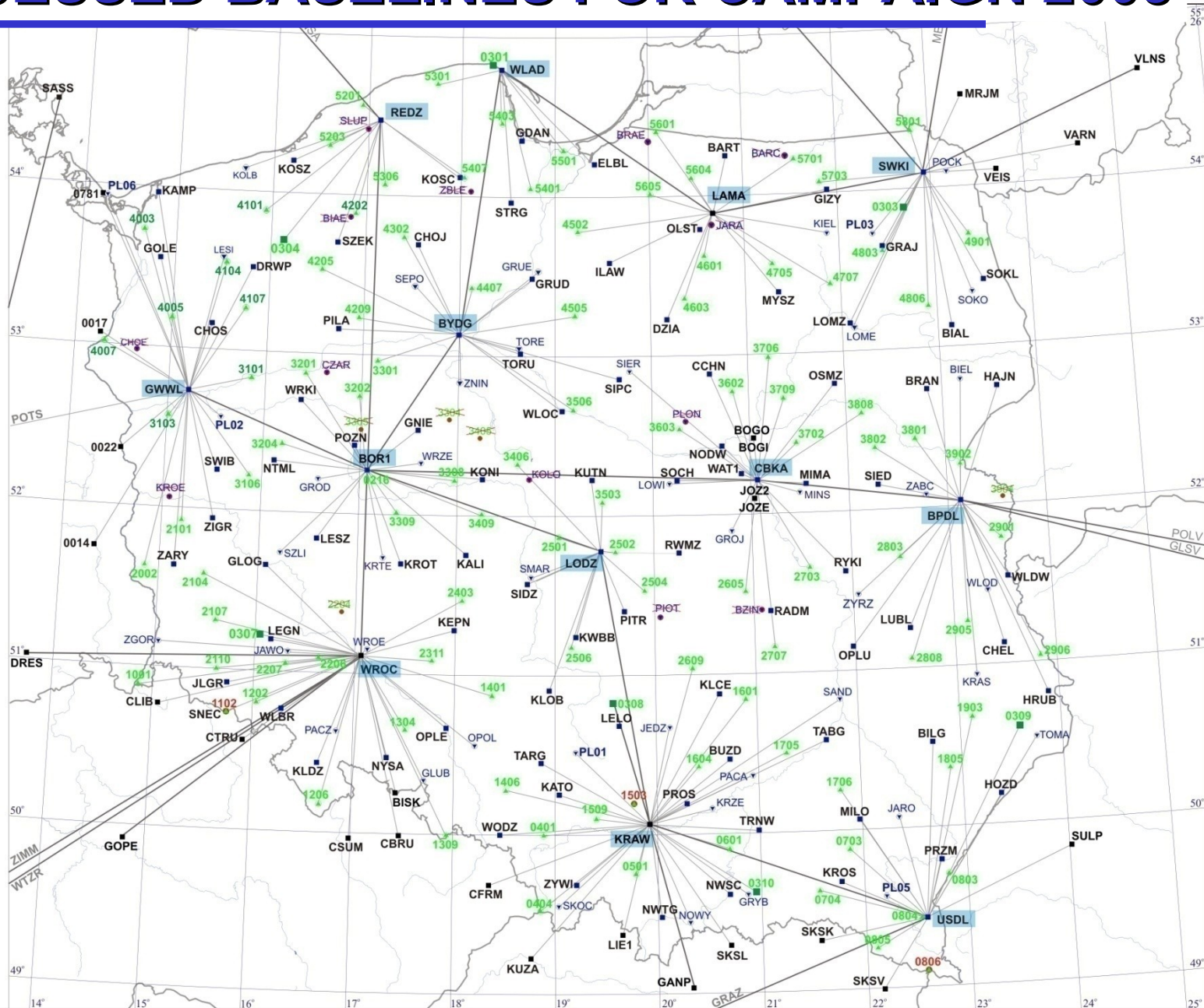
Odwzorowanie: Układ "1992"

Kampania kalibracyjna
sieci ASG-EUPOS
kwiecień/maj 2008

LEGENDA

- 0309 punkt sieci EUREF-POL
- ONSA punkt sieci EPN
- POTS punkt sieci EPN poza obszarem rysunku
- GWWL punkt sieci ASG-EUPOS
- OLST punkt sieci ASG-EUPOS bez dostępnych danych obserwacyjnych
- KOLB punkt sieci EUVN
- CHOE punkt sieci EUVN - zniszczony
- 4007 punkt sieci POLREF
- 1102 punkt sieci POLREF nie pomierzony mimo obecności w harmonogramie
- 2264 punkt sieci POLREF - zniszczony

