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Information Agency

LATREF stations coordinates estimation - LKS-20

NKG Working Group of Reference Frames

Riga, Latvia, 19.-20.05.2022.

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Introduction

Data preparation

Processing versions

Selected version results

Coordinates comparison



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Included CORS

	Station name and location	DOMES number	4-ID
1	ALKS00LVA, Latvia	10731M002	ALKS
2	DLKS00LVA, Latvia	10704M003	DLKS
3	IRBE00LVA, Latvia	10726M001	IRBE
4	VAIN00LVA, Latvia	10736M001	VAIN
5	RIGA00LVA, Latvia	12302M002	RIGA
6	BOR100POL, Poland	12205M002	BOR1
7	MAR600SWE, Sweden	10405M002	MAR6
8	MDVJ00RUS, Russia	12309M005	MDVJ
9	METS00FIN, Finland	10503S011	METS
10	ONSA00SWE, Sweden	10402M004	ONSA
11	POLV00UKR, Ukraine	12336M001	POLV
12	POTS00DEU, Germany	14106M003	POTS
13	PULK00RUS, Russia	12305M001	PULK
14	SVTL00RUS, Russia	12350M001	SVTL
15	TOR200EST, Estonia	10602M001	TOR2
16	TRO100NOR, Norway	10302M006	TRO1
17	VIS000SWE, Sweden	10423M001	VIS0
18	VLNS00LTU, Lithuania	10801M001	VLNS

LATREF stations



Irbene

Alūksne


Rīga

Vainode

Daugavpils

Legend

 LATREF station

 Calibrated antenna



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Data preparation

Coordinates and velocities *IGS14, EPN_A_SNX_W2085 and IGb14, EPN_A_SNX_W2160*

CODE products *final rapid orbits *.EPH_M, clock corrections *.CLK_M, earth rotation parameters *.ERP_M, ionosphere model maps *.ION*

