

Testing the NKG2020 Transformation with a GNSS Campaign in Southern Estonia

Transformation parameters
and network deformation

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Background

- GNSS measurements by Estonian Land and Spatial Development Board in 2020–2022
 - 76 of the second-order RGV points in southern Estonia
- The aim of the re-measurements:
 - To assess the quality of the network,
 - To validate the coordinate transformation parameters,
 - To integrate the second-order network with the ESTPOS GNSS station network



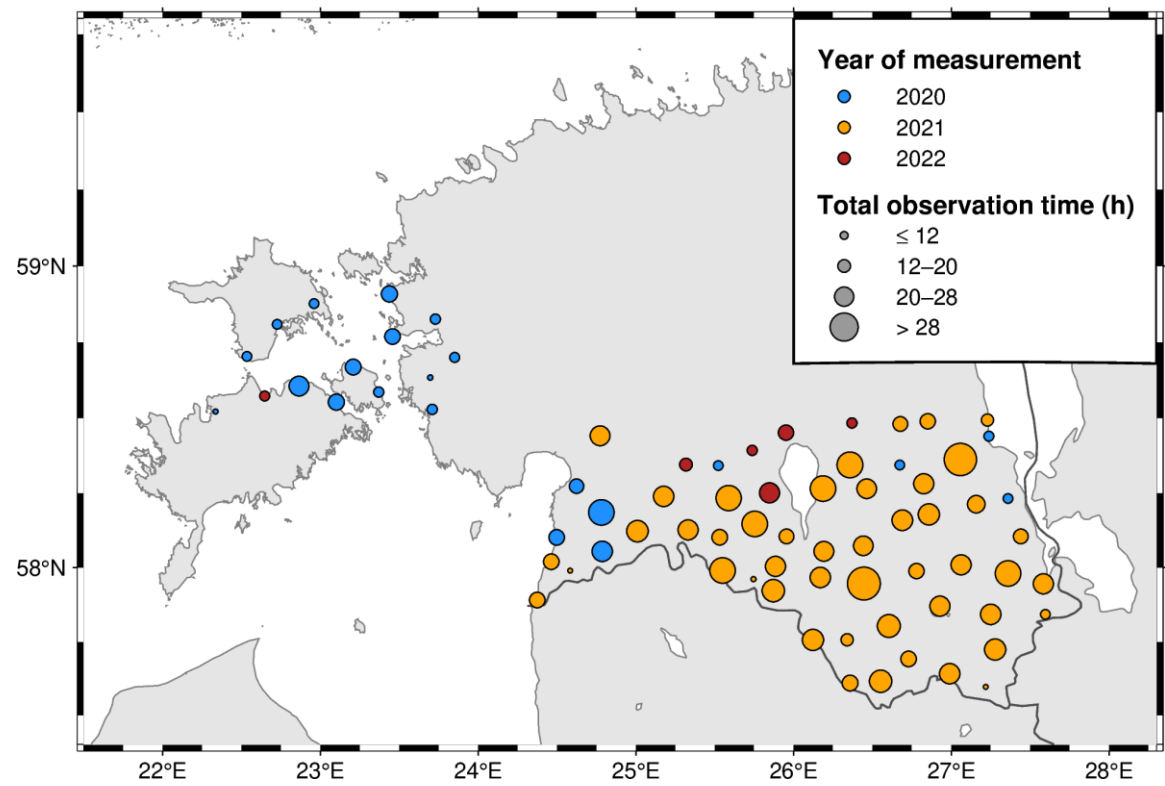
Objectives

- Calculate the coordinates of the measured points at the measurement epoch (mean epoch 2021.32),
- Transform the coordinates into the Estonian national ETRF96 realization EUREF-EST97 according to the NKG2020 transformation algorithm and determine the transformation residuals,
- Assess the suitability of the NKG2020 transformation parameters for the test dataset,
- Assess the deformation of the geodetic network and thereby the need to update the realization of the network.



