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Multi-year solution for the ESTPOS network

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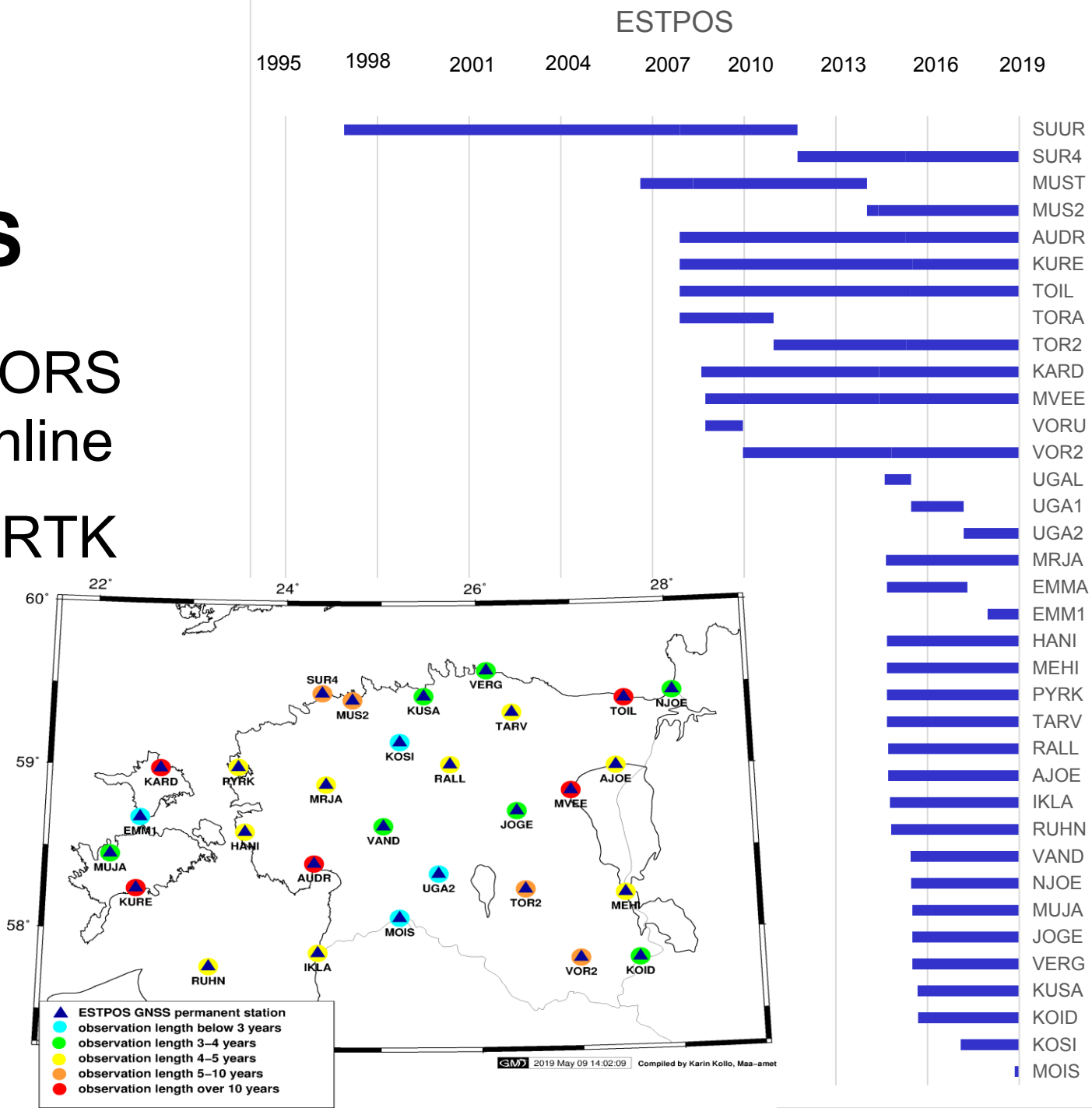
Estonian Land Board