Troposphere delay models *Vienna mapping function 1 2.0°x2.5° grid points*

Ocean tide loading displacement *FES2004 model*

Atmospheric tidal loading displacement *van Dam, T. and R. Ray, 2010*

Observation period *GPS DOY 61-144 (01.03.2022.-23.05.2022.); 84 sessions*

Observation data *RINEX version 2 and 3 with 30 seconds interval*

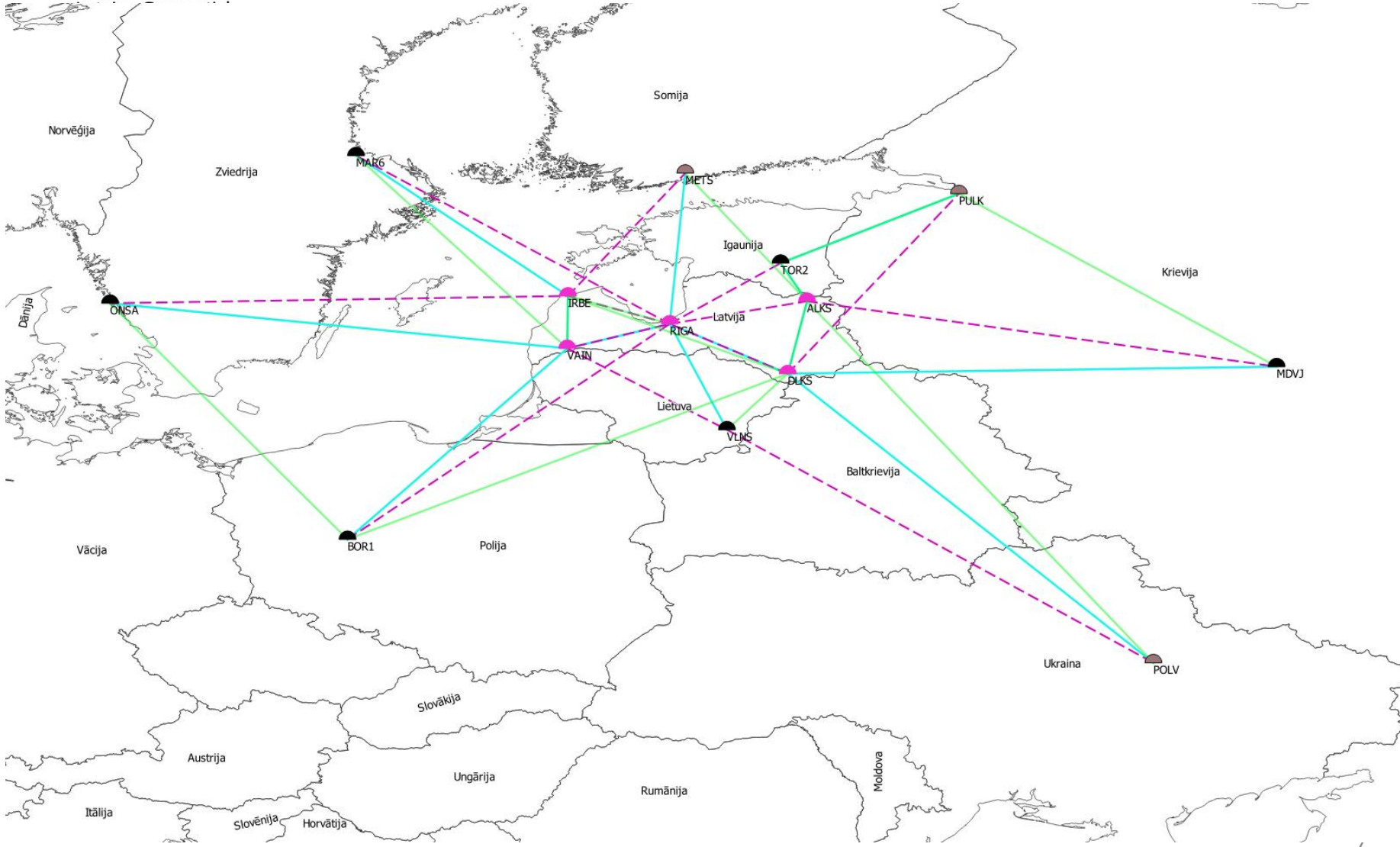


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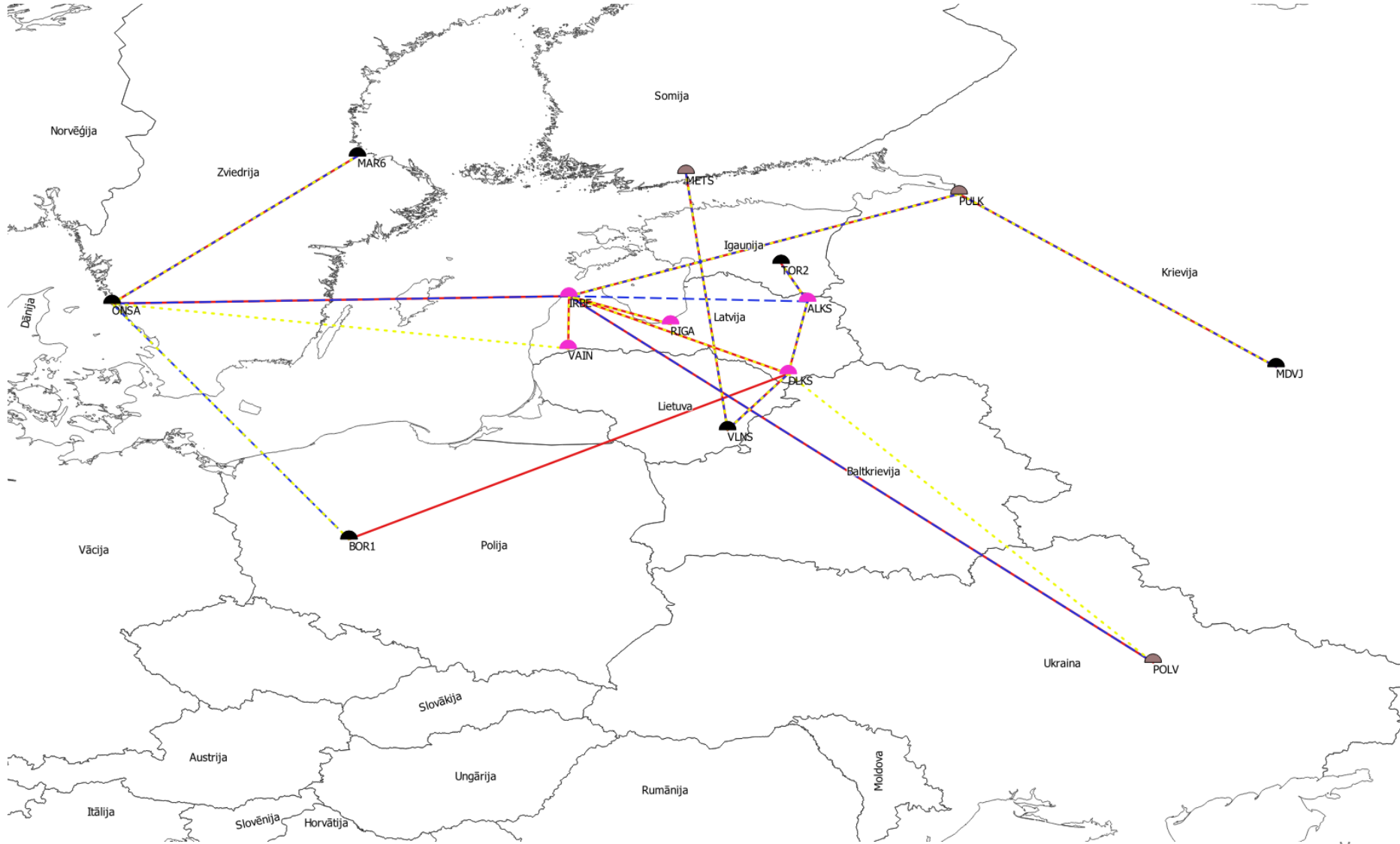
Processing versions and campaigns

Version name	Campaign	LATREF stations	Reference stations	Baseline strategy		ITRF2014		Observation period
	count					realization		
LATREFV3	1	ALKS, IRBE, DLKS, VAIN	BOR1, MAR6, ONSA, VIS0, MDVJ, SVTL, POTS, TOR2, TRO1, RIGA , VLNS	Defined baselines		IGS14 (W2085)		1.03.-23.05.2020.
LATREFV4	4	ALKS, IRBE, DLKS, VAIN	BOR1, MAR6, ONSA, VIS0, MDVJ, SVTL, POTS, TOR2, TRO1, RIGA , VLNS	Defined baselines	OBS-MAX	IGS14 (W2085)	IGb14 (W2145)	11.04.-13.04.2020.
LATREFV5	4	ALKS, IRBE, DLKS, VAIN, RIGA	BOR1, MAR6, ONSA, VIS0, MDVJ, SVTL, TOR2, VLNS	Defined baselines	OBS-MAX	IGS14 (W2085)	IGb14 (W2145)	11.04.-13.04.2020.
LATREFV6	1	ALKS, IRBE, DLKS, VAIN, RIGA	BOR1, MAR6, ONSA, VIS0, MDVJ, SVTL, TOR2, VLNS	Defined baselines		IGb14 (W2145)		1.03.-23.05.2020.
LATREFV7	4	ALKS, IRBE, DLKS, VAIN, RIGA	BOR1, MAR6, ONSA, MDVJ, TOR2, VLNS, METS, POLV, PULK	Defined baselines	OBS-MAX	IGS14 (W2085)	IGb14 (W2145)	11.04.-13.04.2020.
LATREFV8	1	ALKS, IRBE, DLKS, VAIN, RIGA	BOR1, MAR6, ONSA, MDVJ, TOR2, VLNS, METS, POLV, PULK	Defined baselines		IGb14 (W2145)		1.03.-23.05.2020.
LATREFV8.2	1	ALKS, IRBE, DLKS, VAIN, RIGA	BOR1, MAR6, ONSA, MDVJ, TOR2, VLNS, METS, POLV, PULK	Defined baselines		IGb14 (W2145)		05.04.-18.04.2020.

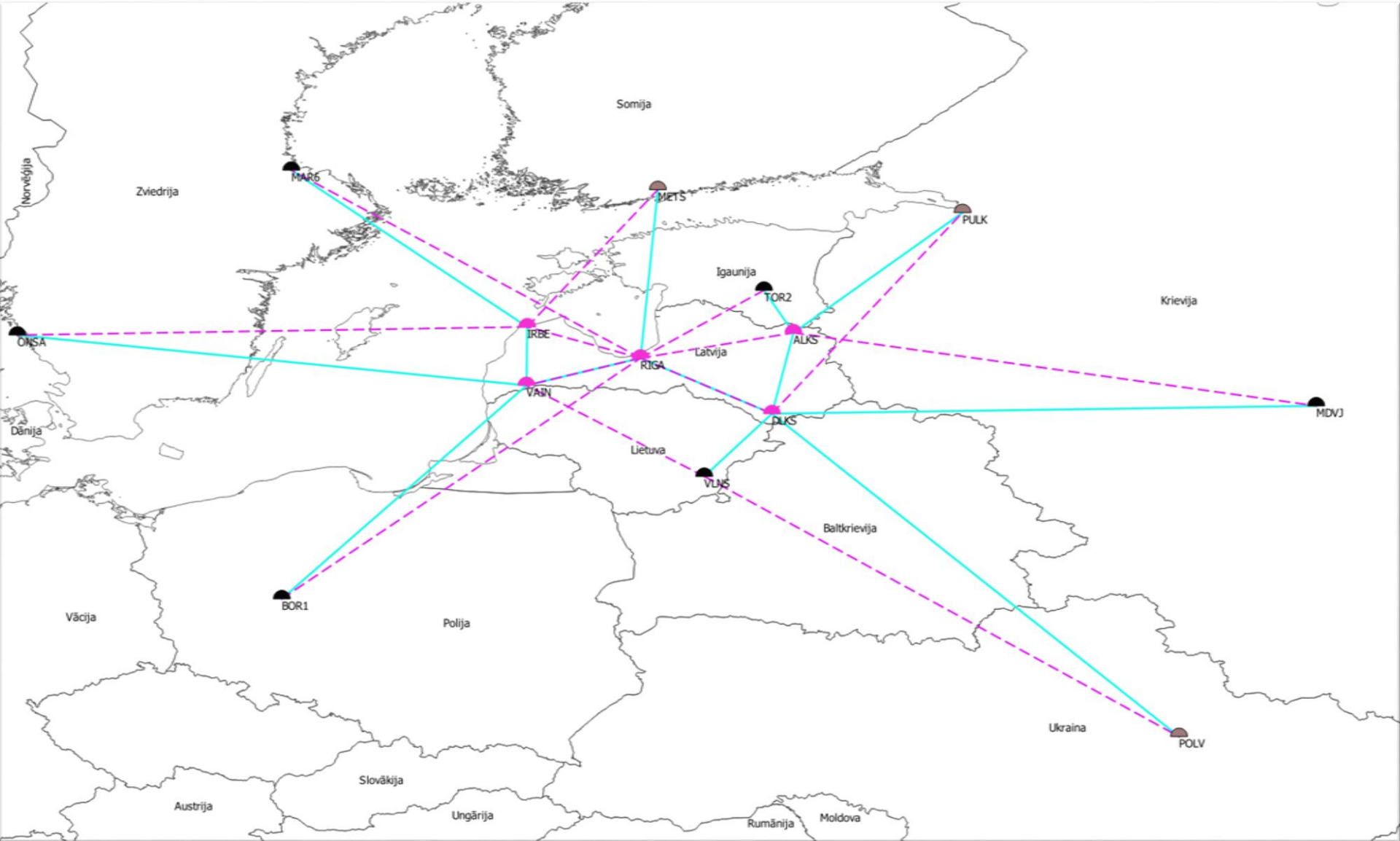
LATREFV7 defined baselines (3 sessions)