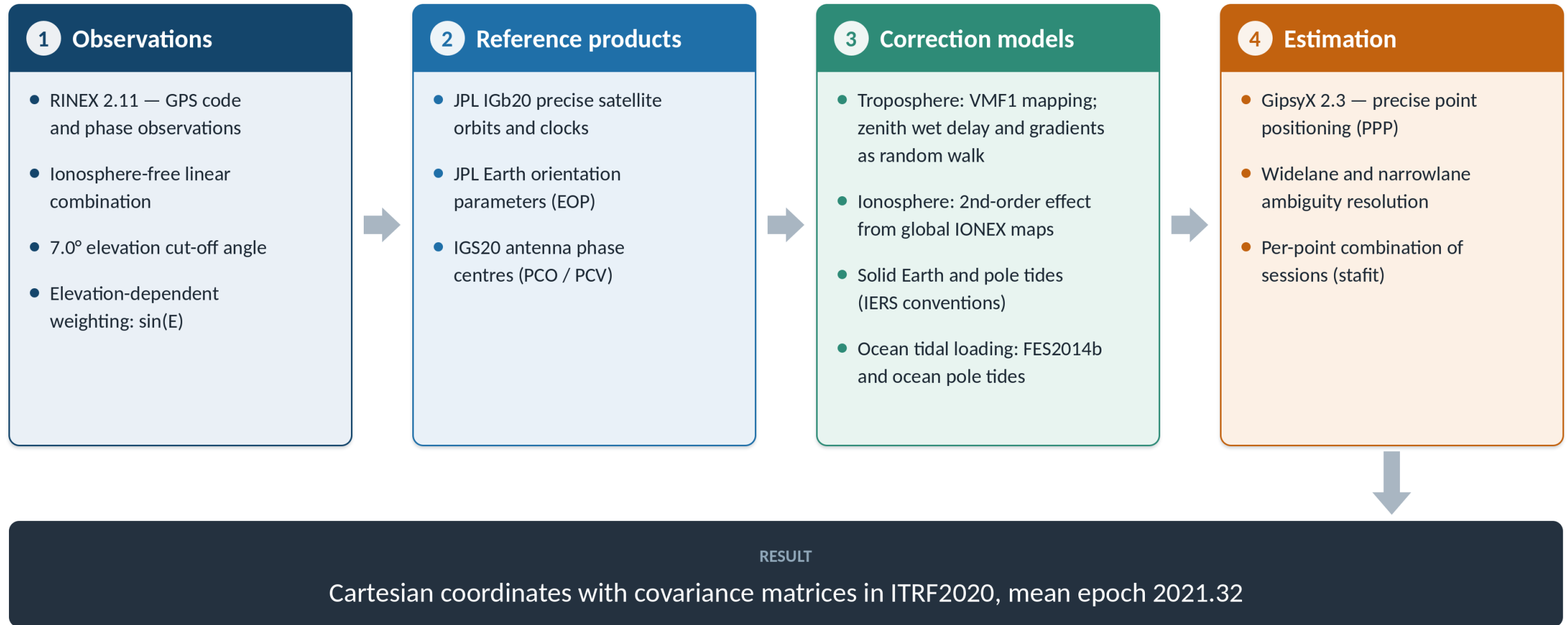
Data

GNSS observations



Year	No of meas. pts	Sess. dur. (h)	Rec. int. (s)	Rec. signals	Instruments (Leica)
2020	23	3–8	5	GPS+ GLO (L1+L2)	GRX1200GGPRO+ LEIAT504GG
2021	47	6–9	5	GPS+ GLO (L1+L2)	GRX1200GGPRO+ LEIAT504GG
2022	6	6–9	5	GPS+ GLO (L1+L2)	GRX1200GGPRO+ LEIAT504GG