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ESTPOS

- Now 29 CORS stations online
- Providing RTK service





ESTPOS as the part of EUREF densification

- Included to EPN densification
- Active geodetic system monitoring
- Majority of stations have observations more than 3 years
- Time span from GPS week 1408
- Cumulative weekly solutions



Observation period

- 30sec – 24h RINEX
- Most GNSS stations were established in 2014-2016 (19 out of 29)
- 9 stations have observation period more than 10 years
- 18 stations have been operational for at least 3 years



GNSS equipment

- Available GPS, GLONASS, GALILEO
- All of the 28 GNSS stations are equipped with Leica GR25 receivers.
- All sites, except TOR2, are equipped with Leica LEIAR25.R4 antennas and LEIT radomes
- TOR2 uses Leica LEIAT504GG antenna and a LEIS dome



Monument description

- All sites are situated on top of buildings, except MVEE





Data used in the processing

Parameter	REPRO (weeks 1408 – 1933)	OPERATIONAL (weeks 1934 – 2034)
Software	Bernese GNSS 5.2	
Satellite system	GPS	GPS+GLONASS
Elevation cut-off angle	3° and 10° (25° for additional testing)	
Orbits	CODE (REPRO_2013 and final products from 2014)	Final products from CODE
Antenna calibration model	eprn_08.atx	eprn_14.atx
EPN SINEX solution	EPN_A_IGb08_C1845.SNX and EPN_A_IGb08_C1934.SNX	None
Positioning mode	Network DD	
Baseline definition	OBS-MAX	
Ambiguity resolution strategy	QIF	
Troposphere model	VMF1	
Ionosphere model	CODE	
Ocean tide loading model	FES2004	
Atmospheric tidal model	Compiled in Bernese	
Stacking daily solutions	minimum constraints using 3 translations	
Reference frame	IGb08	IGS14
Exclusion threshold for the outliers	10, 10, 30 mm for NEU components respectively	



List of reference stations

Full name	Site name	9-char ID	Domes nr
Borowiec	BOR1	BOR100POL	12205M002
Joensuu	JOEN	JOEN00FIN	10512M001
Olsztyn	LAMA	LAMA00POL	12209M001
Maartsbo	MAR6	MAR600SWE	10405M002
Mendeleevo	MDVJ	MDVJ00RUS	12309M005
Metsahövi	METS	METS00FIN	10503S011
Onsala	ONSA	ONSA00SWE	10402M004
Potsdam	POTS	POTS00DEU	14106M003
St. Petersburg	PULK	PULK00RUS	12305M001
Riga	RIGA	RIGA00LVA	12302M002
Sassnitz	SASS	SASS00DEU	14281M001
Visby	VISO	VISO00SWE	10423M001
Vilnius	VLNS	VLNS00LTU	10801M001
Westerbork	WSRT	WSRT00NLD	13506M005