LATREFV7 OBS-MAX (3 sessions)



LATREFV8 defined baselines (84 sessions)





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LATREFV8 campaign results

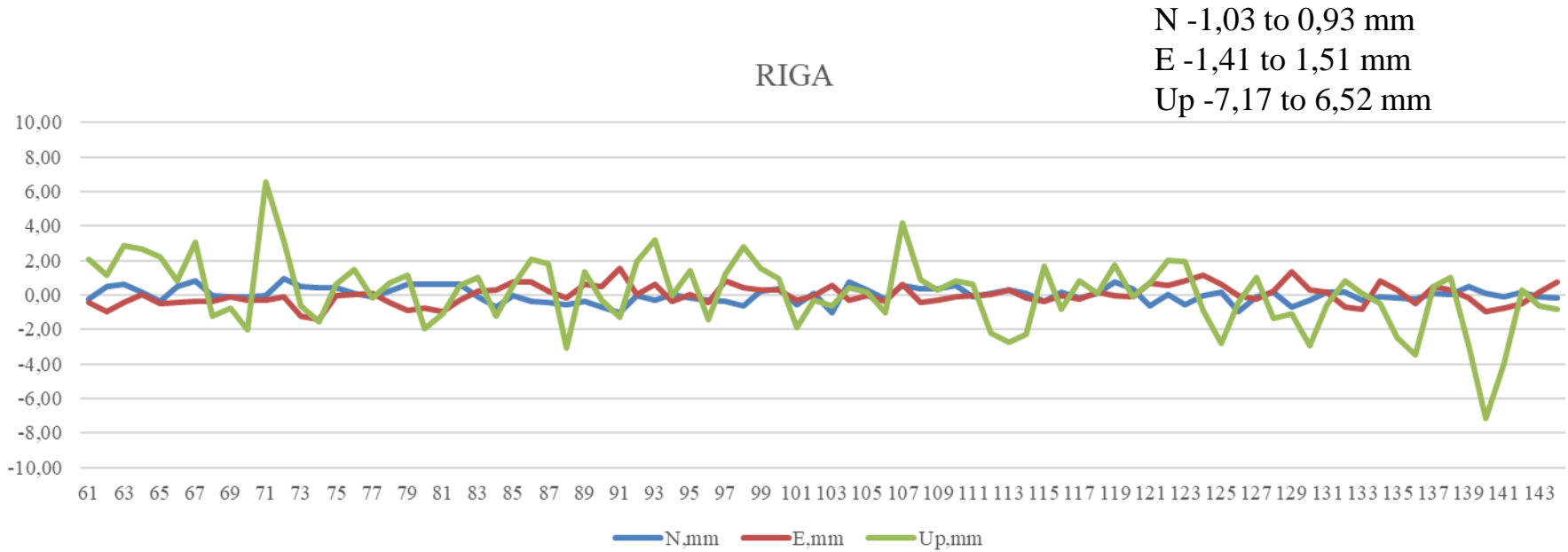
IGb14 coordinates epoch 2020.04.12.

NUM	STATION NAME	X (M)	Y (M)	Z (M)	FLAG
		"Minimum Constraint Solution"			
1	ALKS 10731M002	3064941,14460	1564041,78604	5352595,46356	A
2	DLKS 10704M003	3206756,71631	1607049,89870	5256433,16638	A
3	IRBE 10726M001	3183614,31408	1276707,91201	5359315,31563	A
4	VAIN 10736M001	3282526,39044	1315358,10799	5290482,74083	A
5	RIGA 12302M002	3183898,91799	1421478,70742	5322810,91991	A

Coordinates repeatability 84 sessions (1)



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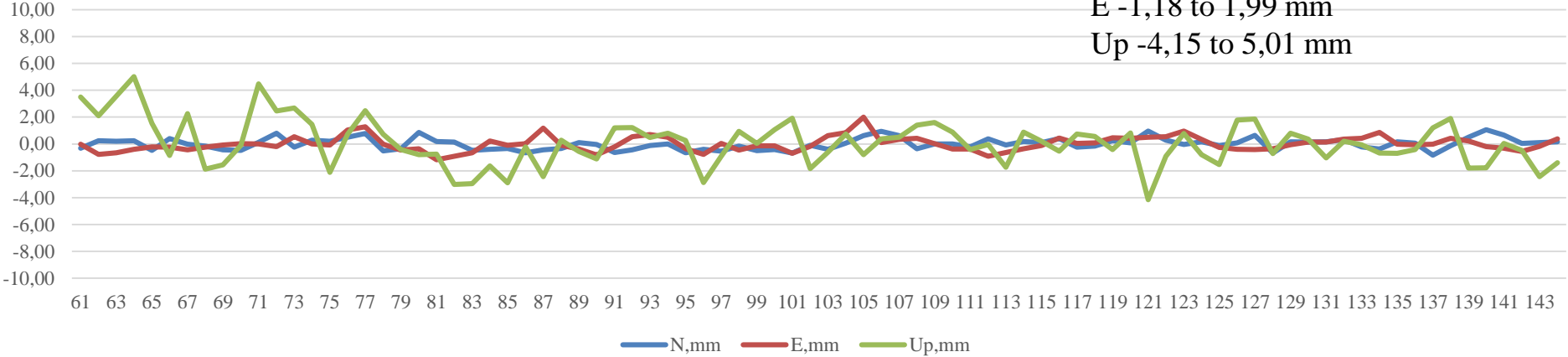


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Coordinates repeatability 84 sessions (2)

