



MAA-AMET



ESTPOS as EUREF densification for Estonia

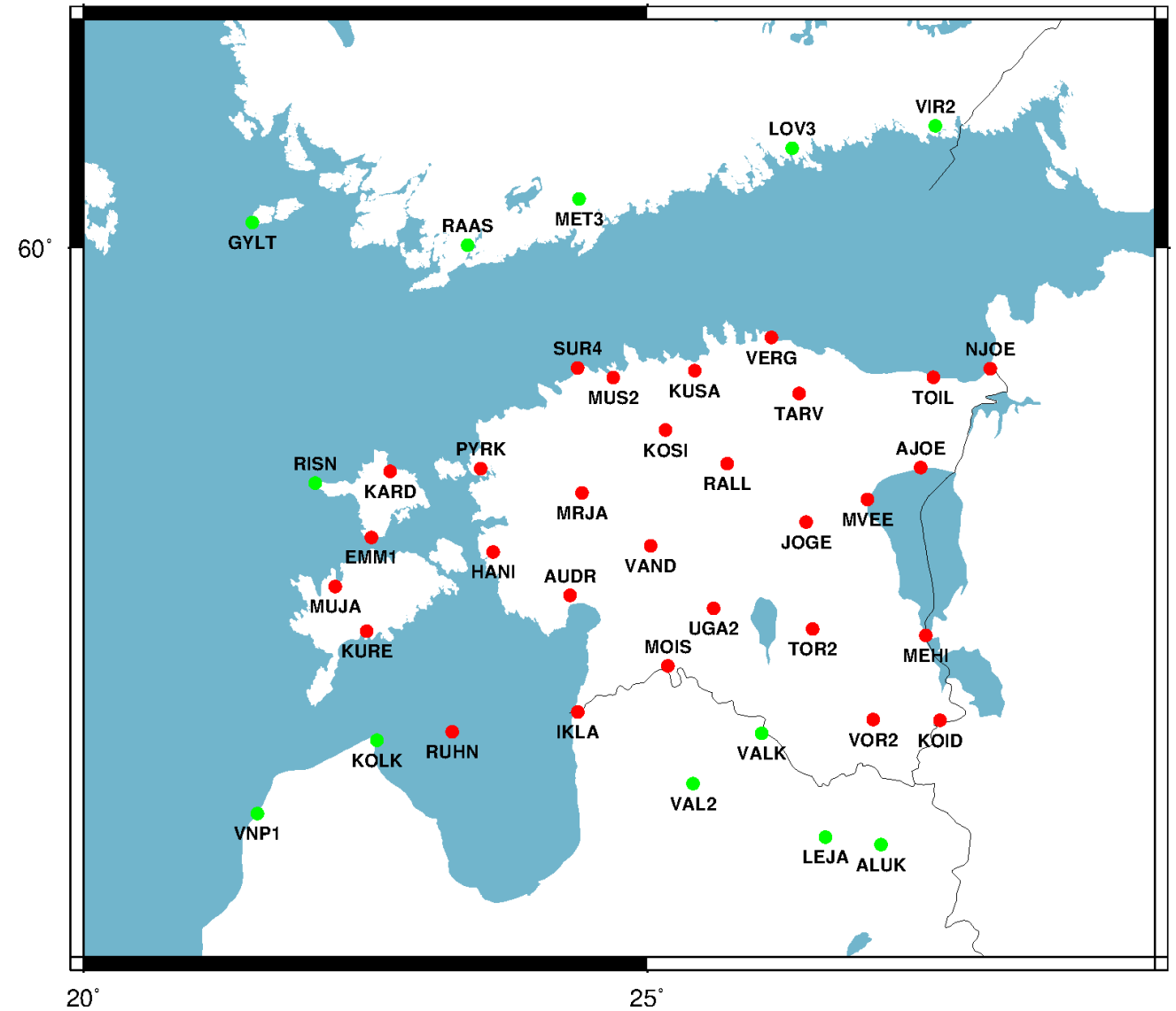
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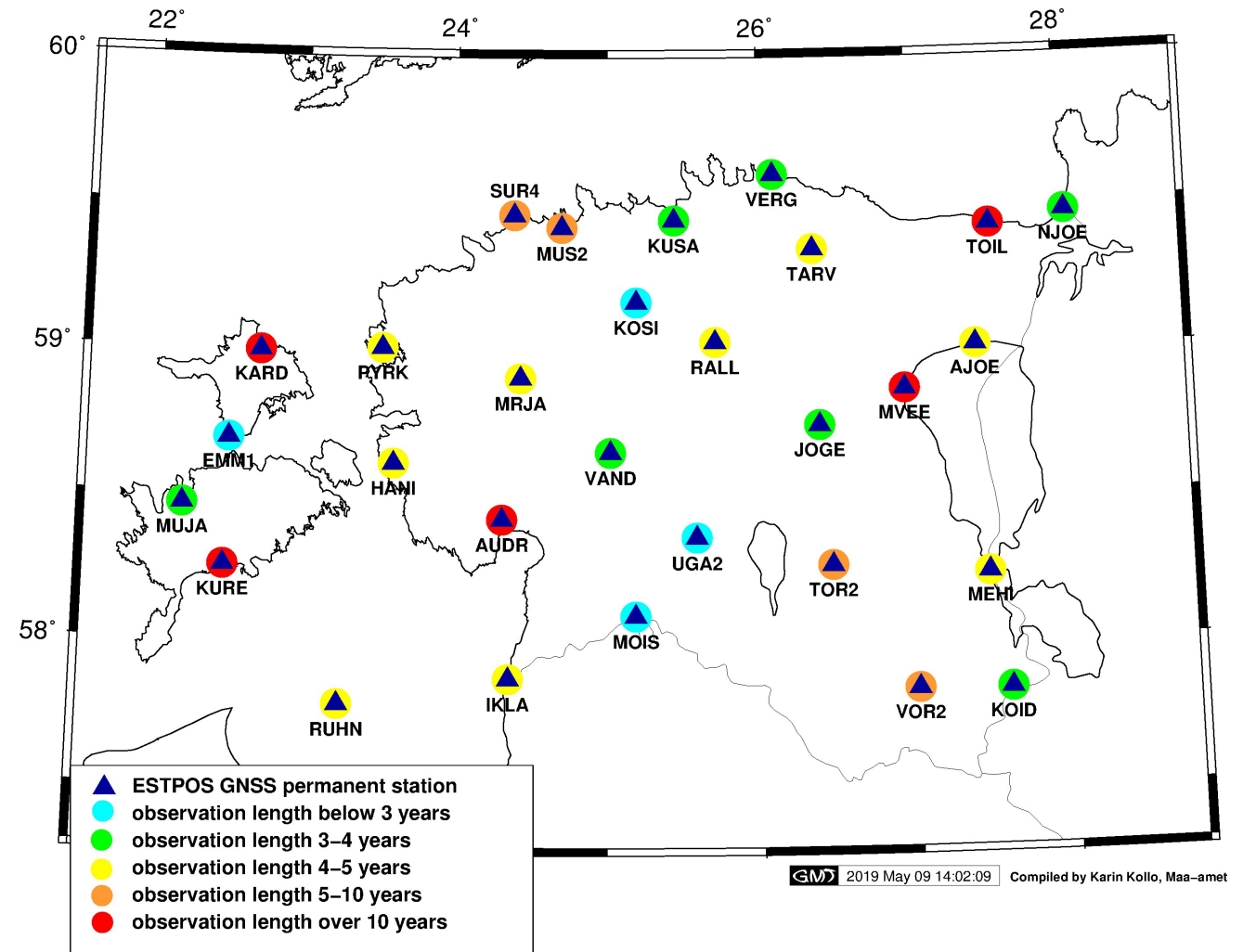
ESTPOS