Opracowanie wykonane przez
Centrum Badań Kosmicznych PAN, © 2008



PROCESSED BASELINES FOR CAMPAIGN 2010/2011

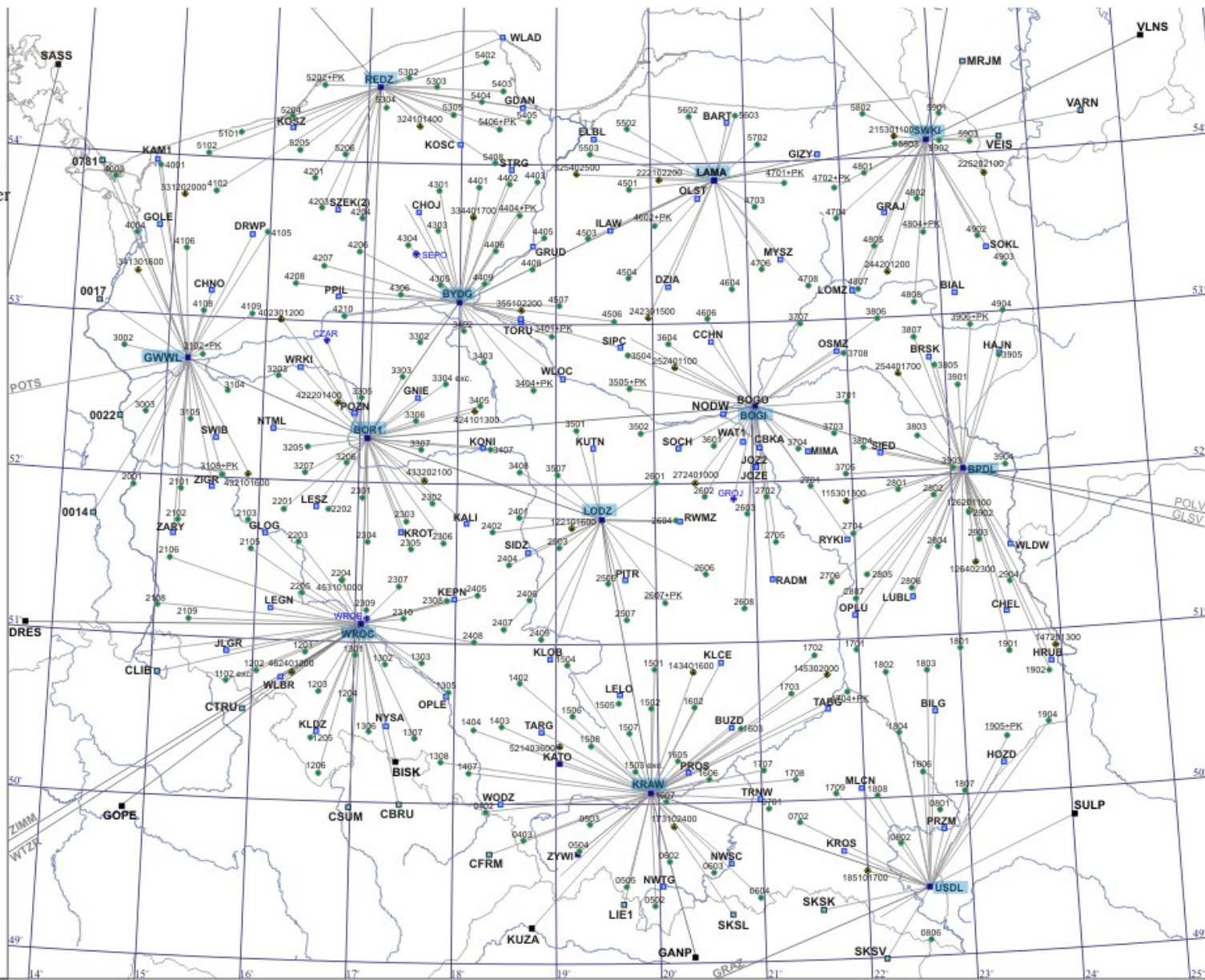
POLAND



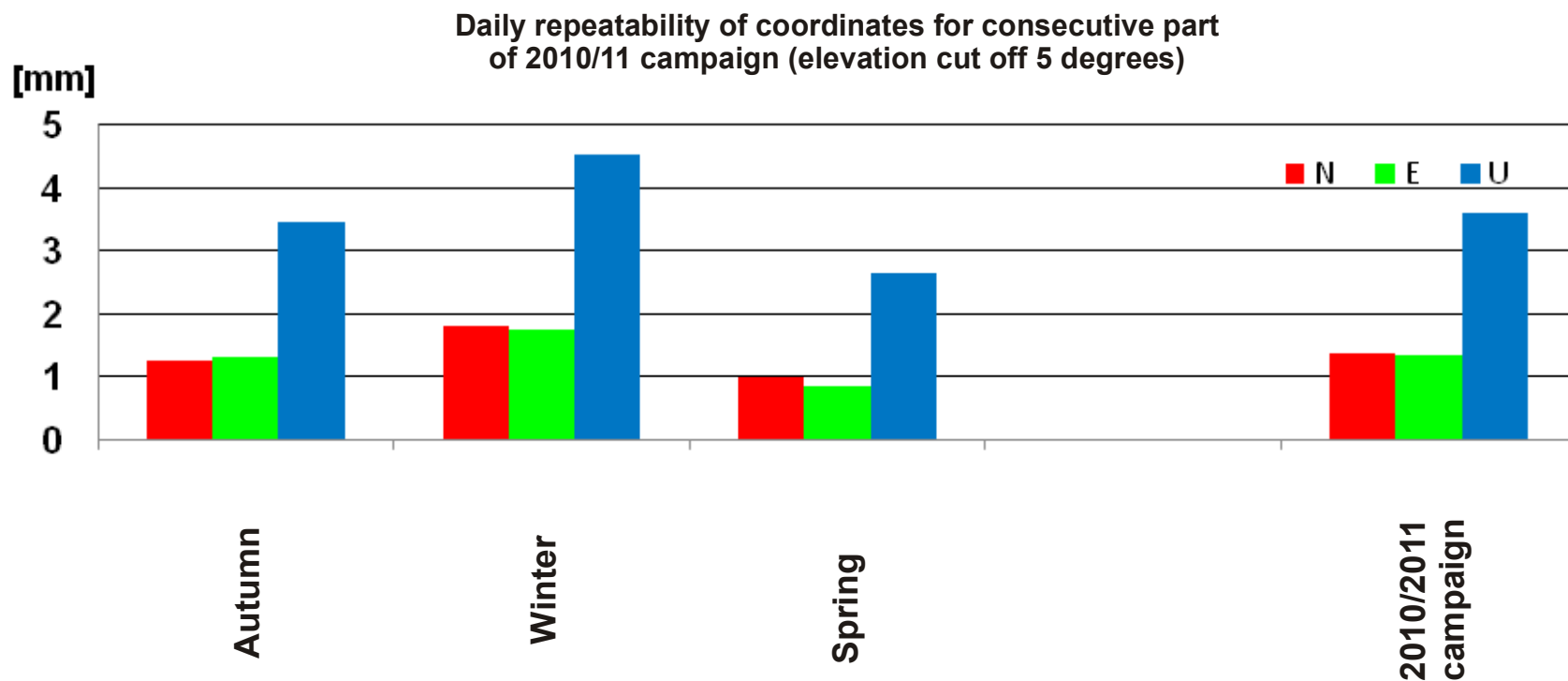
The GNSS Campaign for integration of the ASG-EUPOS permanent stations with first order national geodetic networks

LEGEND

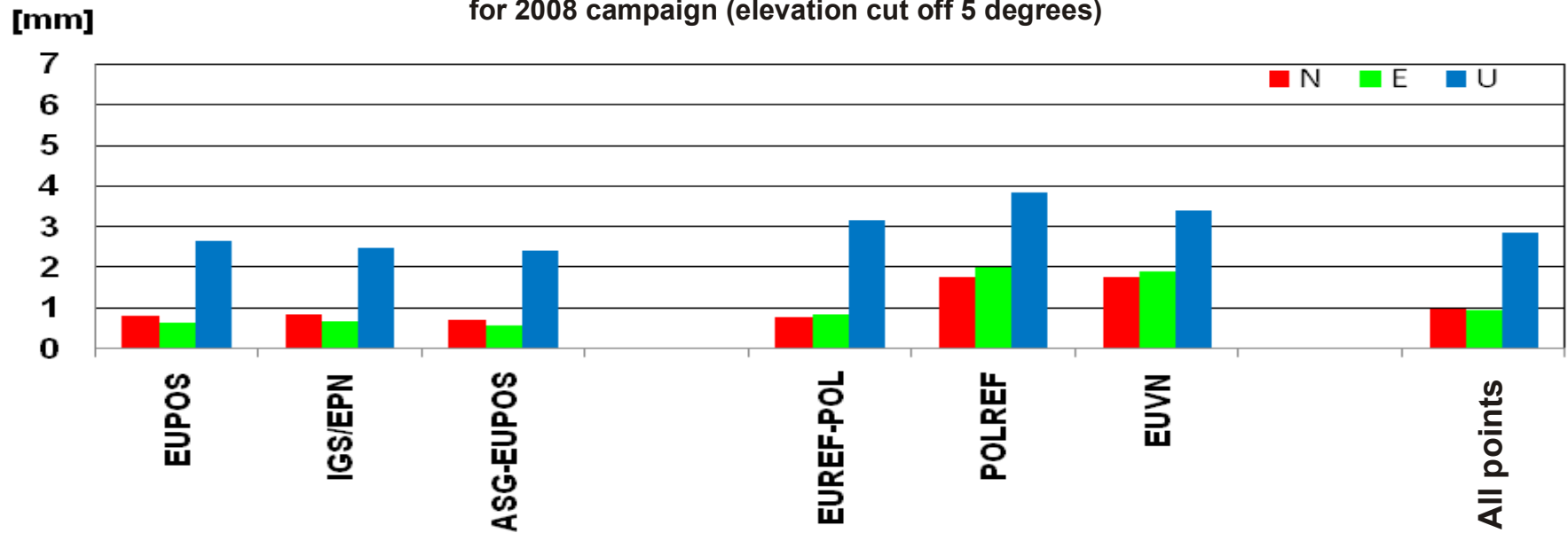
- 3002 points of the POLREF network
- ONSA IGS/EPN permanent stations
- 402301200 points of the EUVN network
- 402301200 Points of the I-order network
- OLST The ASG-EUPOS permanent stations