GNSS data processing chain — GipsyX PPP



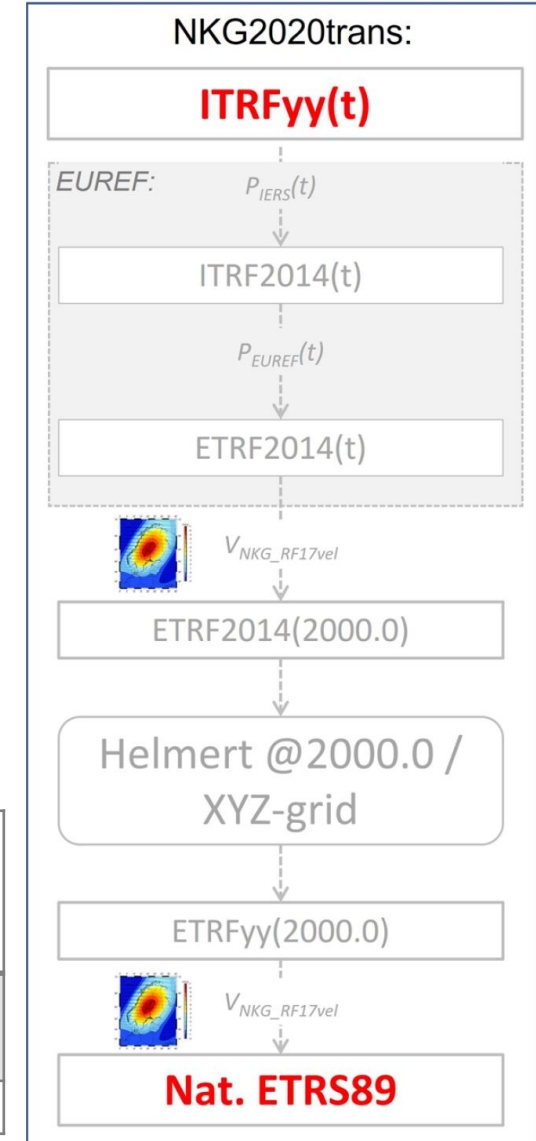
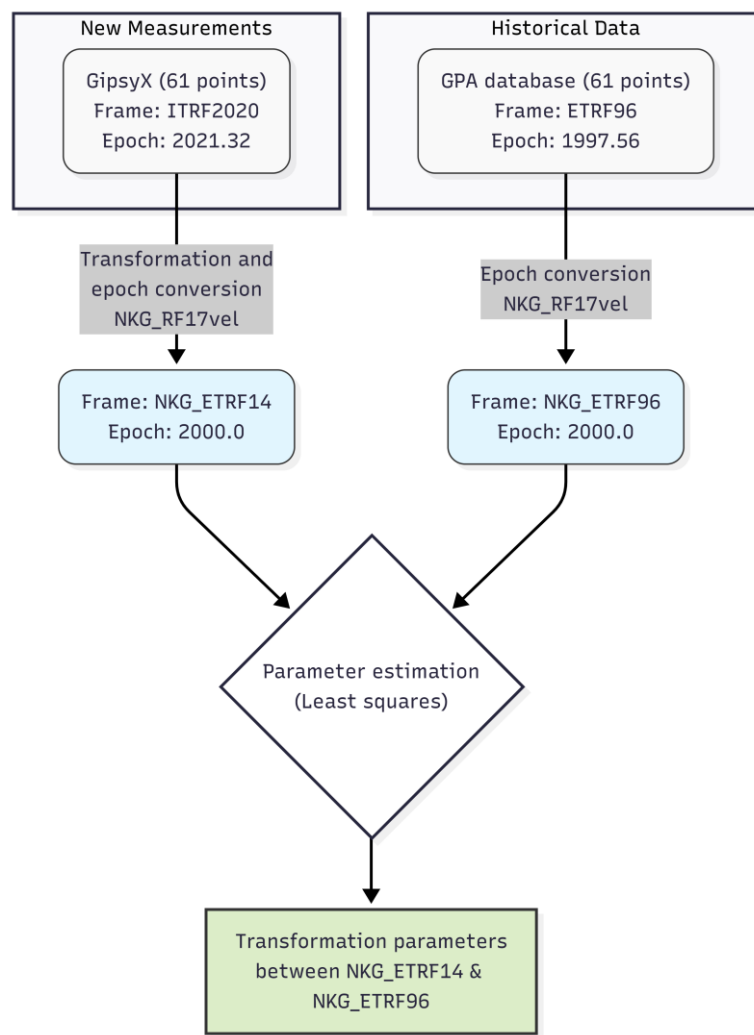
76 points observed · 61 points selected for further analysis (σ of every coordinate component ≤ 1 cm, ≥ 2 sessions)