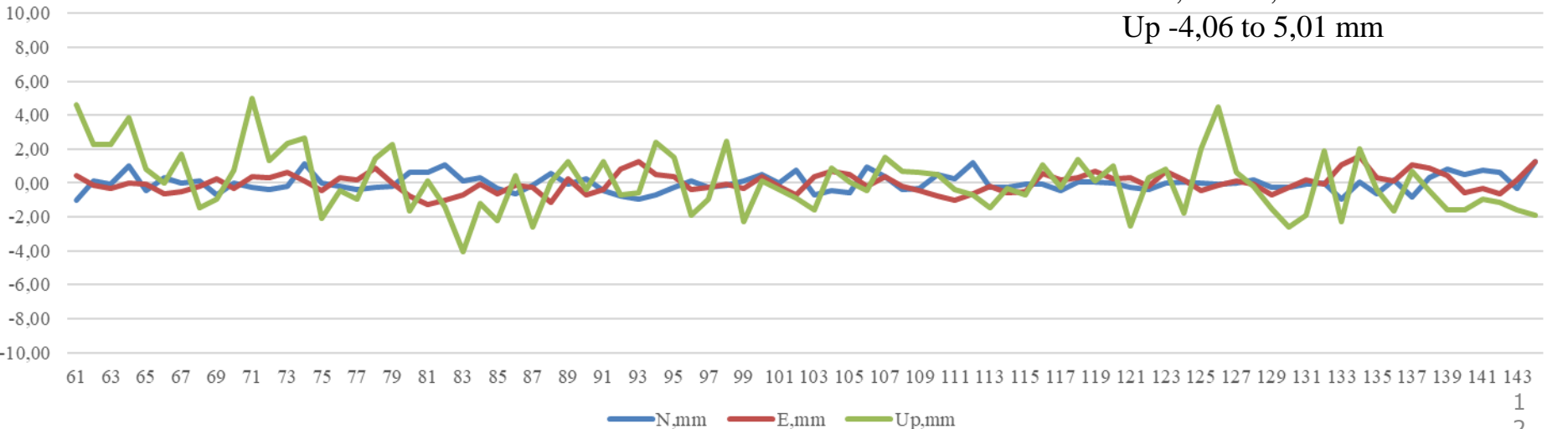
ALKS

N -0,83 to 1,07 mm
E -1,18 to 1,99 mm
Up -4,15 to 5,01 mm



DLKS

N -1,03 to 1,24 mm
E -1,27 to 1,6 mm
Up -4,06 to 5,01 mm



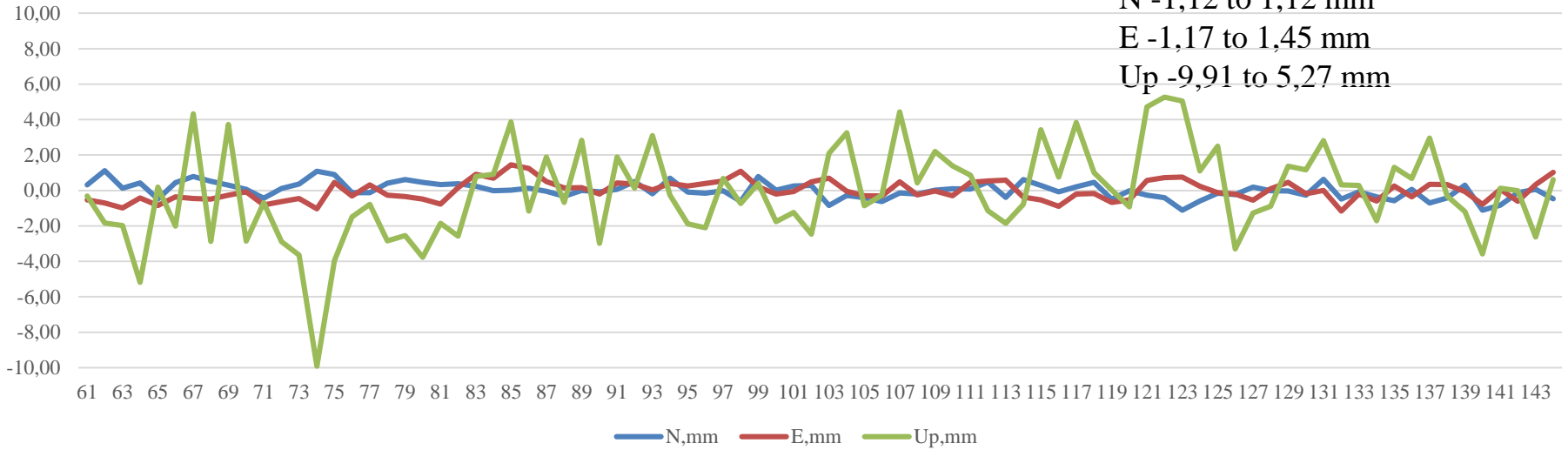


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Coordinates repeatability 84 sessions (3)

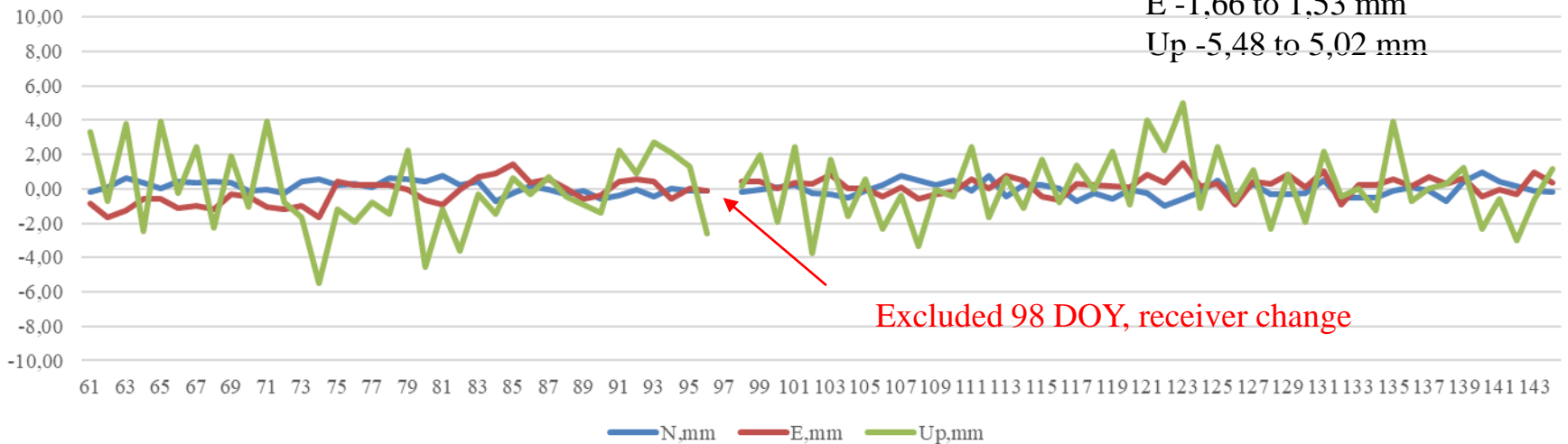
IRBE

N -1,12 to 1,12 mm
E -1,17 to 1,45 mm
Up -9,91 to 5,27 mm



VAIN

N -1,01 to 0,95 mm
E -1,66 to 1,53 mm
Up -5,48 to 5,02 mm





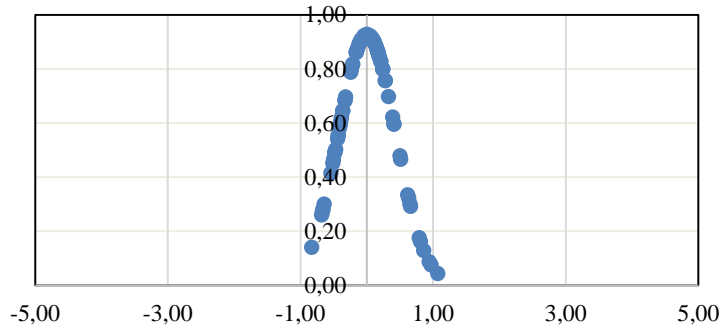
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Repeatability RMS			
Station name	N, mm	E, mm	U, mm
ALKS	0,43	0,54	1,70
DLKS	0,51	0,58	1,77
IRBE	0,46	0,55	2,59
VAIN	0,40	0,67	2,12
RIGA	0,43	0,56	2,02
BOR1	0,89	0,73	2,33
MAR6	0,81	1,06	2,71
MDVJ	0,70	1,27	2,92
METS	0,80	0,85	1,92
ONSA	0,58	1,61	2,91
POLV	1,22	0,91	3,58
PULK	0,70	0,73	2,63
TOR2	0,47	0,61	1,65
VLNS	0,55	0,48	2,12