- 29 CORS stations
- Providing Network-RTK service
- Data collection and data analysis
 - Real-time data streams
 - Static data collection and post-processing
- Monitoring geodetic system
 - Time-series of CORS stations



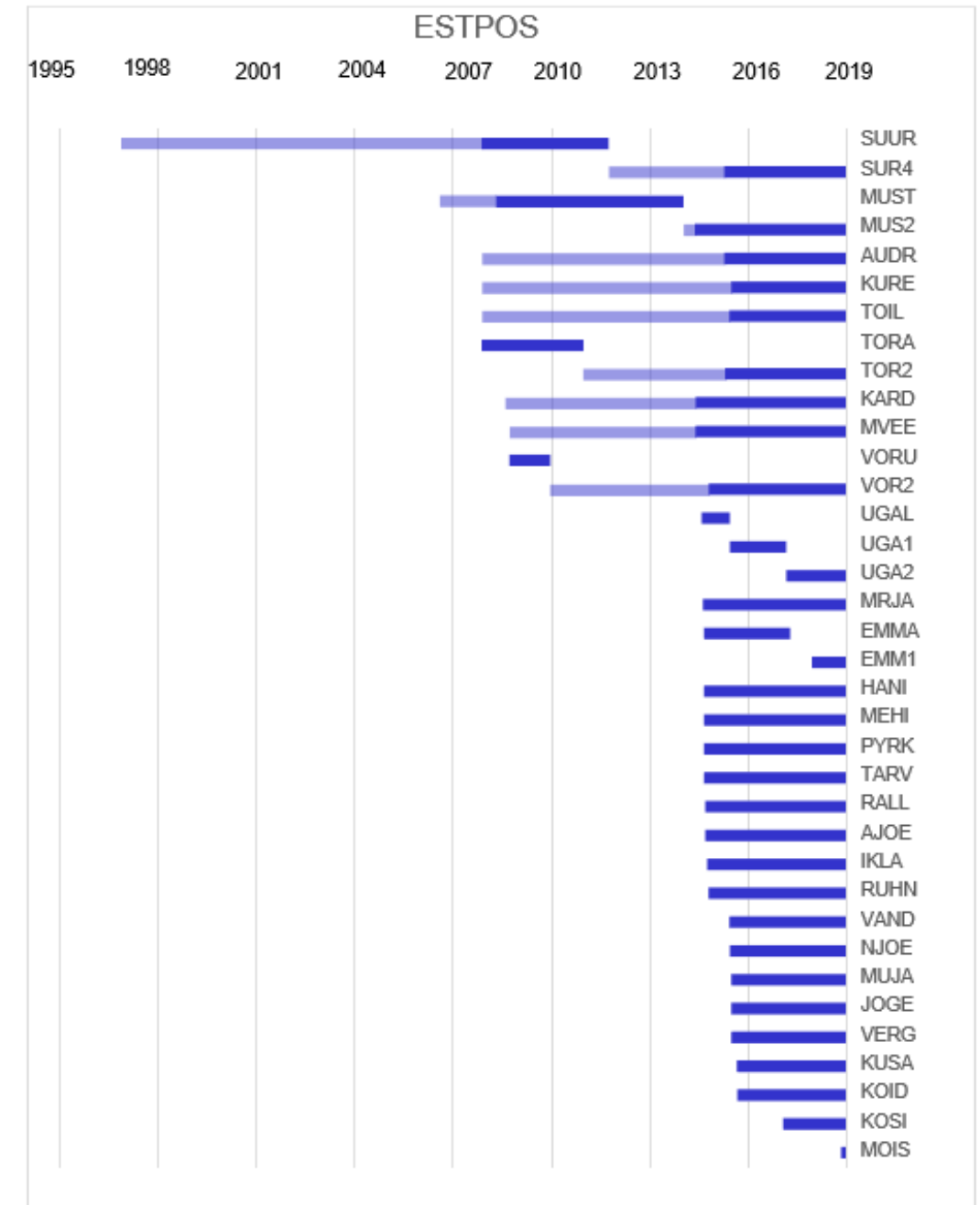
ESTPOS as the part of EUREF densification