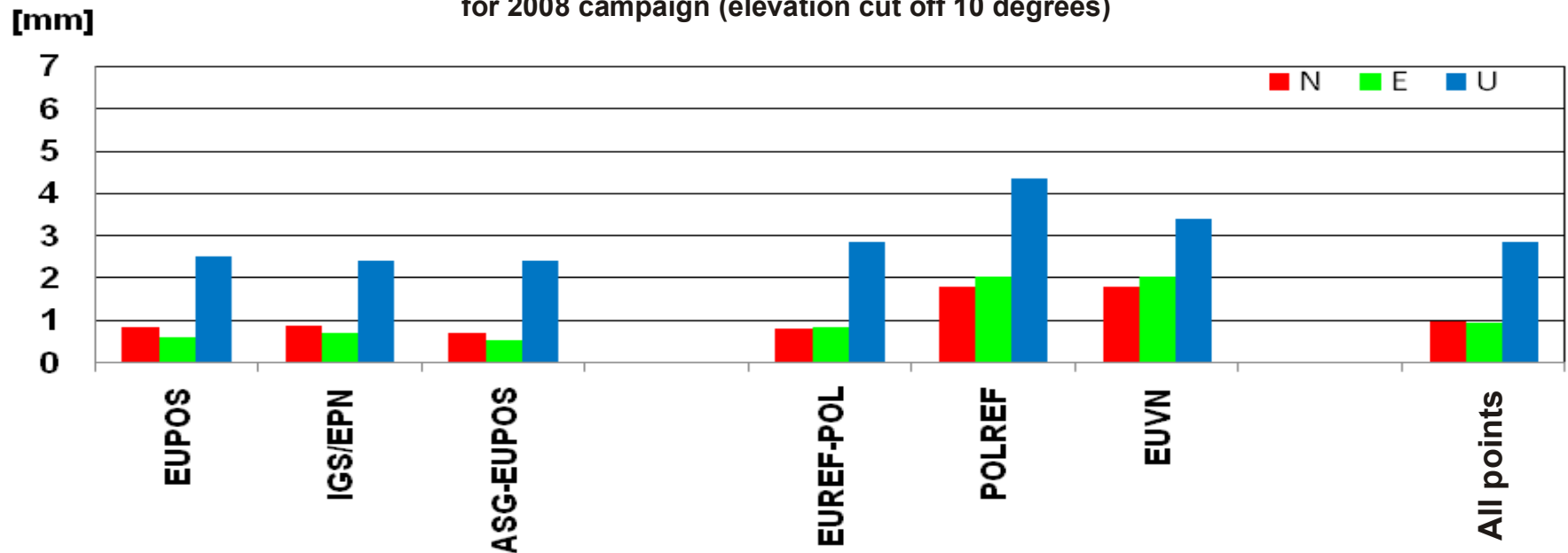
DAILY REPEATABILITY OF POINT CO-ORDINATES (2010/11)



Daily repeatability of coordinates for different types of points
for 2008 campaign (elevation cut off 5 degrees)



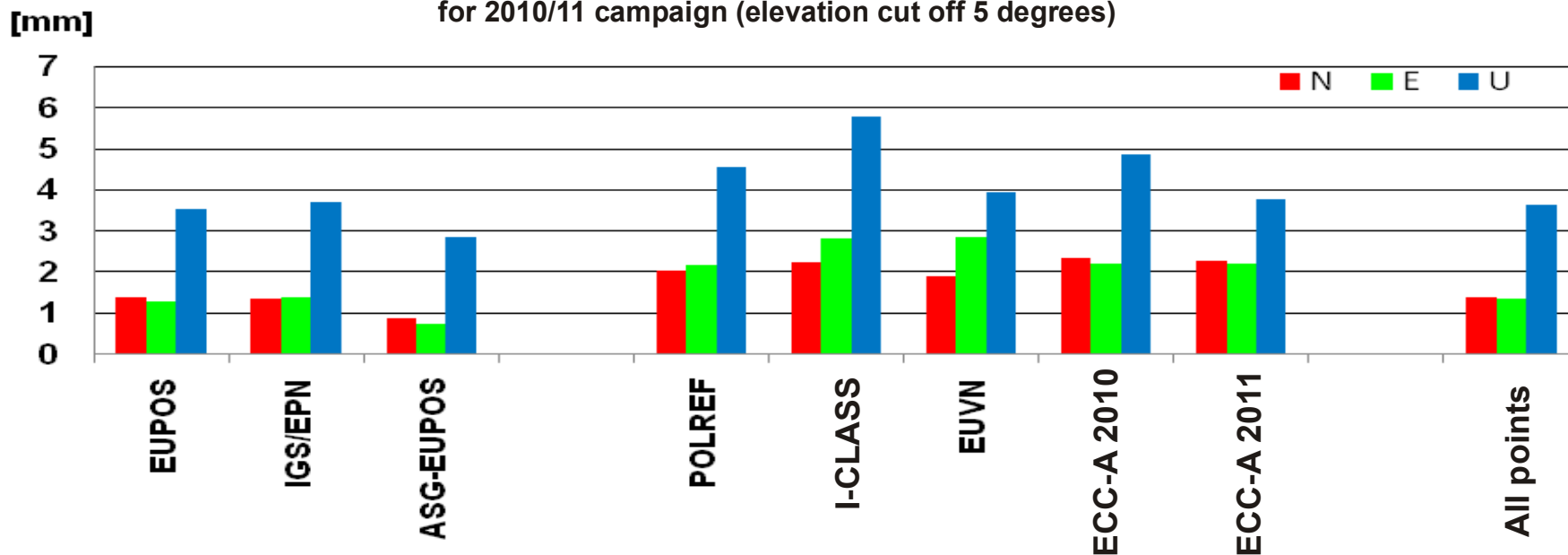
Daily repeatability of coordinates for different types of points
for 2008 campaign (elevation cut off 10 degrees)