Results: standard error of coordinates (mm)

Statistic	X	Y	Z	N	E	U
Mean	2.7	1.5	4.2	3.1	1.8	3.8
Min	1.3	0.8	2.2	1.6	0.9	2.0
Max	9.9	4.9	12.9	10.3	6.3	12.0
STDEV	1.5	0.7	2.0	1.6	0.9	1.9
RMS	3.1	1.7	4.7	3.4	2.0	4.2

Transformation parameters

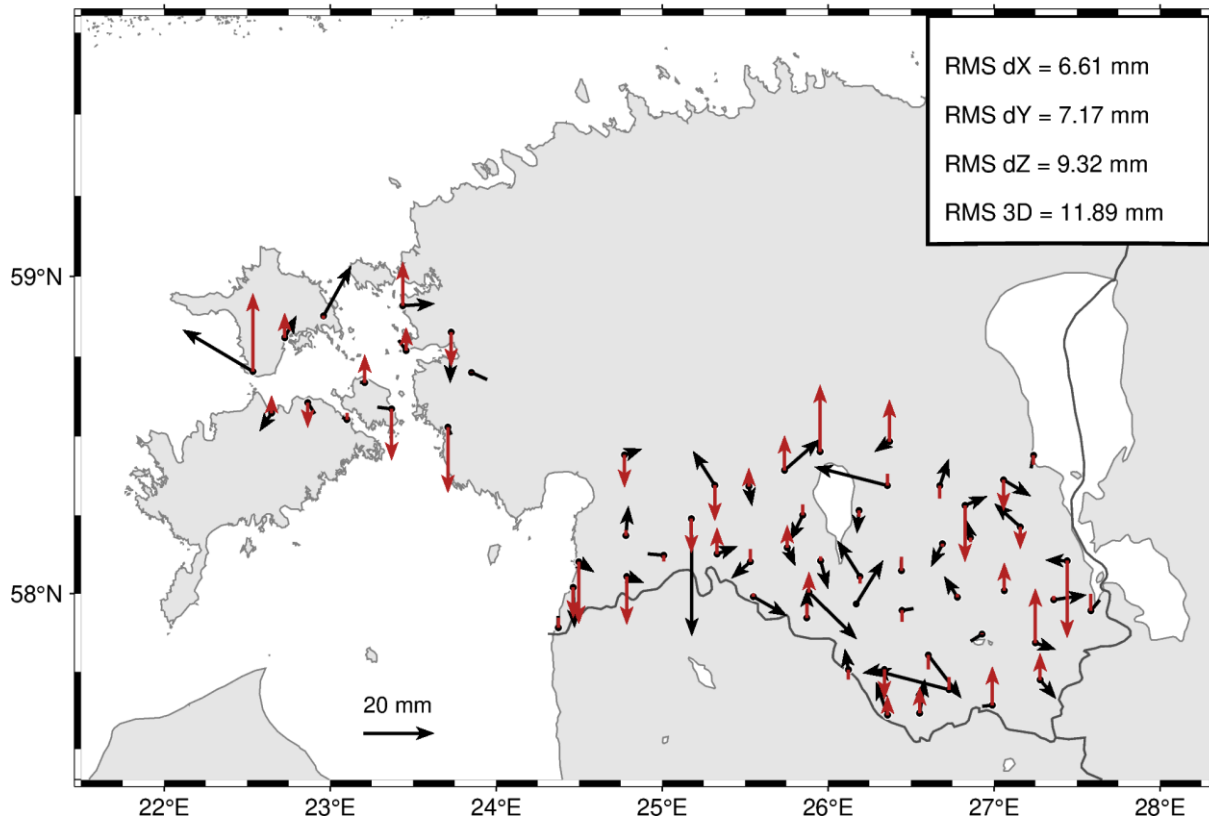


Source	T_X (m)	T_Y (m)	T_Z (m)	D (ppb)	R_X (mas)	R_Y (mas)	R_Z (mas)	a posteriori σ_0 (mm)
Calculated	+0.06812	+0.19329	-0.24692	+19.529	+3.85720	-4.69049	-5.91339	7.94
NKG2020	-0.05027	-0.11595	+0.03012	+3.191	-3.10814	+4.57237	+4.72406	2.26