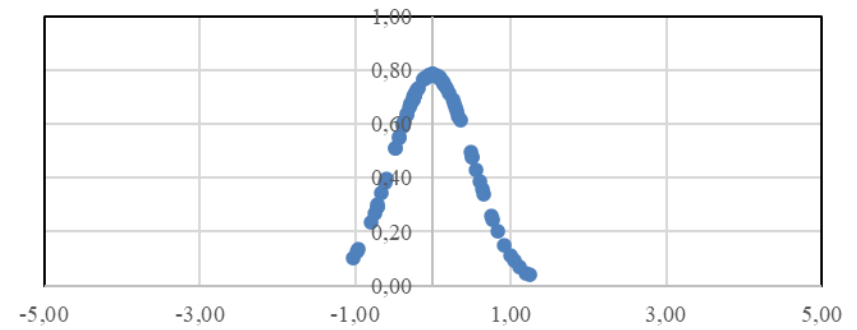
Total	0,67	0,85	2,41

Coordinate repeatability normal distribution N

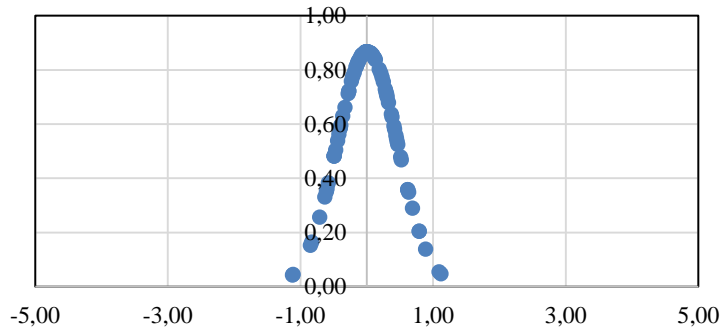
ALKS



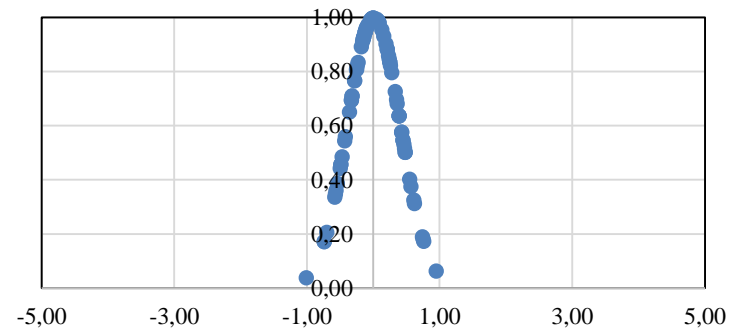
DLKS



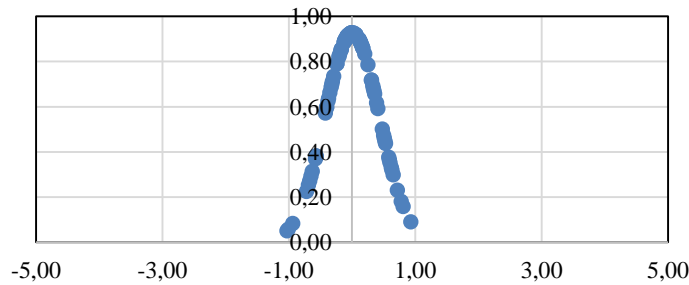
IRBE



VAIN



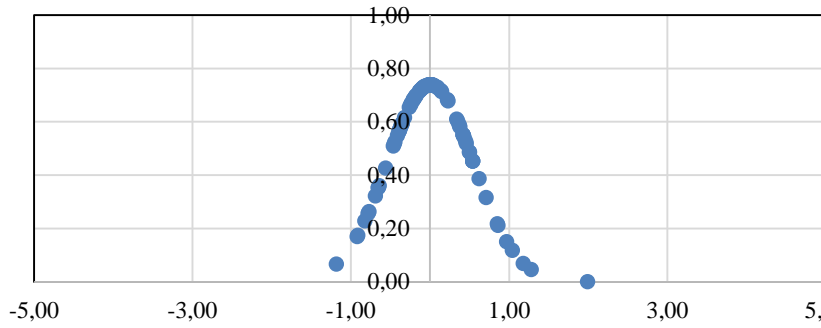
RIGA



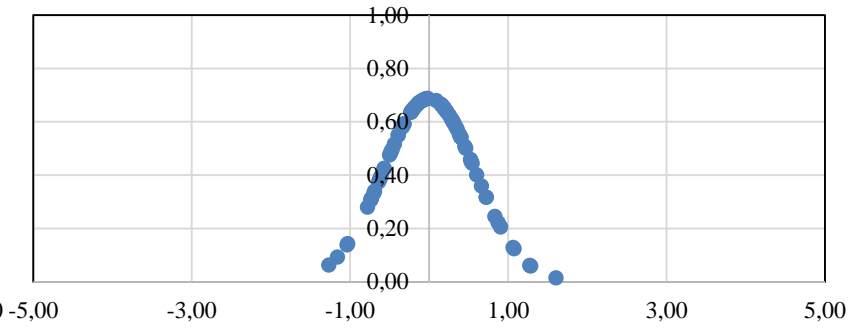
$$f(x; \mu; \sigma) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\left(\frac{(x-\mu)^2}{2\sigma^2}\right)}$$