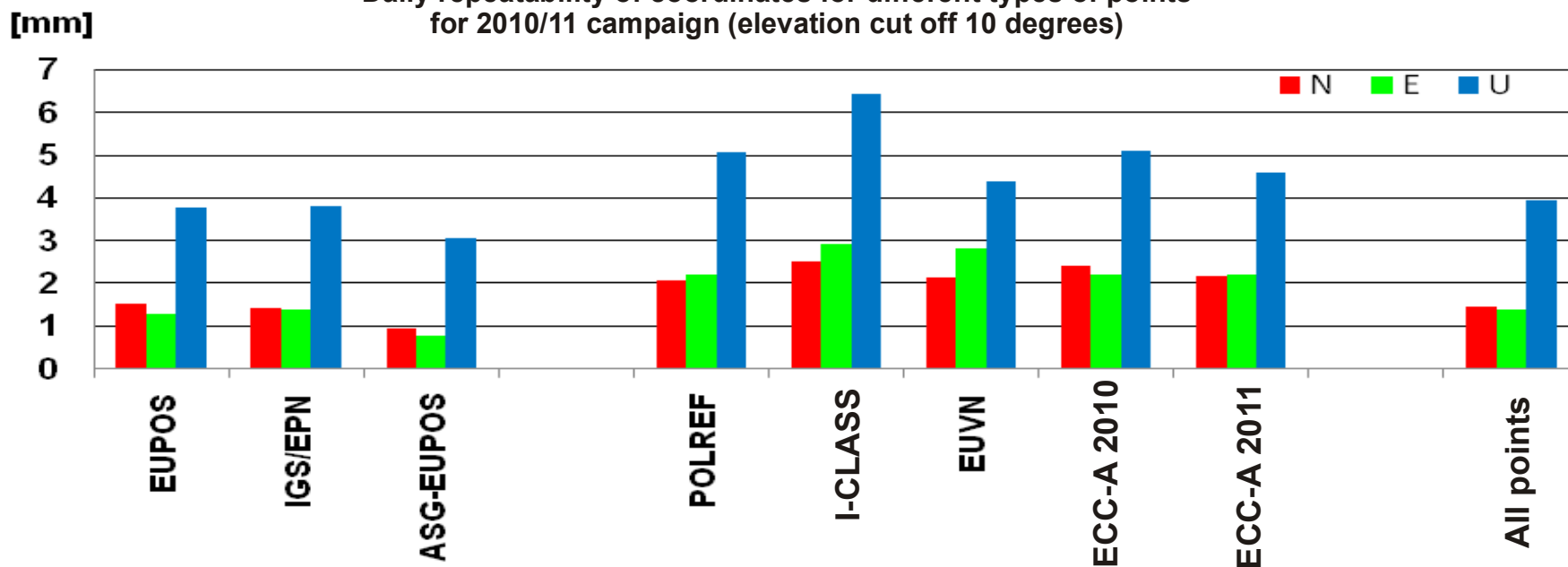
COMPARISON OF RESULTS FOR 5 AND 10 DEGREES (2008)

Points	ASG-EUPOS 2008 - 5 degrees			ASG-EUPOS 2008 -10 degrees		
	N	E	U	N	E	U
EUPOS	0.80	0.63	2.65	0.83	0.60	2.50
IGS/EPN	0.85	0.65	2.45	0.86	0.69	2.40
ASG-EUPOS	0.68	0.55	2.41	0.69	0.54	2.41
EUREF-POL	0.77	0.81	3.16	0.80	0.84	2.83
POLREF	1.75	1.97	3.82	1.79	2.03	4.33
EUVN	1.74	1.90	3.38	1.78	2.03	3.40
Joint	0.96	0.92	2.83	0.99	0.94	2.87

Daily repeatability of coordinates for different types of points
for 2010/11 campaign (elevation cut off 5 degrees)



Daily repeatability of coordinates for different types of points
for 2010/11 campaign (elevation cut off 10 degrees)



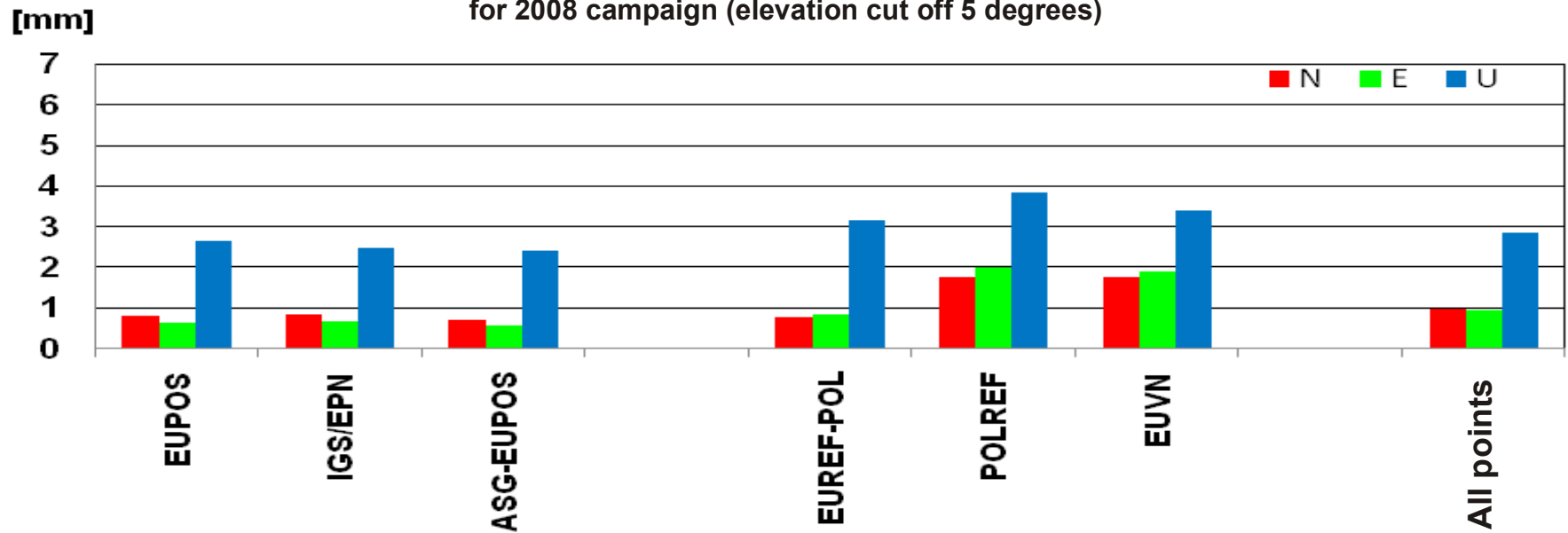


COMPARISON OF RESULTS FOR 5 AND 10 DEGREES (2010/2011)