Processing

- Daily sinex
- Weekly sinex
- Multi-year solution

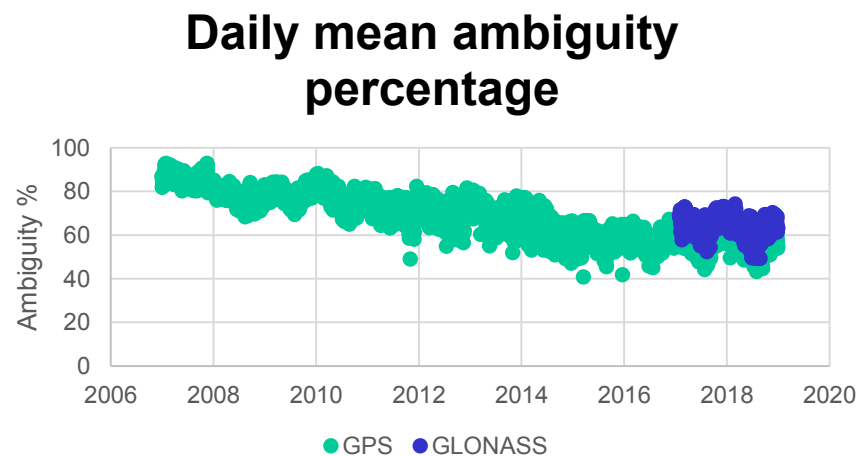
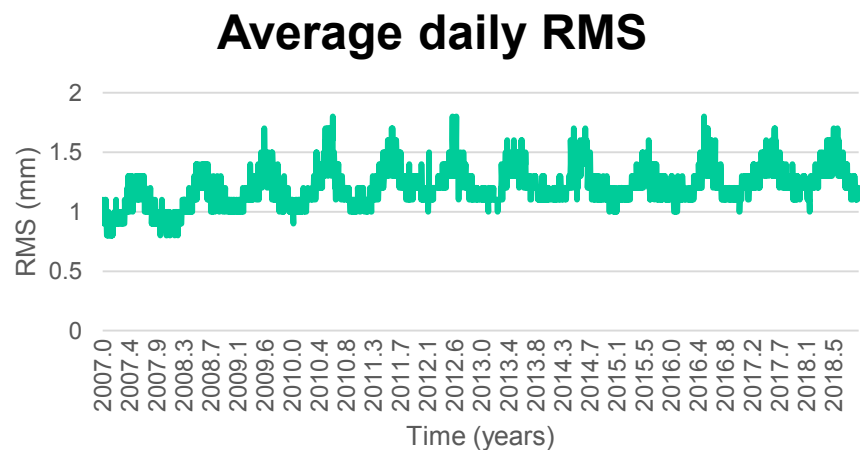
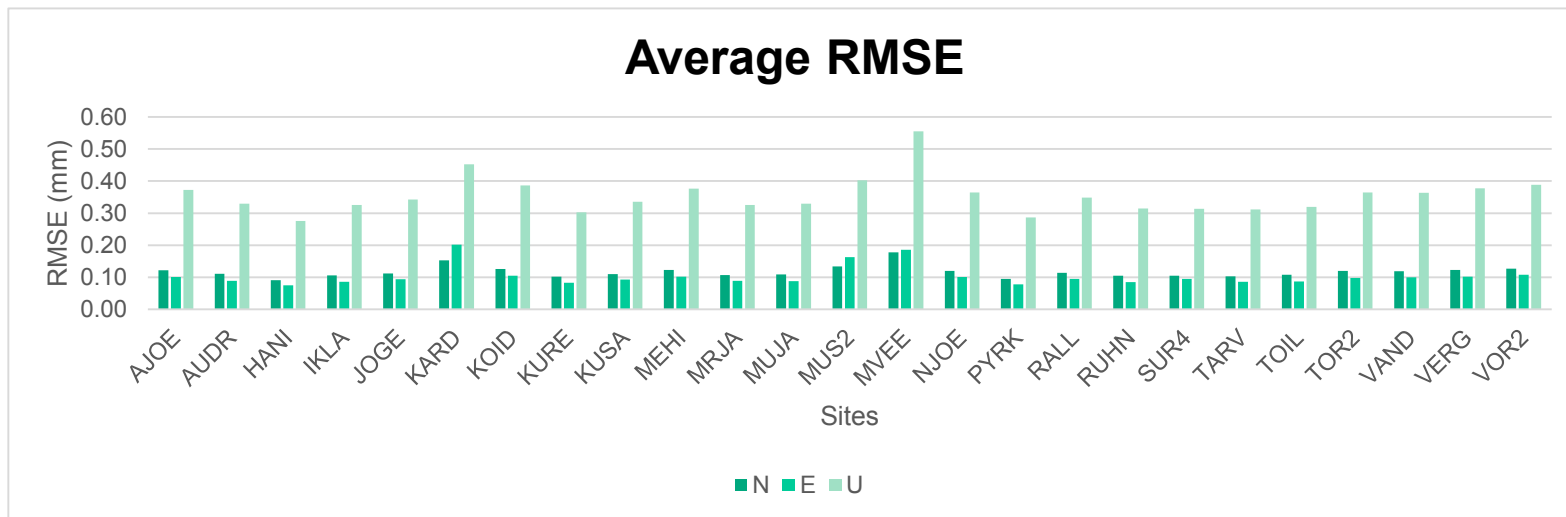


Processing strategy

- Network approach (DD)
- FES2004 ocean tide model
- The QIF (Quasi Ionosphere Free) strategy
- Vienna Mapping Function troposphere model
- Global ionosphere maps by CODE
- Alternative strategies 10° and 25° cut-off angles