Coordinate repeatability normal distribution E

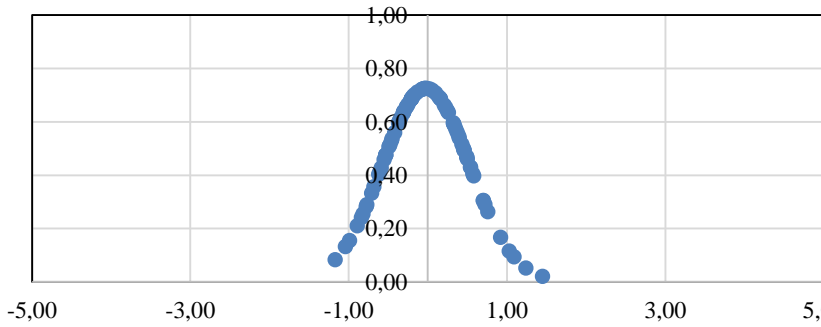
ALKS



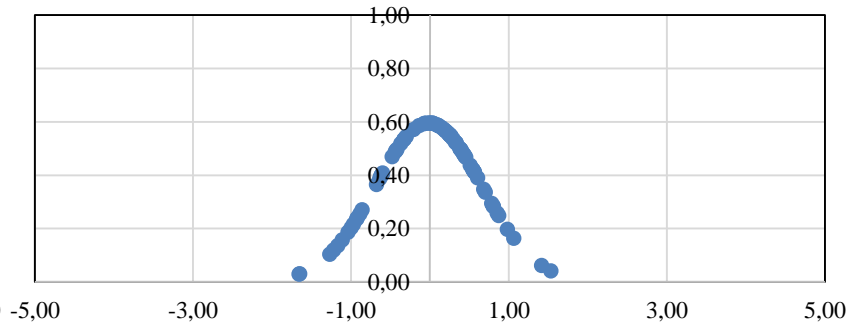
DLKS



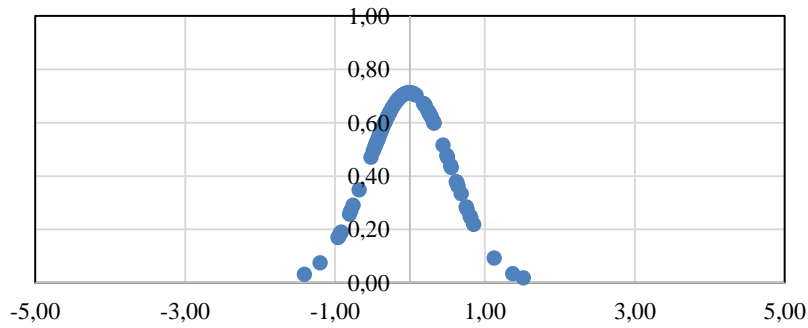
IRBE



VAIN

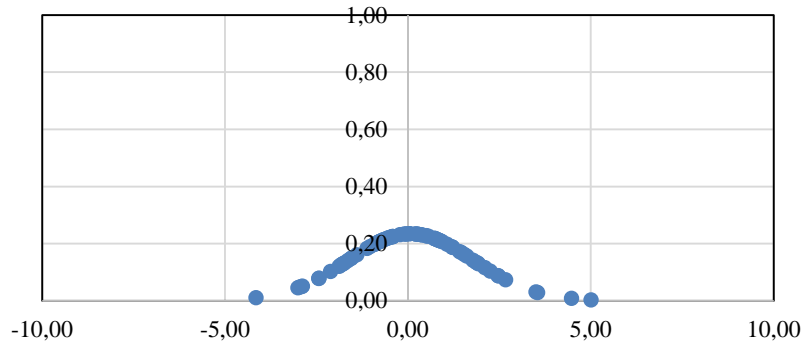


RIGA

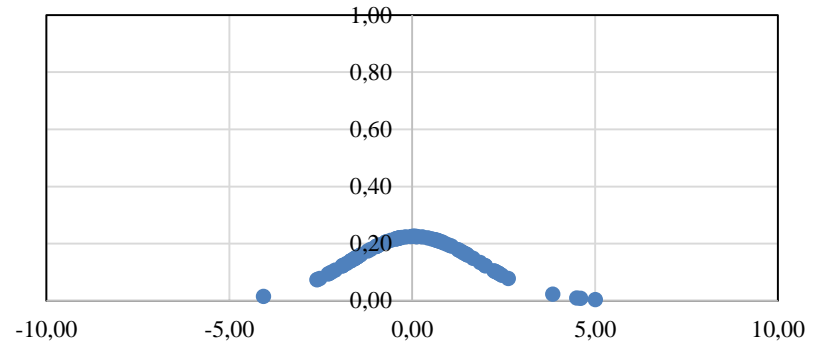


Coordinate repeatability normal distribution Up

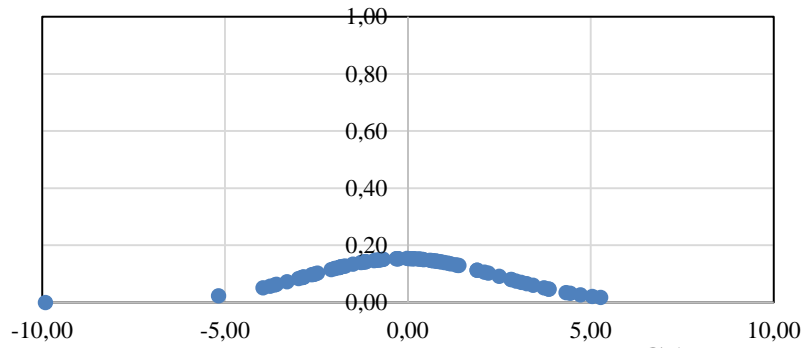
ALKS



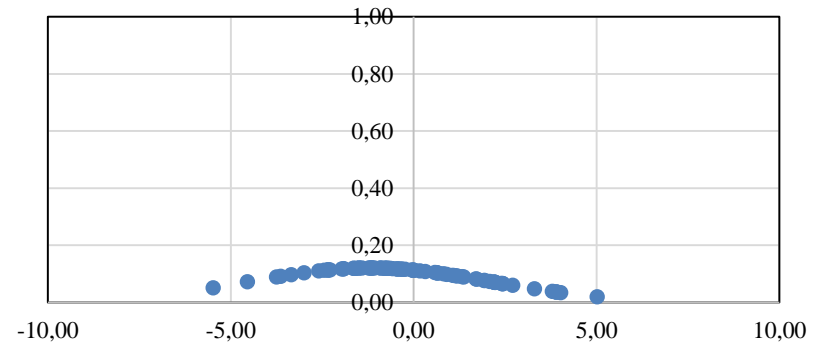
DLKS



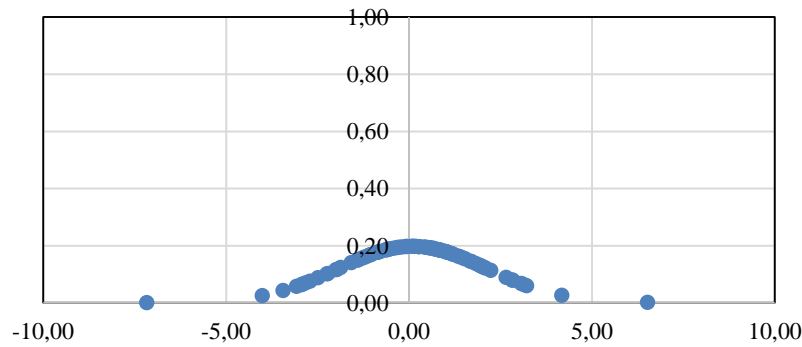
IRBE



VAIN



RIGA





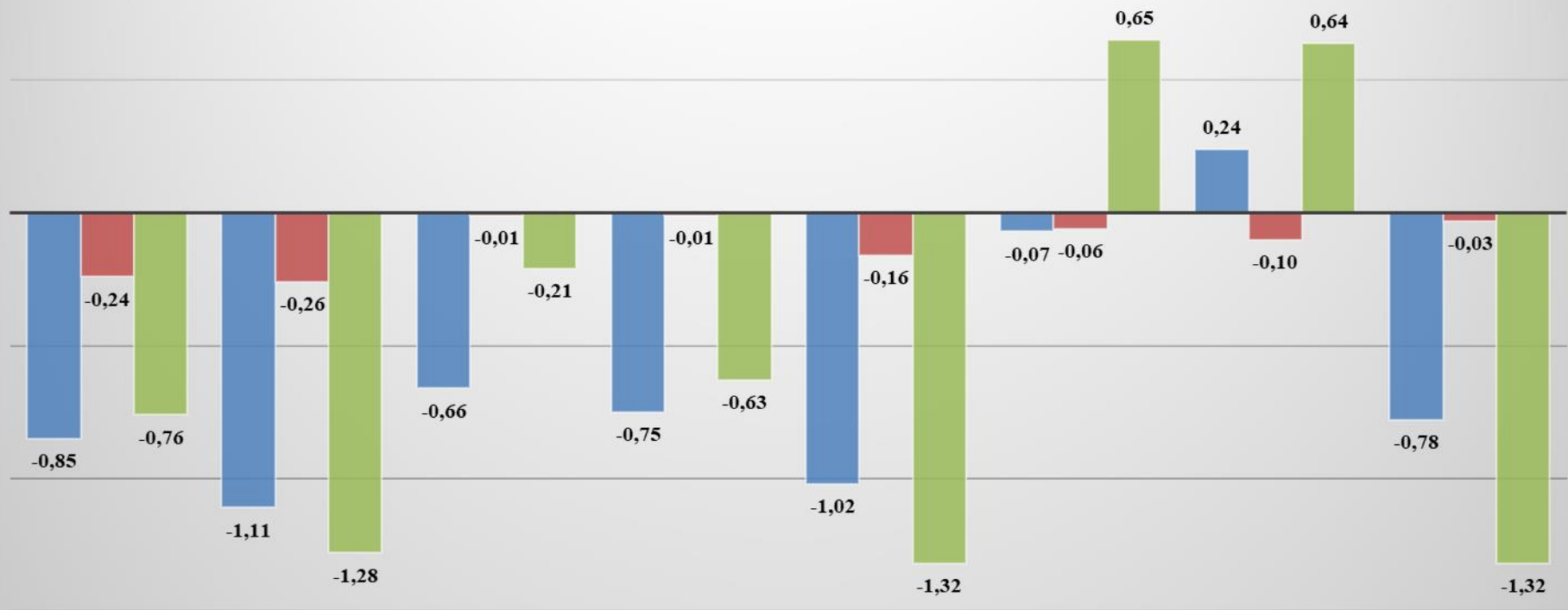
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Coordinate differences when shorten observation period

According to EPN guidelines on EUREF densification, if campaign observation period is more than one month and less than three years, one of the approaches is to shorten observation period and apply rule of one month.