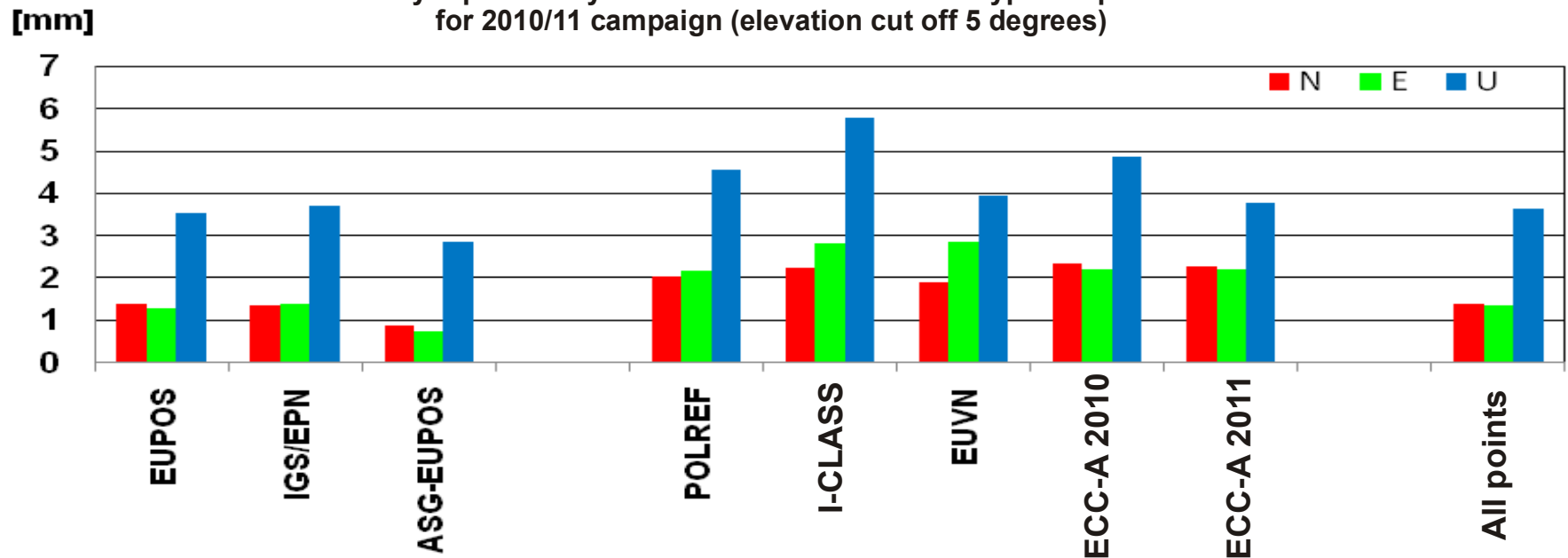


Points	ASG-EUPOS 2010 - 5 degrees			ASG-EUPOS 2010 - 10 degrees		
	N	E	U	N	E	U
EUPOS	1.37	1.25	3.51	1.49	1.26	3.74
IGS/EPN	1.33	1.37	3.68	1.41	1.36	3.79
ASG-EUPOS	0.84	0.70	2.84	0.92	0.74	3.04
POLREF	2.02	2.17	4.55	2.05	2.17	5.05
I-class	2.21	2.81	5.76	2.49	2.91	6.40
EUVN	1.89	2.85	3.93	2.12	2.80	4.37
ECC.-A 2010	2.32	2.18	4.86	2.37	2.17	5.09
ECC.-A – 2011	2.25	2.18	3.75	2.16	2.20	4.56
Joint	1.36	1.33	3.61	1.43	1.36	3.91

Daily repeatability of coordinates for different types of points
for 2008 campaign (elevation cut off 5 degrees)



Daily repeatability of coordinates for different types of points
for 2010/11 campaign (elevation cut off 5 degrees)







JOINT SOLUTION (2008 AND 2010/11)



For joint solution **692** points were used.

Mean diurnal repeatability in *NEU* components is, respectively:

$\pm 1.39\text{mm}$, $\pm 1.31\text{mm}$ i $\pm 3.43\text{mm}$



COMPARISON OF RESULTS OF JOINT SOLUTION (2008 AND 2010/11) AND EPN (EPN_A_ITRF2005_C1600.SSC)



Point	dN	dE	dU	comment
BOGI 12207M003	0.3	0.3	2.9	
BOGO 12207M002	0.2	0.6	0.3	
BOR1 12205M002	-0.5	0.5	-0.7	
JOZE 12204M001	1.6	-0.3	0.9	
JOZ2 12204M002	0.8	0.4	3.3	
KRAW 12218M001	1.7	1.4	1.3	
LAMA 12209M001	-0.2	0.3	3.1	
WROC 12217M001	0.8	-0.6	3.7	
GWWL 12225M001	-0.9	-0.3	-0.2	
KATO 12219S001	0.7	1.8	-0.3	
LODZ 12226M001	0.5	1.6	-1.2	
REDZ 12227M001	0.3	0.6	1.9	
SWKI 12228M001	0.6	-1.0	2.7	
USDL 12229M001	0.3	0.8	-1.3	
ZYWI 12220S001	-1.1	0.5	-2.7	



COMPARISON OF RESULTS FOR 2008 AND 2010/11 CAMPAIGNS



Differences for re-measured field points

	NUM		NAME		FLG		RESIDUALS IN MILLIMETERS			

...										
	196		0216 BOROWIEC		A A		2.3	-1.2	-1.6	
	239		1202		A A		5.6	-2.9	-13.7	
	243		1206		A A		0.5	-1.9	-4.6	
	300		2101		A A		0.5	-6.1	3.3	
	536		5403		A A		-2.9	4.6	-5.7	
	615		GROJ		A A		-0.6	6.3	4.5	
...										

	RMS / COMPONENT			2.6			2.5	4.6		



COMPARISON OF RESULTS FOR GPS AND GPS/GLONASS (2010/11)



**Points of the greatest differences between the
solutions: GPS and GPS/GLONASS
and mean differences for all points**

	NUM		NAME		FLG		RESIDUALS IN MILLIMETERS			

...										
	562		220E		A A		0.0	-0.6	-12.5	
	585		I334		A A		-2.4	-11.6	14.5	
	586		I340		A A		2.7	3.1	10.8	
.										

			RMS / COMPONENT				0.8	0.8	1.9	

- EUREF-POL (1992, 2001), POLREF (1994 and 1995), EUVN (1997) networks and fundamental national horizontal network (1996/97) (EUREF89)
- for re-measurement in 2008 and 2010 (ITRF2005/ ETRF2000).

Because of the difference between reference systems used for realisation of different networks, comparison was made using 7-parameter Helmert transformation.