- Included to EPN densification
- Active geodetic system monitoring
- Time span: GPS weeks 1408 – 2034
- Cumulative weekly solutions



Observation period

- 30 sec – 24h RINEX
- Most GNSS stations 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 GNSS stations are equipped with Leica GR25 receivers.
- All sites are equipped with Leica LEIAR25.R4 antennas and LEIT radomes

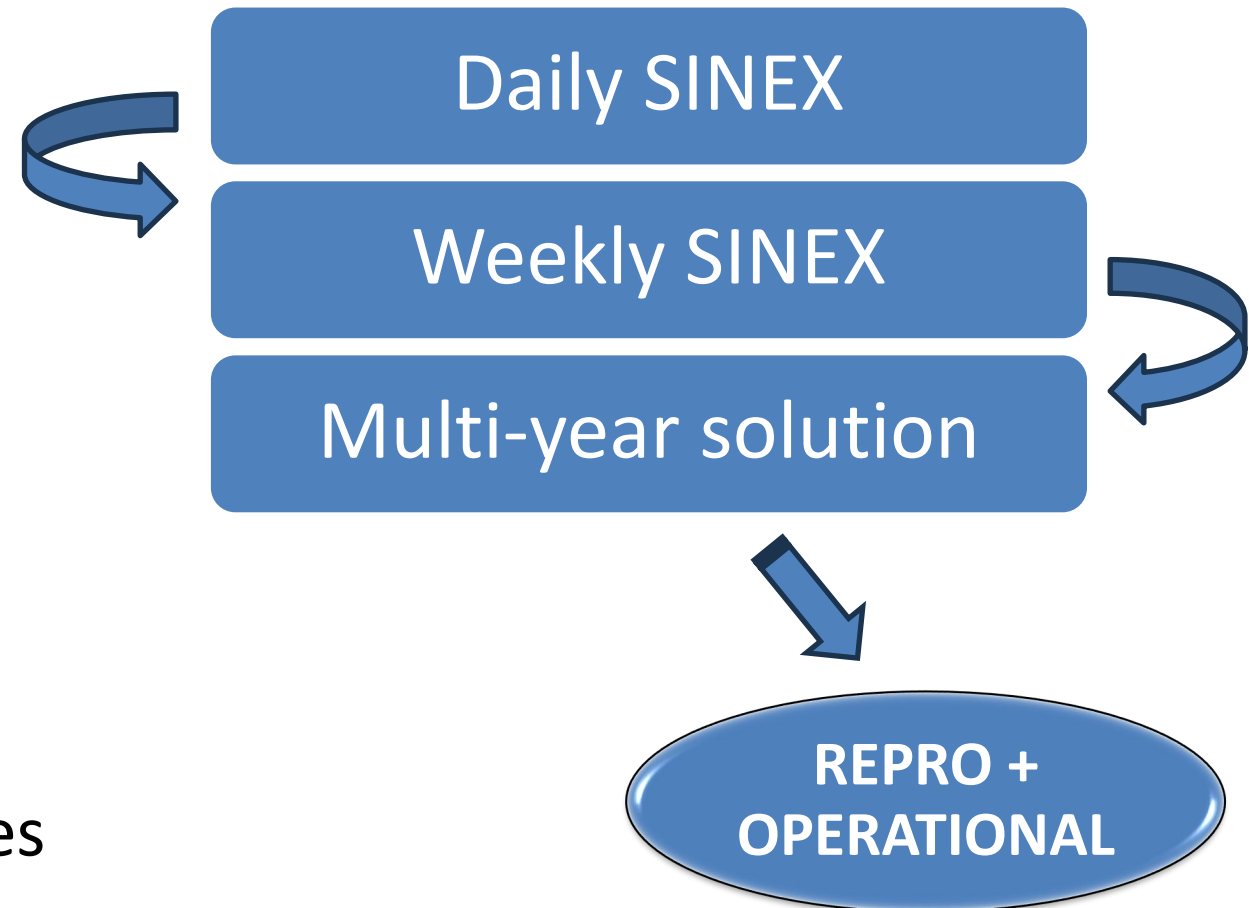


Data used in the processing

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	e pn_08.atx	e pn_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	