Results: daily solutions





Weekly solutions

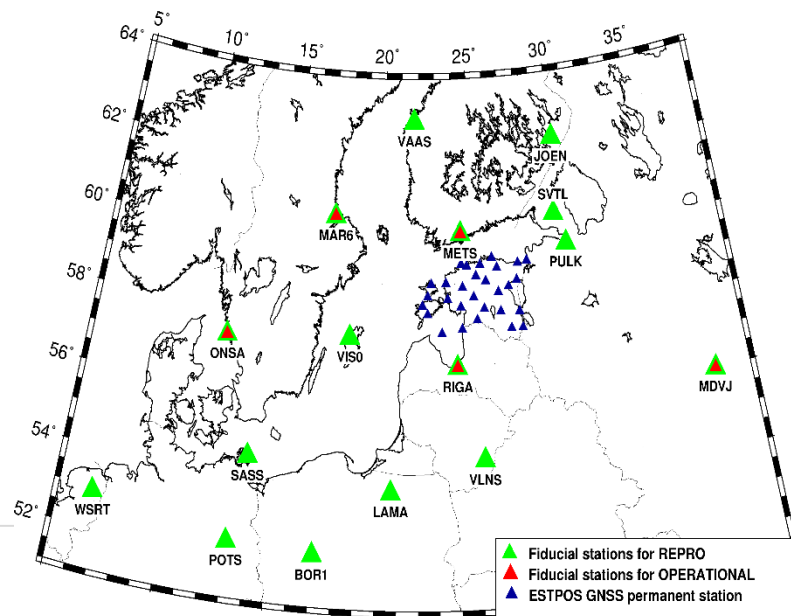
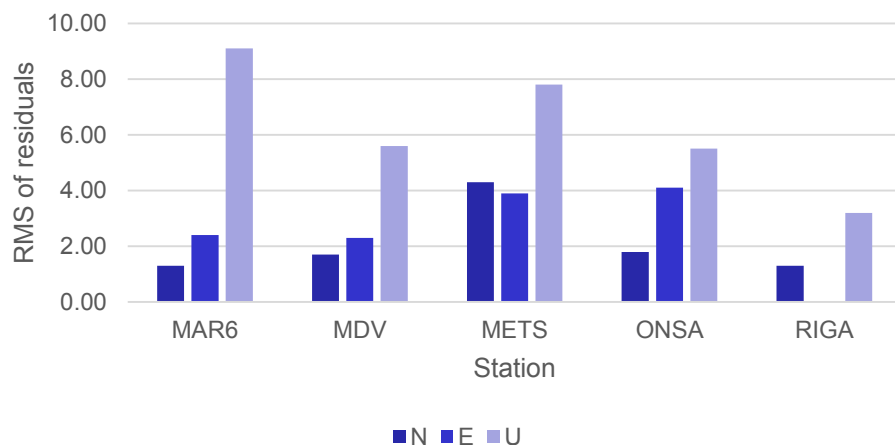
- Bernese ADDNEQ2 program by combining daily SINEX solutions
- Weekly SINEX aligned to a reference solution using minimum constraints over 3 translation parameters
 - REPRO: EPN_A_IGb08_C1845.SNX and EPN_A_IGb08_C1934.SNX
 - OPERATIONAL: coordinates of the reference stations <ftp://epncb.oma.be/epncb/station/coord/EPN>