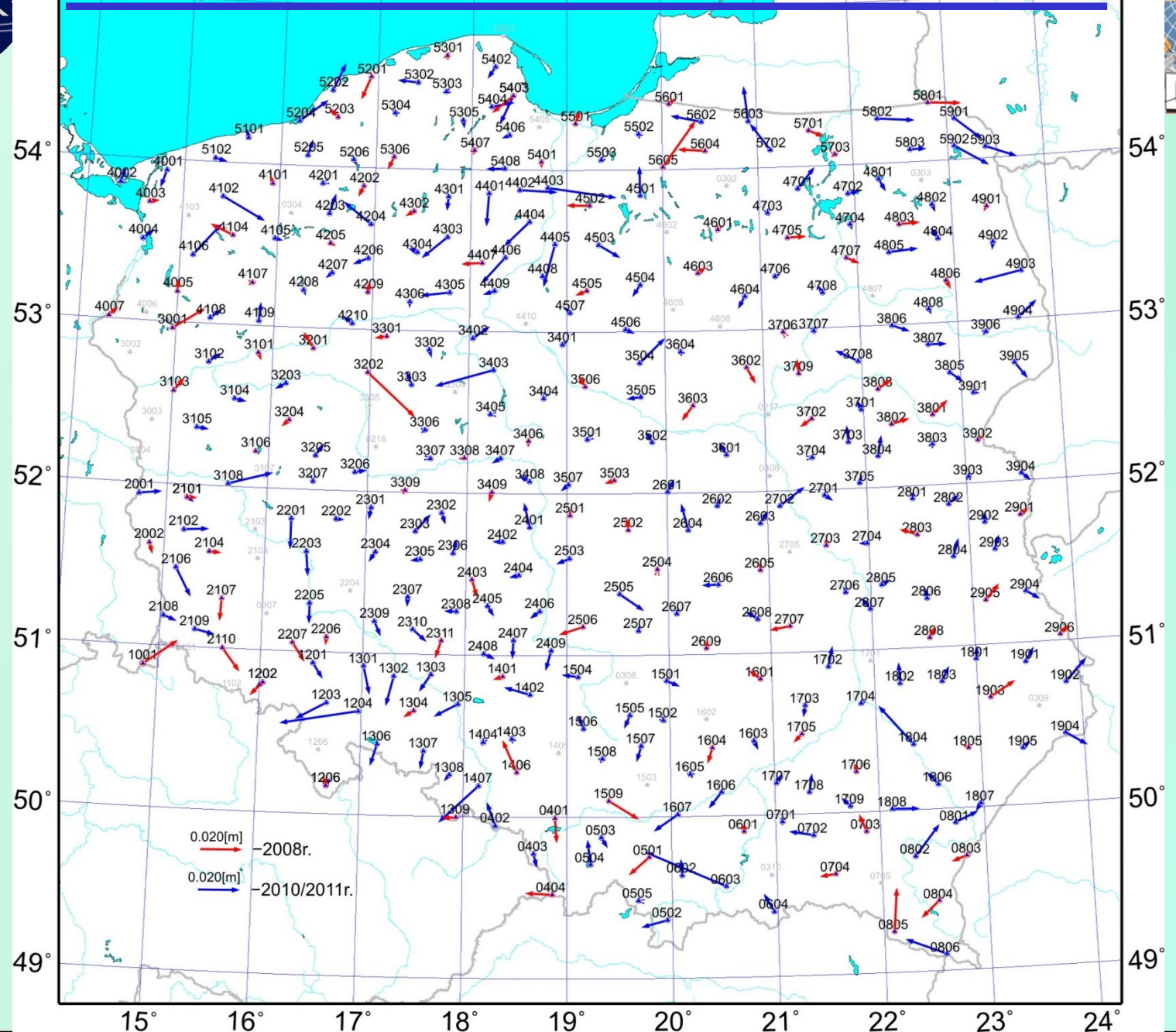
$$\begin{bmatrix} X_2 \\ Y_2 \\ Z_2 \end{bmatrix} = \begin{bmatrix} X_1 \\ Y_1 \\ Z_1 \end{bmatrix} + \begin{bmatrix} T_X \\ T_Y \\ T_Z \end{bmatrix} + D_{1,2} \cdot \begin{bmatrix} X_1 \\ Y_1 \\ Z_1 \end{bmatrix} + \begin{bmatrix} 0 & -R_Z & R_Y \\ R_Z & 0 & -R_X \\ -R_Y & R_X & 0 \end{bmatrix} \cdot \begin{bmatrix} X_A \\ Y_A \\ Z_A \end{bmatrix}$$

RESULTS OF COMPARISON OF JOINT SOLUTION ASG-EUPOS NETWORK WITH POLREF NETWORK

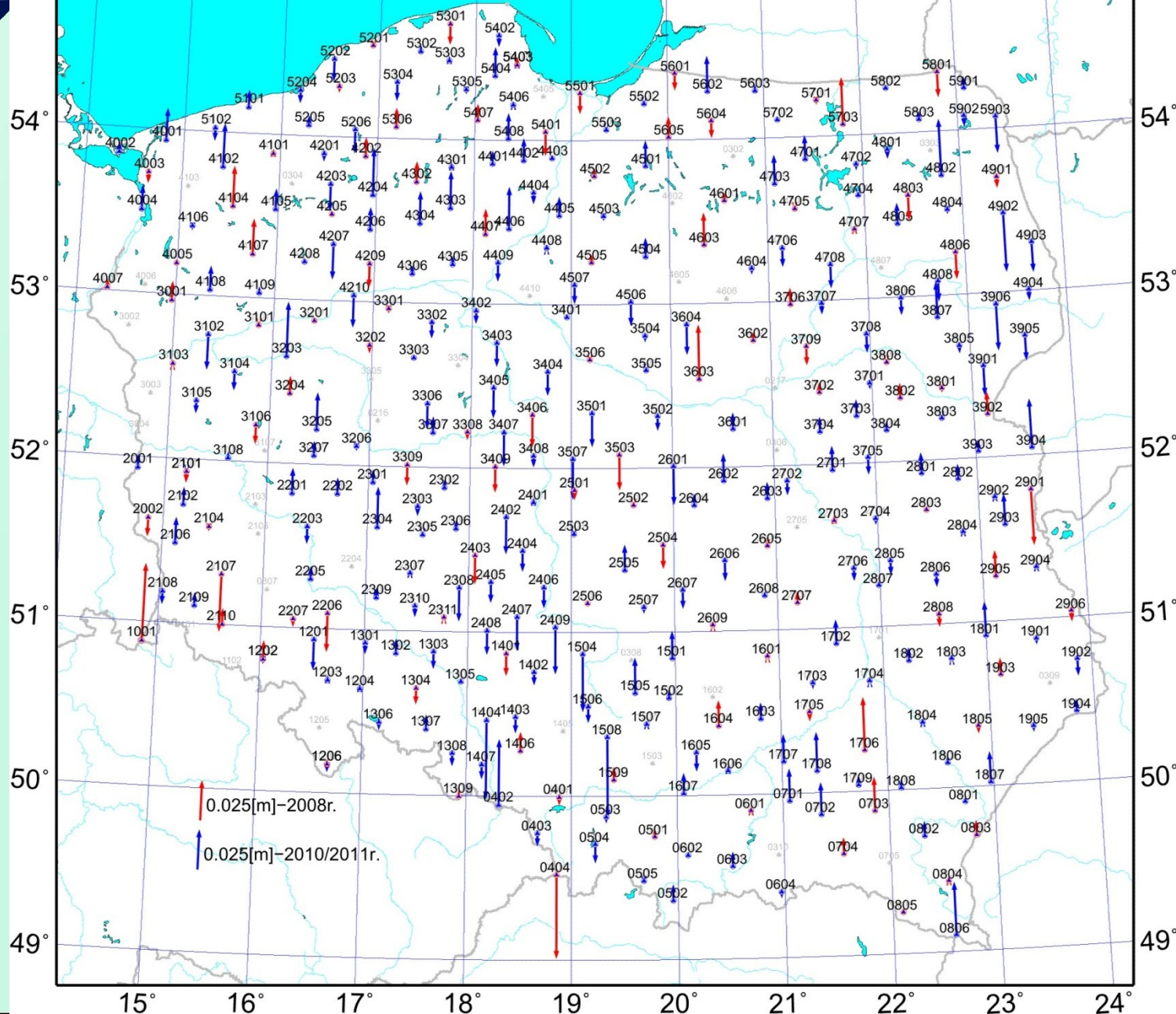
2008 (102 points)	RMS	6.5	6.8	14.4		
2010 (224 points)	RMS	6.9	8.4	14.4		
2008 i 2010 (323 points)	RMS	7.3	8.2	14.8		



DIFFERENCES IN HORIZONTAL COMPONENTS



DIFFERENCES IN VERTICAL COMPONENT



Points with larges differences in NEU components (not shown on the maps):

	NAME		RESIDUALS IN MM				

...							
	GROJ		12.3	110.0	3.6		M
	GRUE		-42.7	31.3	6.9		M
	JARO		-8.3	-123.0	12.6		M
	SEP0		-1.3	40.8	-25.9		M
	SEPO		-80.1	-47.1	18.0		M
	WRO0		4.2	127.9	-165.7		M
...							