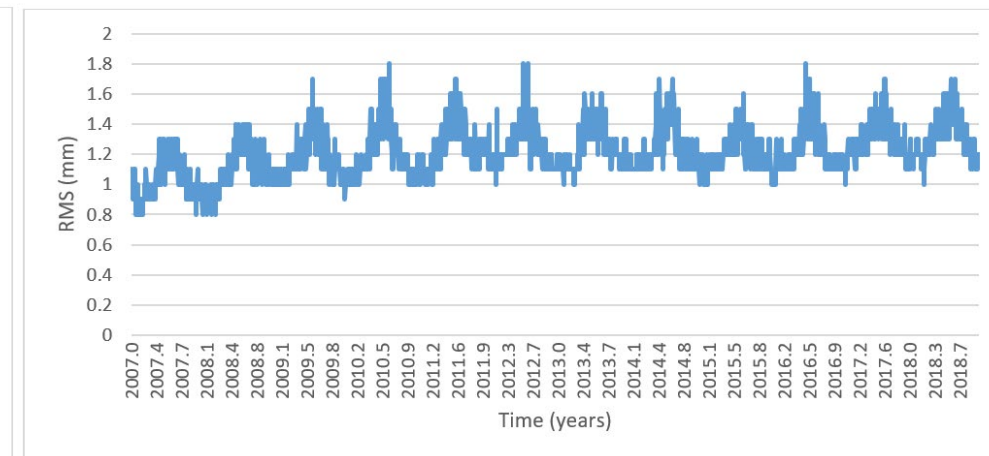
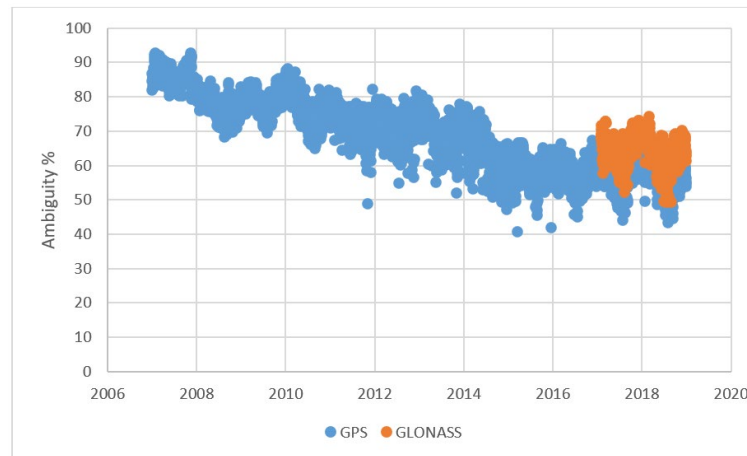
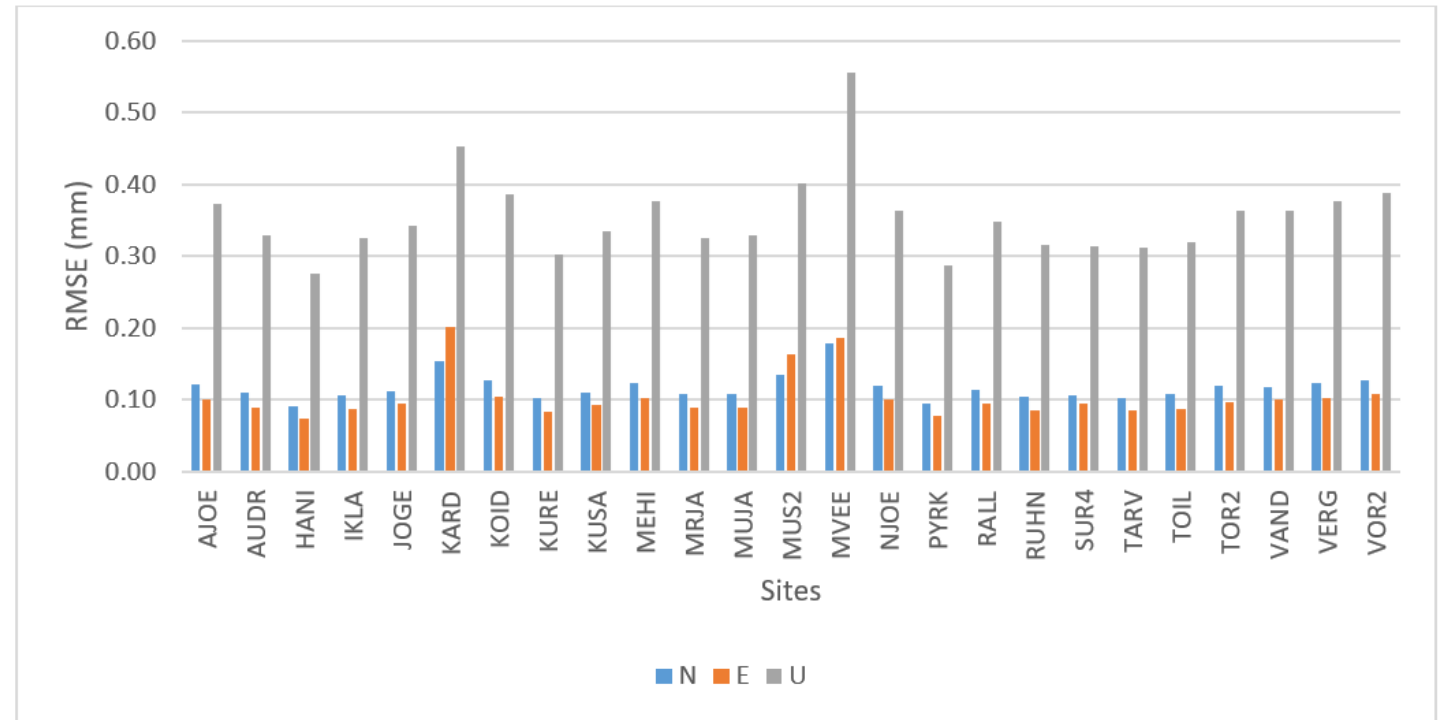
Processing strategy