Observation period 01.03.2020. - 23.05.2020						Observation period 05.04.2020.-18.04.2020					
<u>IGb14 LATREFV8</u>						<u>IGb14 LATREFV8.2</u>					
Epoch: 2020-04-12 00:00:00						Epoch: 2020-04-12 00:00:00					
NUM	STATION NAME	X (M)	Y (M)	Z (M)	X (M)	Y (M)	Z (M)	dX (M)	dY (M)	dZ (M)	
1	ALKS	10731M002	3064941,14460	1564041,78604	5352595,46356	3064941,14456	1564041,78620	5352595,46345	0,000	0,000	0,000
2	DLKS	10704M003	3206756,71631	1607049,89870	5256433,16638	3206756,71617	1607049,89859	5256433,16614	0,000	0,000	0,000
3	IRBE	10726M001	3183614,31408	1276707,91201	5359315,31563	3183614,31426	1276707,91234	5359315,31591	0,000	0,000	0,000
4	VAIN	10736M001	3282526,39044	1315358,10799	5290482,74083	3282526,39000	1315358,10793	5290482,74028	0,000	0,000	0,001
5	RIGA	12302M002	3183898,91799	1421478,70742	5322810,91991	3183898,91815	1421478,70756	5322810,92023	0,000	0,000	0,000
6	BOR1	12205M002	3738358,19303	1148173,94666	5021815,89830	3738358,19223	1148173,94652	5021815,89774	0,001	0,000	0,001
7	MAR6	10405M002	2998189,20502	931451,99506	5533398,88231	2998189,20533	931451,99538	5533398,88260	0,000	0,000	0,000
8	MDVJ	12309M005	2845455,75008	2160954,42657	5265993,31869	2845455,75059	2160954,42602	5265993,31881	-0,001	0,001	0,000
9	METS	10503S011	2892570,52357	1311843,66116	5512634,27069	2892570,52389	1311843,66130	5512634,27039	0,000	0,000	0,000
10	ONSA	10402M004	3370658,31984	711877,35948	5349787,10488	3370658,31945	711877,35968	5349787,10498	0,000	0,000	0,000
11	POLV	12336M001	3411557,02924	2348464,17484	4834397,00098	3411557,02911	2348464,17415	4834397,00124	0,000	0,001	0,000
12	PULK	12305M001	2778606,51490	1625494,87347	5487811,08837	2778606,51535	1625494,87380	5487811,08902	0,000	0,000	-0,001
13	TOR2	10602M001	3010733,46375	1498577,20984	5401387,62643	3010733,46412	1498577,21014	5401387,62689	0,000	0,000	0,000
14	VLNS	10801M001	3343600,32310	1580417,95403	5179337,41548	3343600,32231	1580417,95401	5179337,41448	0,001	0,000	0,001

RIGA station LATREFV8 coordinates compare to other campaigns and EPN official coordinates, IGb14 (2020.04.12.)



V4: OBS-MAX
 V4: DEFINED
 V5: OBS-MAX
 V5: DEFINED
 V6: DEFINED
 V7: OBS-MAX
 V7: DEFINED

■ X (MM) ■ Y (MM) ■ Z (MM)

↑ EPN:
 IGb14 velocities:
 VX = -17,87 mm/y
 VY = 14,17 mm/y
 VZ = 8,63 mm/y

Coordinate comparison to NKG REPRO1



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LATREFV8 results				
LOCAL GEODETIC DATUM IGb14 EPOCH: 2020-04-12 00:00:00				
NUM	STATION	X (M)	Y (M)	Z (M)
1	ALKS	3064941,1446	1564041,7860	5352595,4636
2	DLKS	3206756,7163	1607049,8987	5256433,1664
3	IRBE	3183614,3141	1276707,9120	5359315,3156
4	VAIN	3282526,3904	1315358,1080	5290482,7408

NKG REPRO1 results (extrapolate to epoch 12.04.2020.)							
LOCAL GEODETIC DATUM IGb14 EPOCH: 2020-04-12 00:00:00							
NUM	STATION	X (M)	Y (M)	Z (M)	VX(MM/Y)	VY(MM/Y)	VZ(MM/Y)
1	ALKS	3064941,1450	1564041,7860	5352595,4636	-18,62	12,36	9,56
2	DLKS	3206756,7166	1607049,8988	5256433,1659	-21,05	13,44	4,59
3	IRBE	3183614,3133	1276707,9109	5359315,3138	-17,23	14,29	8,43
4	VAIN	3282526,3907	1315358,1077	5290482,7404	-18,52	14,21	8,58

Differences LATREFV8-NKG REPRO1				
NUM	STATION	dX (MM)	dY (MM)	dZ (MM)
1	ALKS	-0,44	0,01	-0,02
2	DLKS	-0,24	-0,07	0,45
3	IRBE	0,79	1,10	1,81
4	VAIN	-0,28	0,31	0,45



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LATREF stations coordinates transform from IGb14 to ETRF2014 same epoch 2020.04.12. with EPN transformation

ETRF2014 (2020.04.12. epoch) = LKS–20 (2020.04.12. epoch)

NUM	STATION NAME	X (M)	Y (M)	Z (M)
1	ALKS 10731M002	3064941,7582	1564041,3592	5352595,2369
2	DLKS 10704M003	3206757,3272	1607049,4565	5256432,9289
3	IRBE 10726M001	3183614,8947	1276707,4712	5359315,0757
4	VAIN 10736M001	3282526,9700	1315357,6565	5290482,4935
5	RIGA 12302M002	3183899,5126	1421478,2670	5322810,6819

RIGA station coordinates LATREFV8 campaign comparison to EPN official coordinates in ETRF2014 (354/2014 – 261/2021)

	X (M)	Y (M)	Z (M)
LATREFV8	3183899,5126	1421478,2670	5322810,6819
EPN	3183899,5134	1421478,2671	5322810,6832
Difference	-0,8	-0,1	-1,3