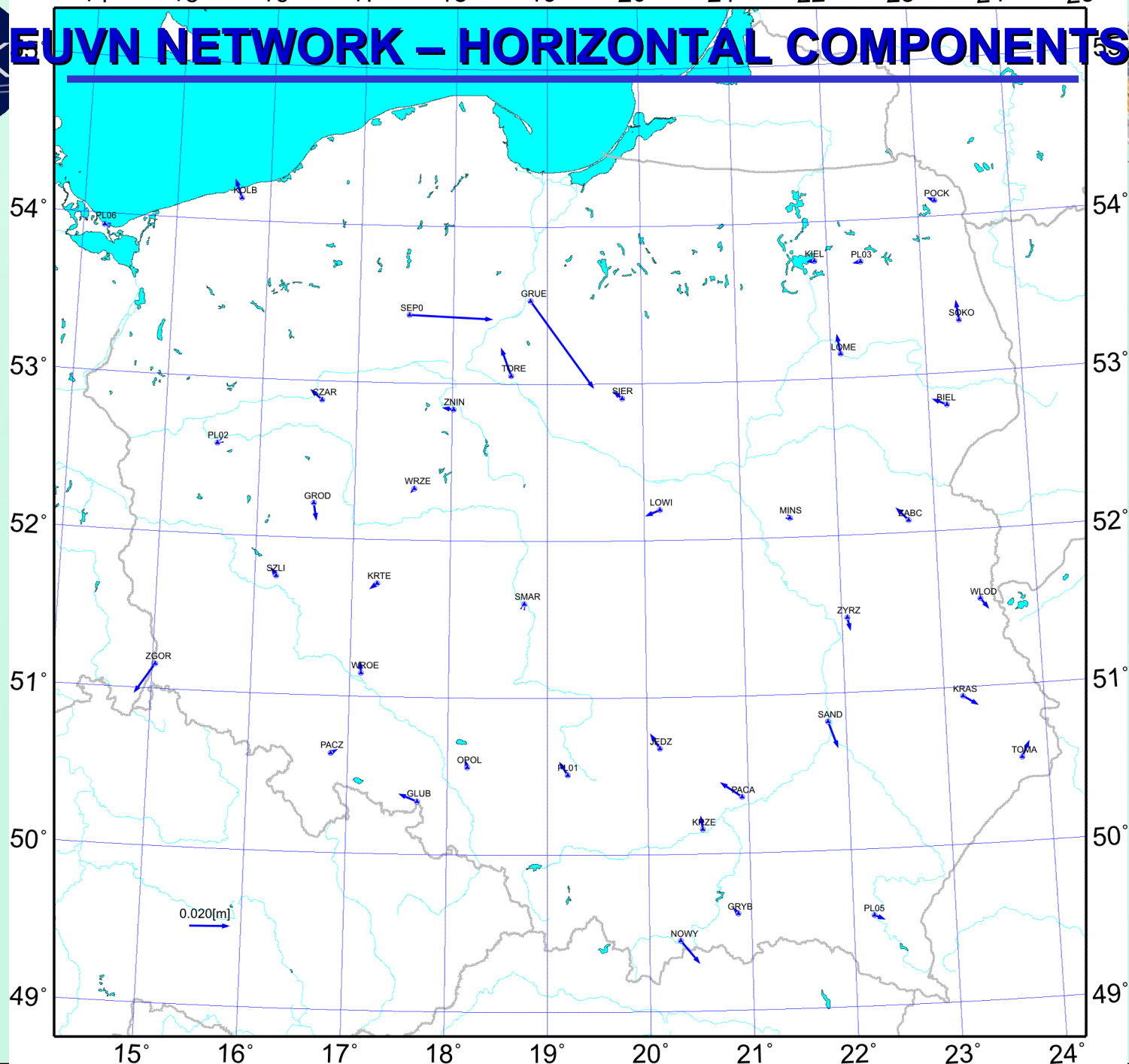
	RMS / COMPONENT		9.5	9.6	8.5		

Benchmarks location



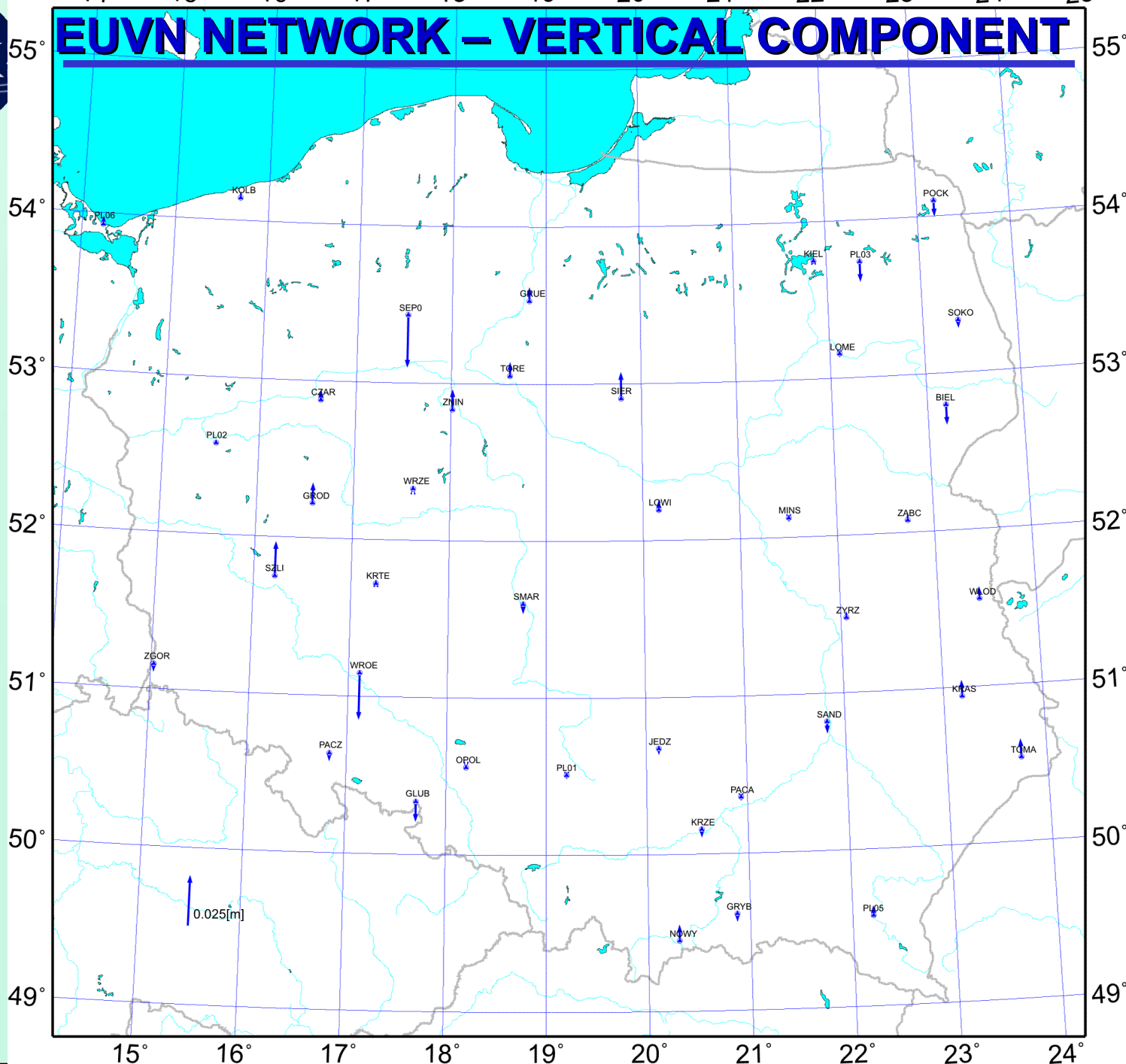


EUVN NETWORK – HORIZONTAL COMPONENTS





EUVN NETWORK – VERTICAL COMPONENT





FUNDAMENTAL NATIONAL HORIZONTAL NETWORK - I-CLASS



Points with larges differences in horizontal components:

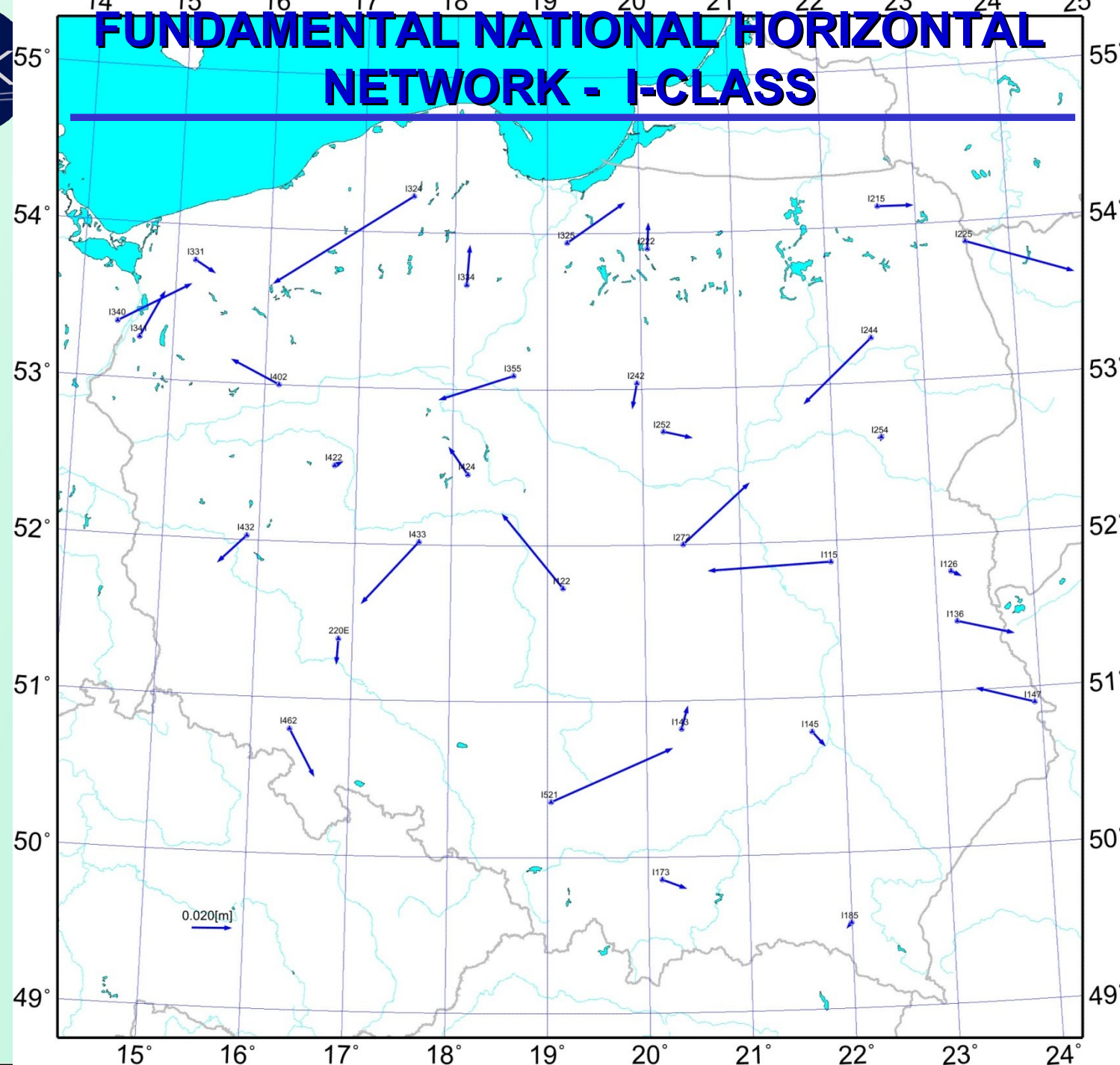
NUM	NAME		RESIDUALS IN MM		

565	I115		-2.6 -61.5		
566	I122		37.3 -30.5		
576	I225		-18.4 53.4		
578	I244		-31.9 -35.1		
581	I272		29.8 33.7		
582	I324		-44.9 -69.3		
586	I340		20.4 35.8		
595	I521		26.6 60.5		

	RMS / COMPONENT		19.1 29.2		



FUNDAMENTAL NATIONAL HORIZONTAL NETWORK - I-CLASS



CONCLUSIONS



- ❑ Stability of coordinates determination for joint solution of 2008 and 2010/11 campaigns is on average below ± 1.5 mm in horizontal components and about ± 3.5 mm for heights.
- ❑ The results of comparisons for the different solutions do not show significant differences caused by different measurement epoch, elevation cut off for calculation and types of observations (GPS or GPS/GLONASS).
- ❑ The results show a good agreement for catalogue coordinates of points EUREF-POL, POLREF and EUVN networks with the new appointment.

CONCLUSIONS



- ❑ Re-measurement of POLREF and EUVN points allowed to update the coordinates and verify its accuracy and stability over time.
- ❑ Measured points of I-class horizontal network show a high inhomogeneity in the accuracy of the designation, and the error rate several times higher than for new networks, designed for GPS technique.



THANK YOU FOR YOUR ATTENTION