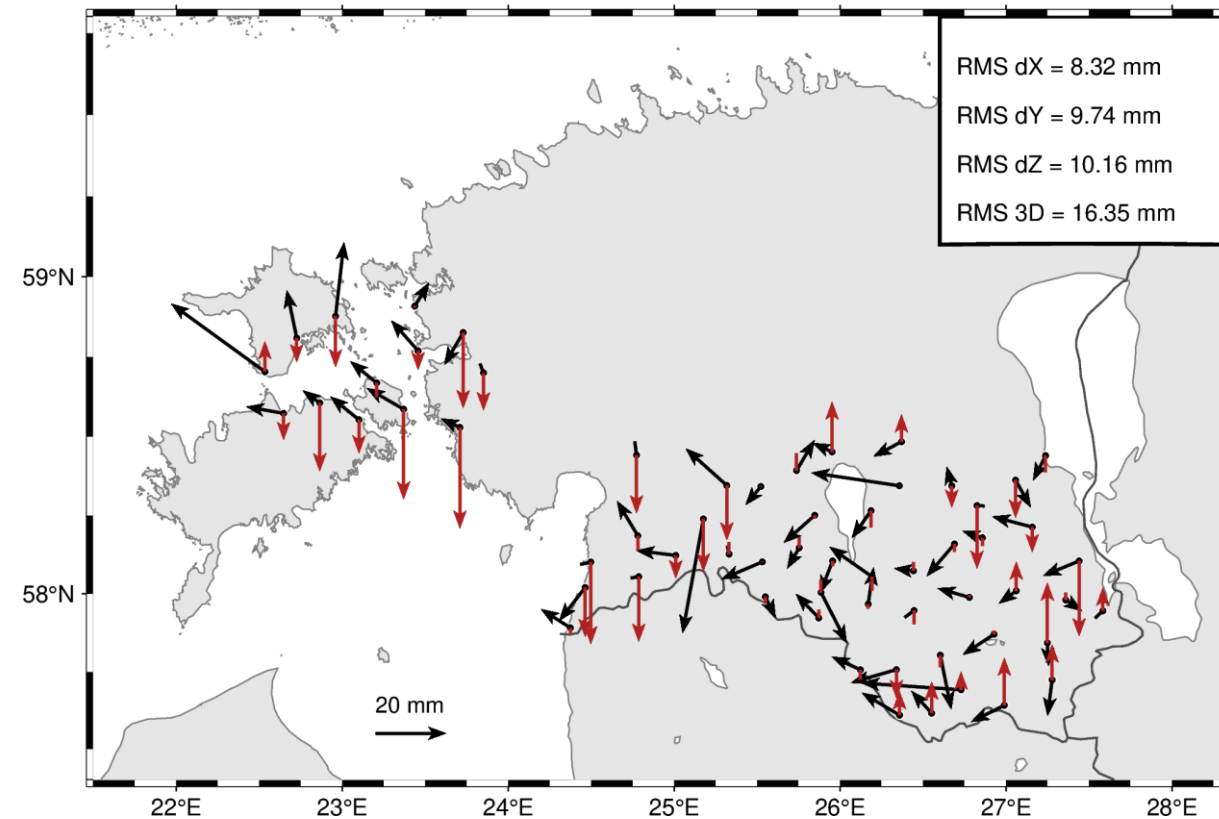


Comparison of transformations