- Network approach (DD)
- FES2004 ocean tide model
- The QIF (Quasi Ionosphere Free) strategy
- Vienna Mapping Function troposphere model
- Global ionosphere maps by CODE
- Main strategy 3° cut-off angle
- Alternative strategies 10° and 25° cut-off angles



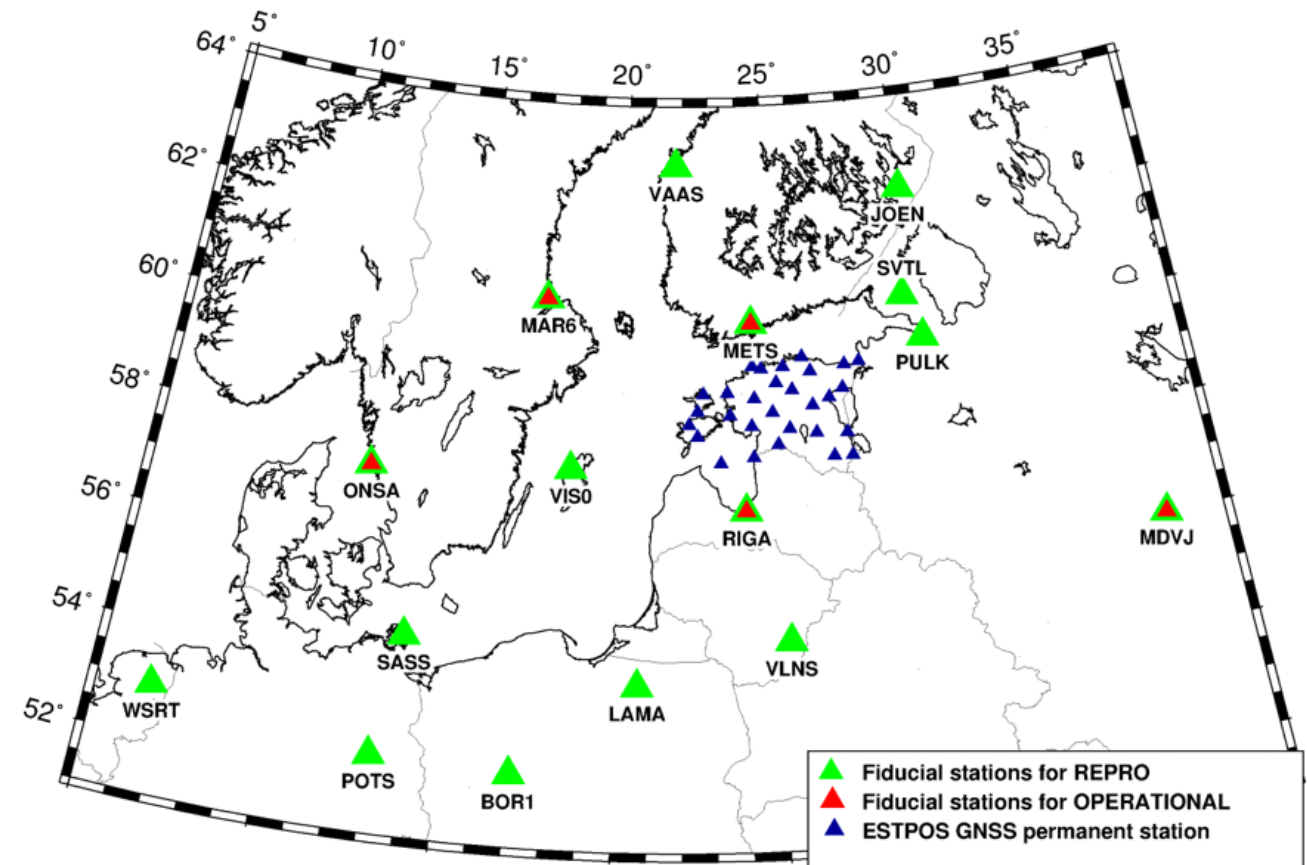
Daily solutions

- Average RMSE of NEU components
- Average daily RMS
- Daily mean ambiguity resolution percentages