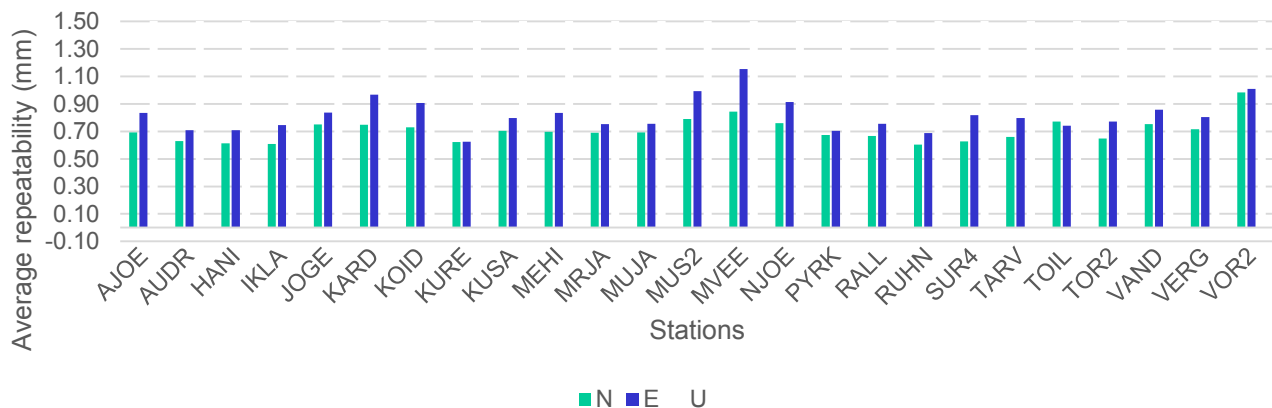
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Results: weekly solutions

RMS of residuals after Helmert transformation



Average weekly repeatability





Multi-year solution

- Conversion to IGS14 (1408-1933)
- CATREF software used
- Time span 1408-2034

Reference stations used for the alignment

Station	Soln no
BOR1	2
BOR1	3
JOEN	1
KURE	1
KURE	2
LAMA	3
MAR6	2
MDVJ	1
ONSA	2
POTS	4
POTS	5
POTS	6
PULK	1
SVTL	3
SVTL	4
TOIL	1
VAAS	1
VAAS	2
VISO	1
VLNS	1
VLNS	2