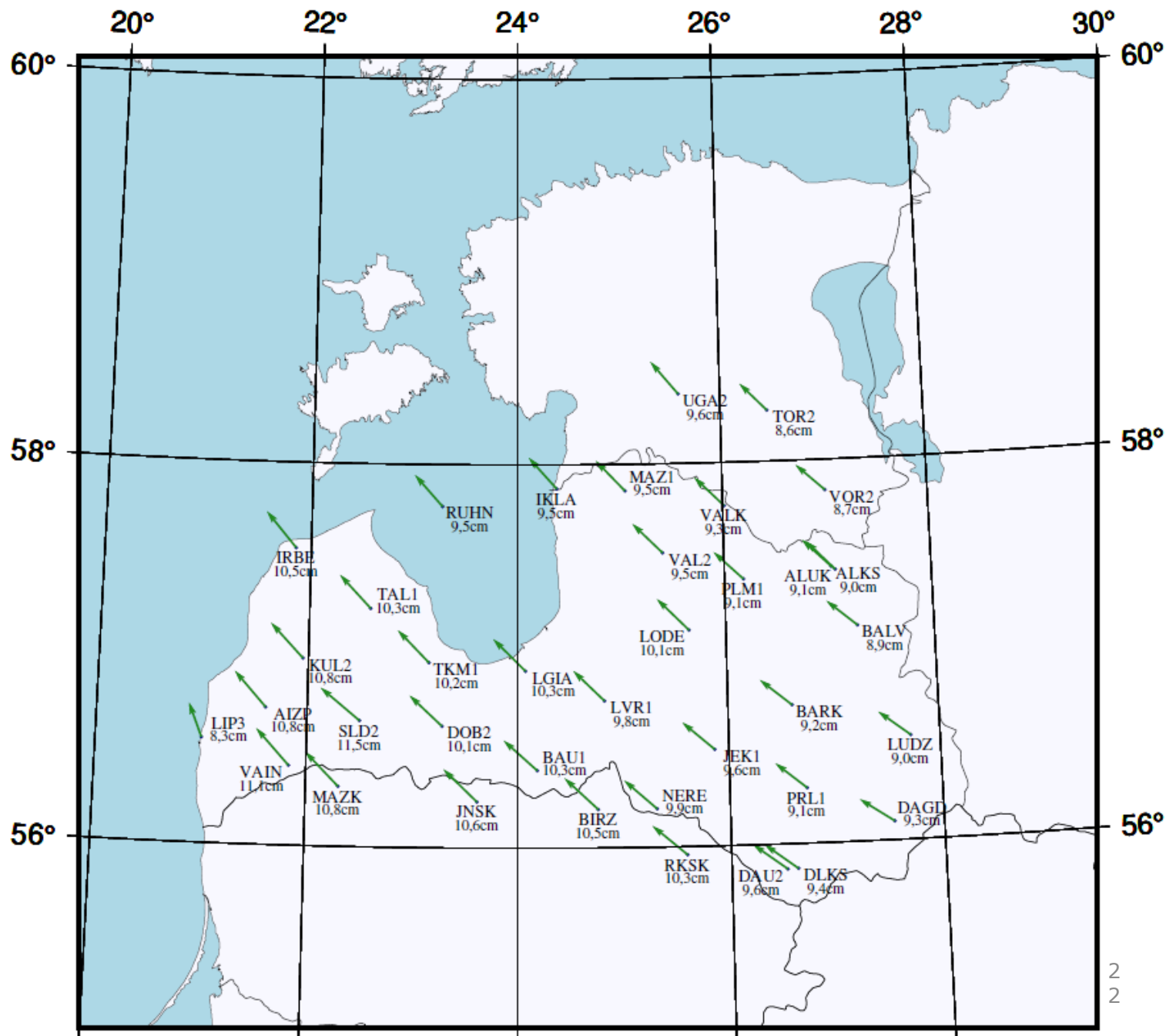
EPN ETRF2014 velocities $VX=1,1$ mm/y; $VY = 0,1$ mm/y; $VZ= 1,0$ mm/y

Horizontal difference: LKS-92(1992.75) ⇨ LKS-20(2020.28)



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x : ~ 5 cm to 8 cm
y : ~ -3 cm to -9 cm

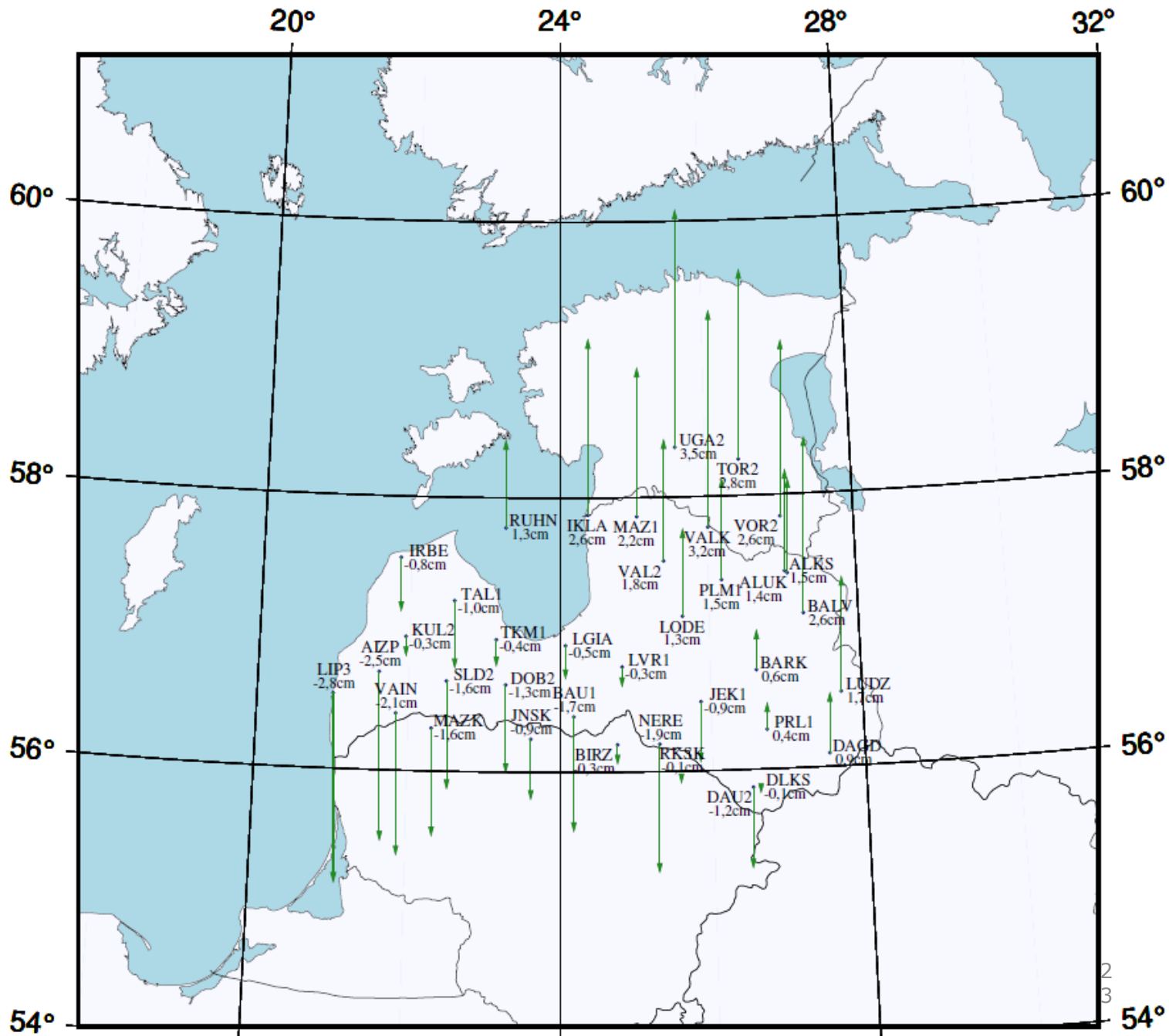


Height (h) difference: LKS-92(1992.75) ⇨ LKS-20(2020.28)



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~ -2,8 cm to 3,5 cm





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Summary

LATREF stations final solution coordinates RMS XYZ less than 0,1 mm

LATREF stations final solution coordinates (repeatability) RMS XYZ less than :

N 0,51 mm

E 0,67 mm

Up 2,59 mm

Station name	Repeatability RMS for 84 sessions		
	σ_N ,mm	σ_E ,mm	σ_U ,mm
ALKS	0,43	0,54	1,70
DLKS	0,51	0,58	1,77
IRBE	0,46	0,55	2,59
VAIN	0,40	0,67	2,12
RIGA	0,43	0,56	2,02



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Future plans

National working group had approved LATREF coordinates

Next step will be LATPOS network coordinates validation, transformation parameters between LKS-92 and LKS-20

Change of legislation to new Latvian coordinate system LKS-20

Velocity calculation for LATREF stations

Data available:

VAIN00LVA (2016 year);

ALKS00LVA (2018 year);

DLKS00LVA (2019 year);

RIGA00LVA and IRBE00LVA more than 10 years

What is the best way to calculate IGB14 and ETRF2014 velocities?

Is it enough with 3 year observations?



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Thank you for your attention!