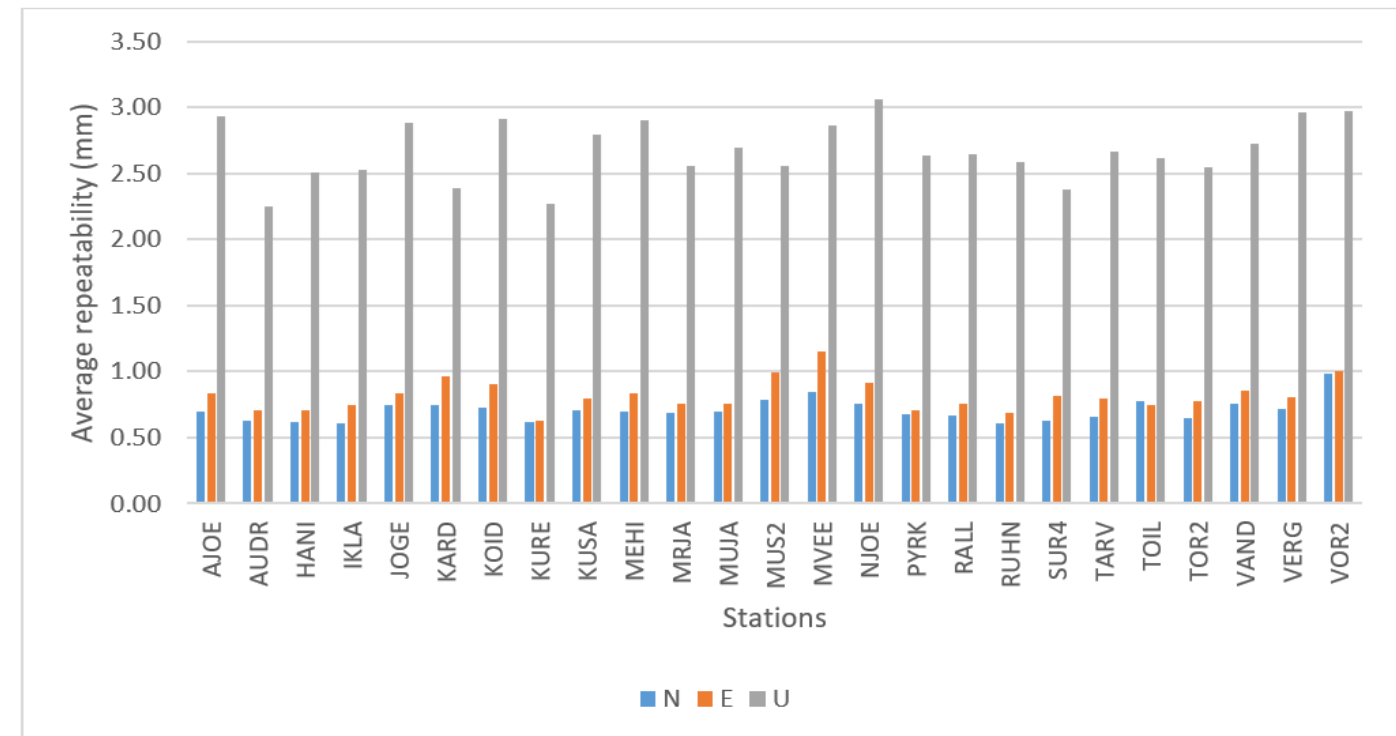
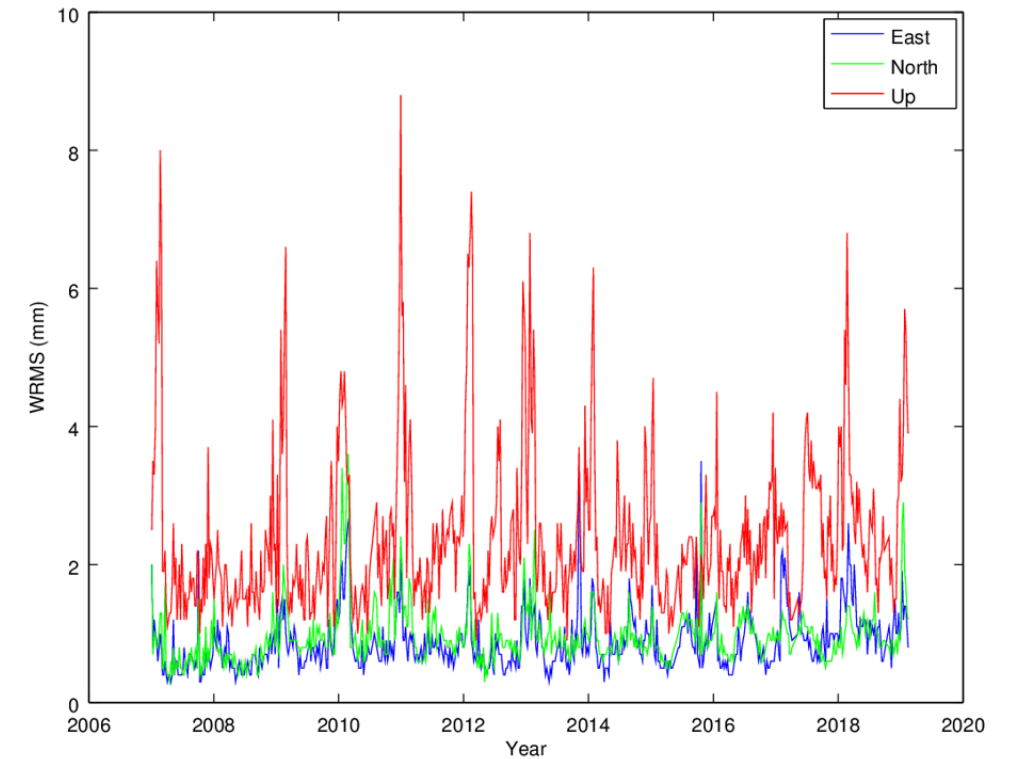
Weekly solutions