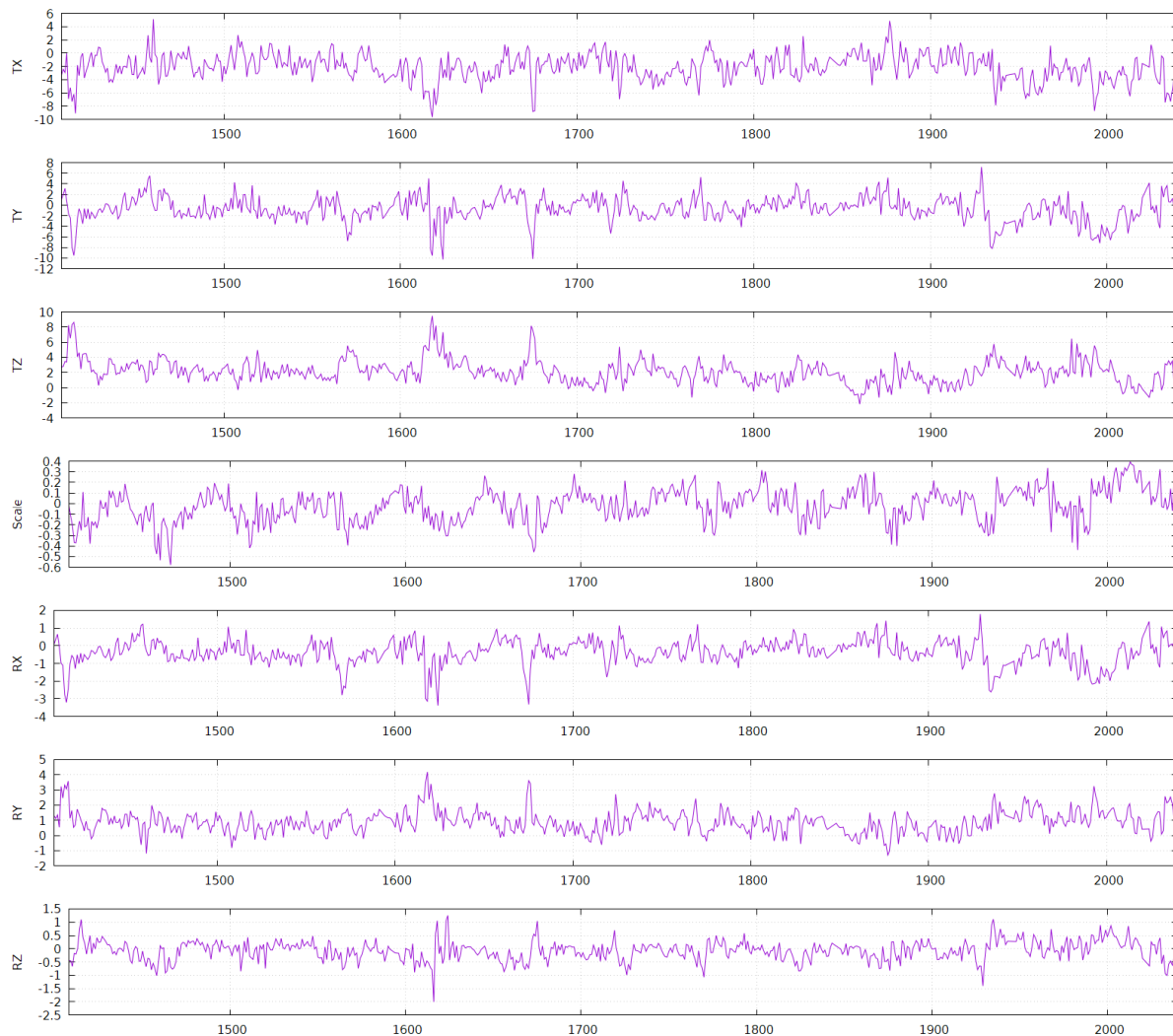
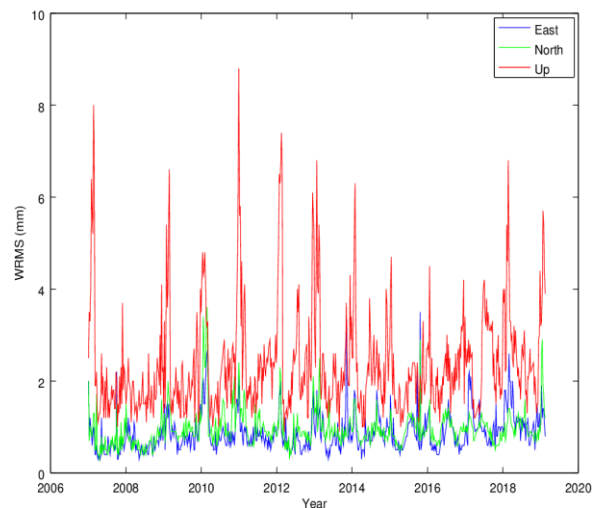
Stacking weekly solutions

- The positions and velocities aligned:
 - EPN cumulative solution
EPN_A_IGS14_C2025
 - minimal constraints over 14 parameters (3 translations, scale and 3 rotations and their changes)
- Discontinuities mainly for instrument change



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Results: multi-year solution