- Bernese ADDNEQ2 program for 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>



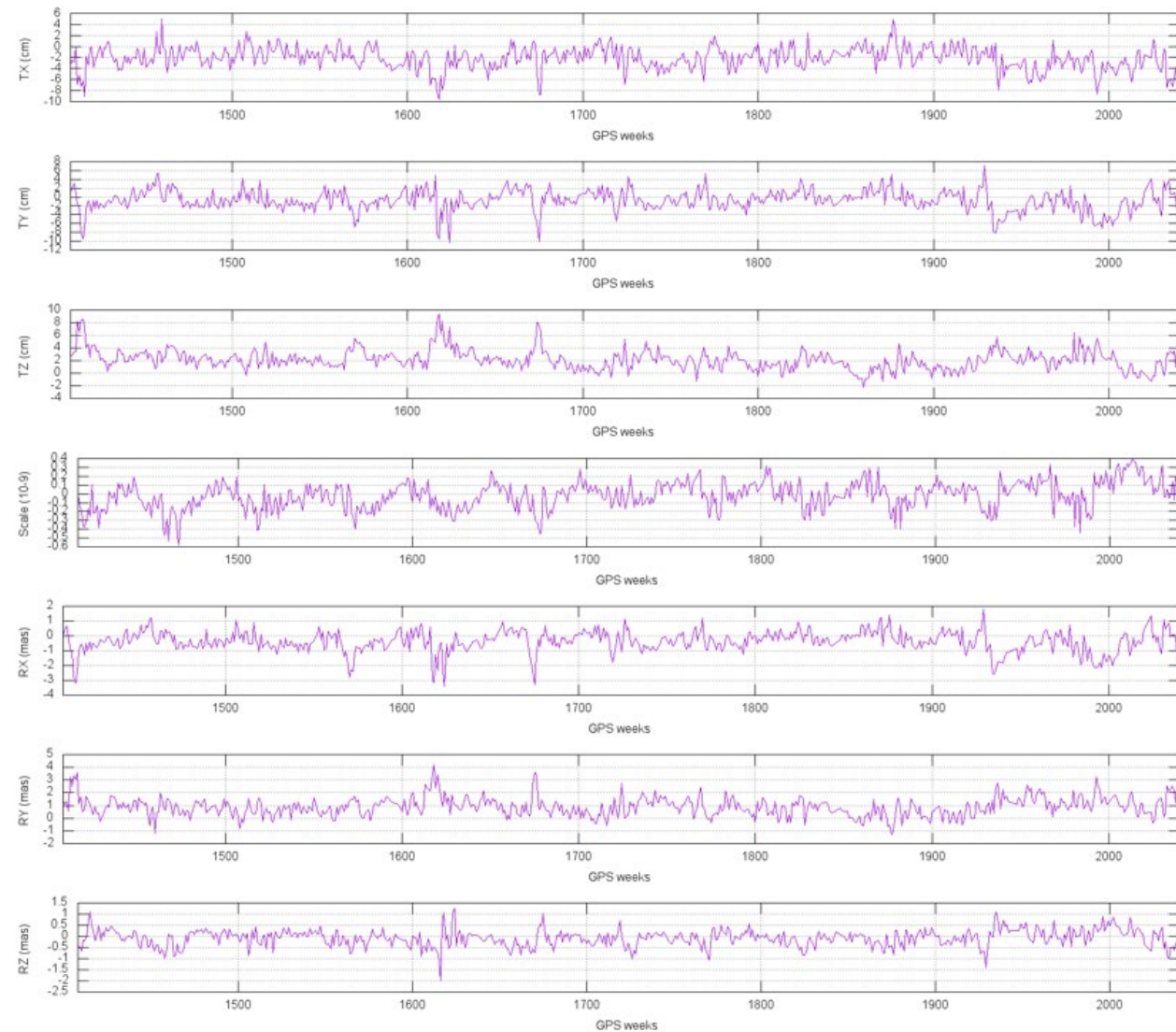
Weekly solutions

- Time series of the weighted RMS (north, east and up components)
- Average weekly repeatability of NEU components



Multi-year solution

- Conversion to IGS (1408-1933)
- CATREF software
- 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



Additional comparisons

	RMS of residuals		
	dN (mm) or dVN (mm/yr)	dE (mm) or dVE (mm/yr)	dU (mm) or dUN (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.	0.20	0.16	0.28
Velocity from NKG2016LU	-	-	0.32
Coordinates from C2040 (ETRF2000)	0.18	0.27	0.72

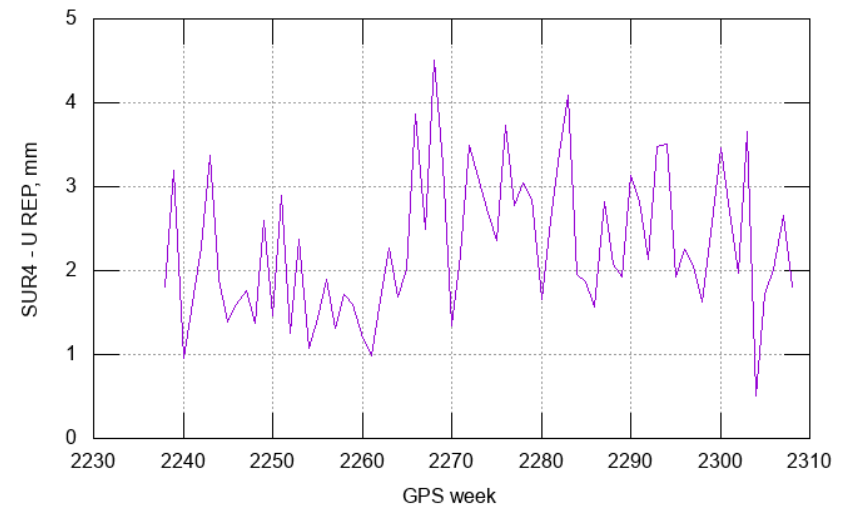
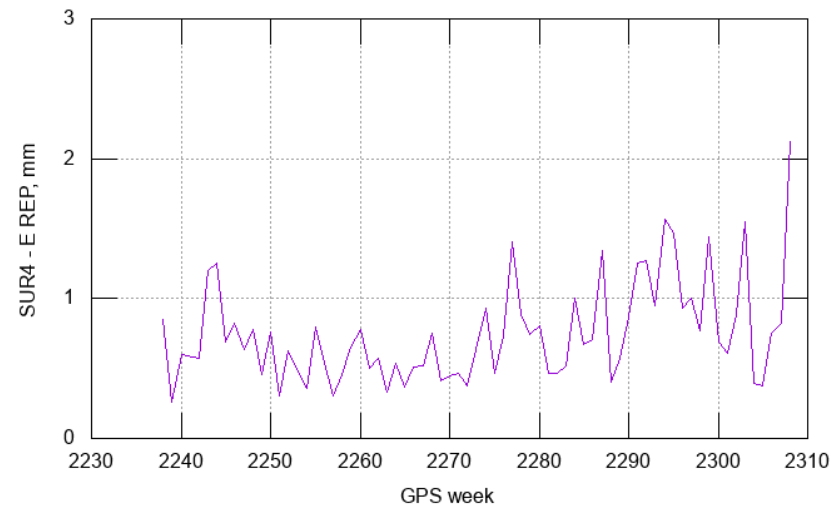
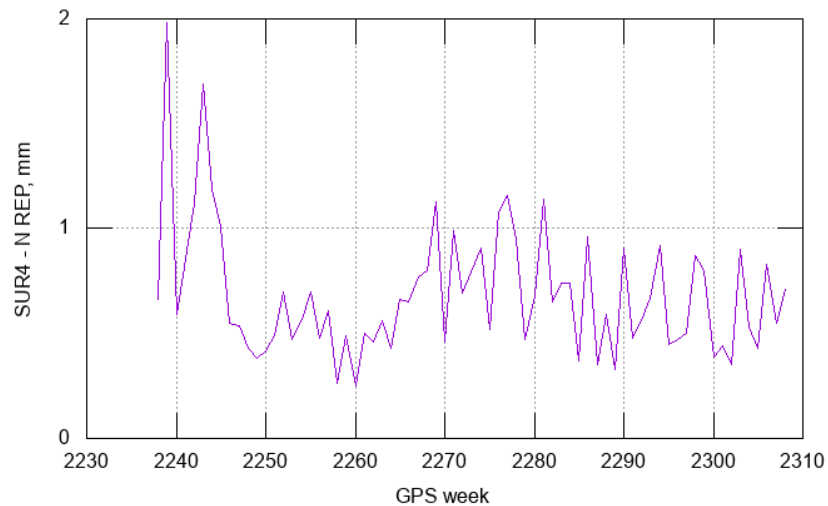
Final coordinates and velocities

- 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
- Proposed to EUREF as new EUREF densification for Estonia

Characteristic	Value
Average daily RMS	1.2 mm
Average coordinate RMS error	0.12 mm, 0.10 mm, 0.35 mm for NEU components
Daily mean ambiguity resolution percentage	69% REPRO and 66% OPERATIONAL solution
Mean RMS of residuals	1.11, 0.99, 1.97 mm for NEU components
Average weekly repeatability	below 1 mm for NE and below 3.5 mm for U components
RMS of differences from C2025, coordinates	1.32 mm, 0.98 mm, 1.94 mm
RMS of differences from C2025, velocities	0.10 mm/yr, 0.07 mm/yr and 0.17 mm/yr

Conclusions

- EUREF2019 Symposium accepted the results of ESTPOS multi-year solution as Class A standard (EUREF 2019, Resolution No 1)
 - Class A designates the stations which coordinates are at the 1 cm precision and velocities are at the 1 mm/year precision at all epochs
- Monitoring of Estonian geodetic systems with means of active reference – weekly solutions (repeatability as example)





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Questions ...

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