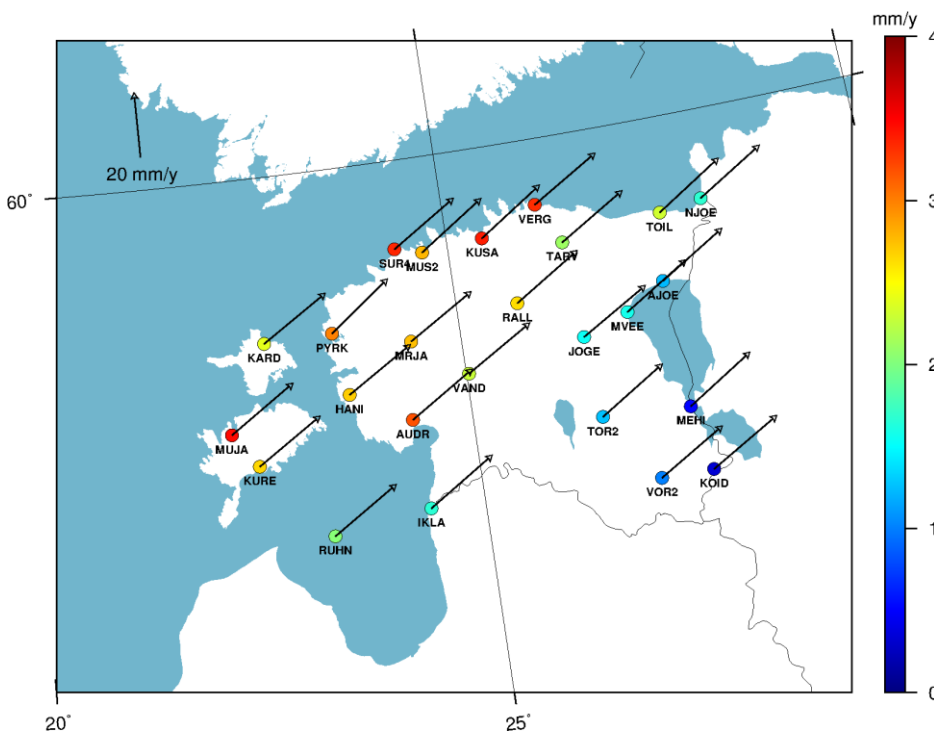


Additional comparisons

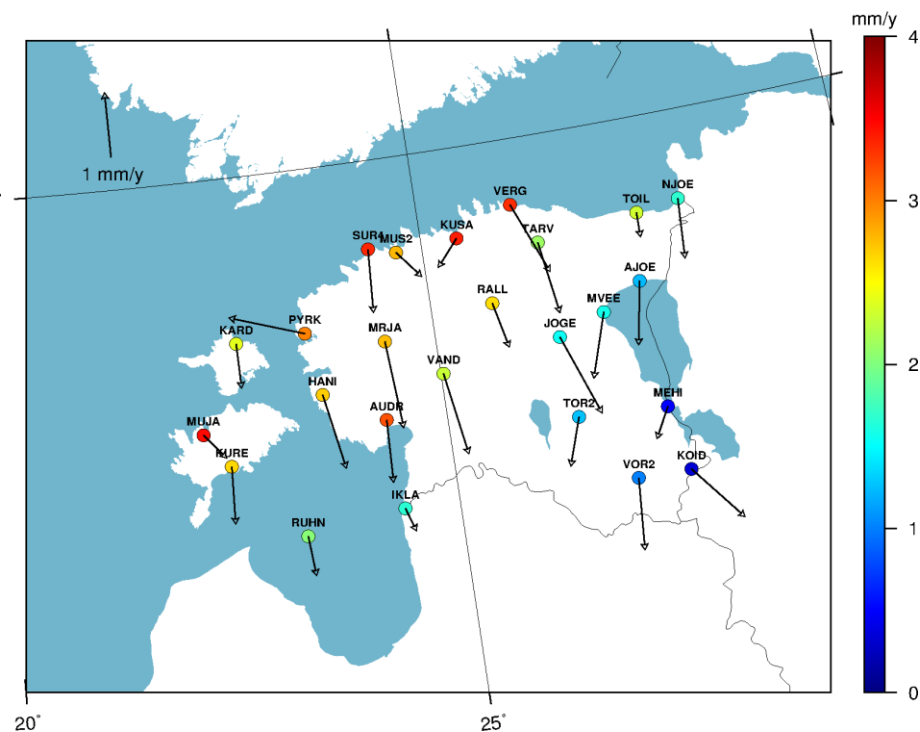
	RMS of residuals		
	dN (mm) or dVN (mm/yr)	dE(mm) or dVE(mm/yr)	dU (mm) or dVU (mm/yr)
Coordinates from C2025	0.69	0.69	2.26
Velocity from C2025	0.09	0.08	0.16
Velocity from Lahtinen et al.	0.29	0.16	0.28
Velocity from NKG2016LU	-	-	0.32
Coordinates from C2040 (ETRF2000)	0.18	0.27	0.72



Velocity in IGS14 and ETRF89



IGS14



ETRF89



Final coordinates and velocities

- Final coordinates and velocities are given at the epoch 2013.00 (middle epoch of observations)
 - Coordinates and velocities in IGS14
 - Coordinates and velocities in ETRF89
- Transformation service from EPN web-page used



Multi-year solution for the ESTPOS

- ESTPOS multi-year solution was presented to the EUREF GB
- It was accepted by EUREF GB as class A standard