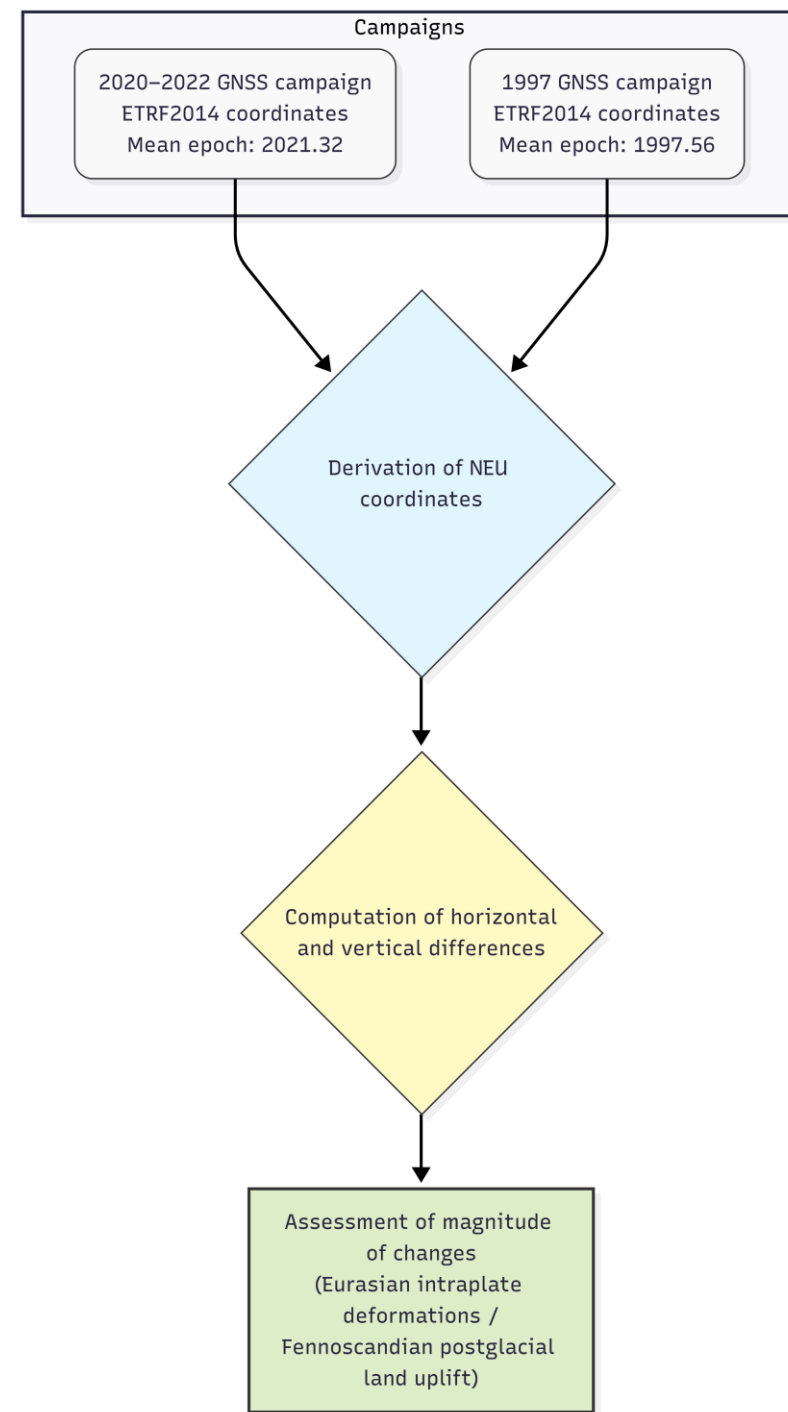
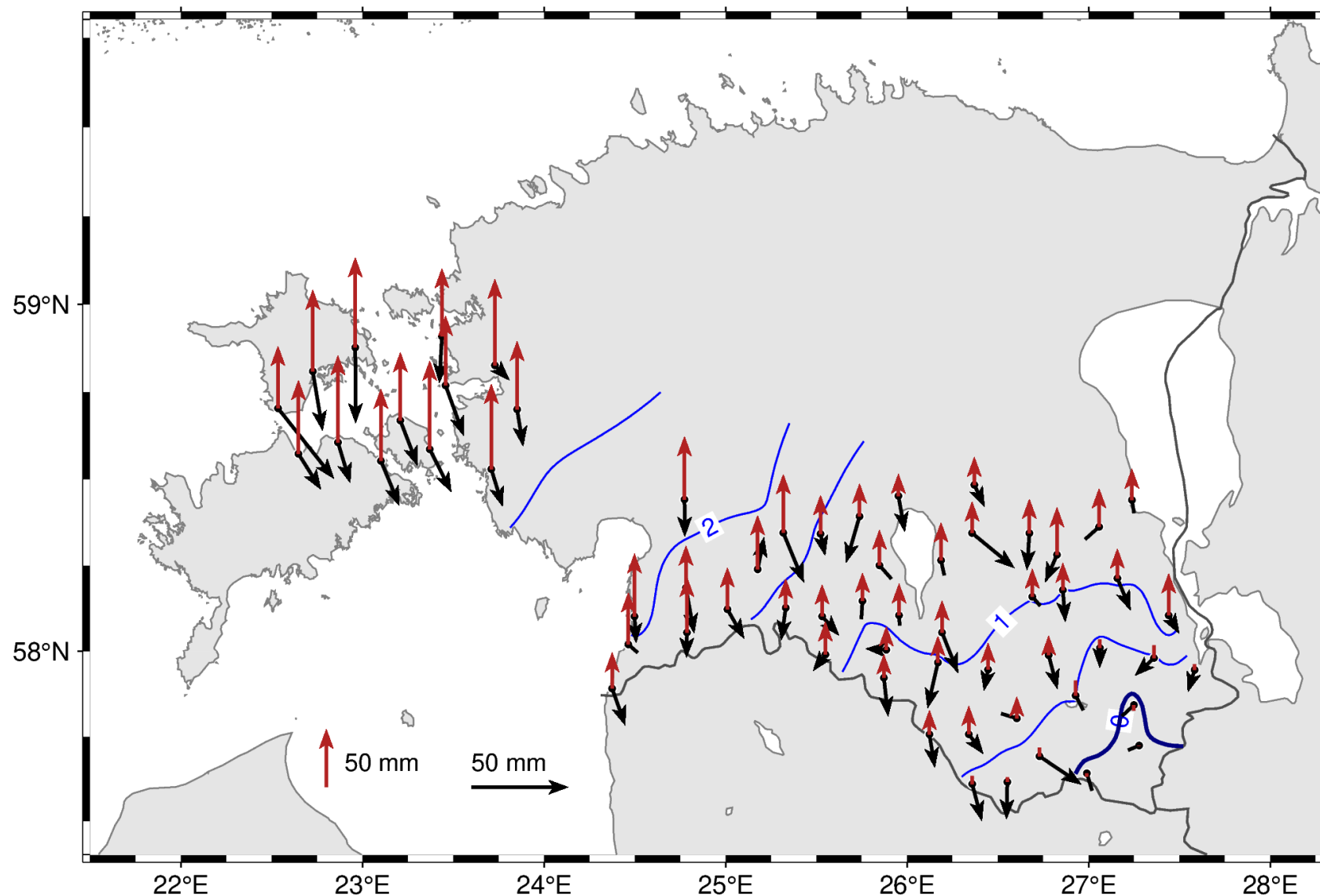
Residuals with calculated parameters



NKG2020 transformation residuals

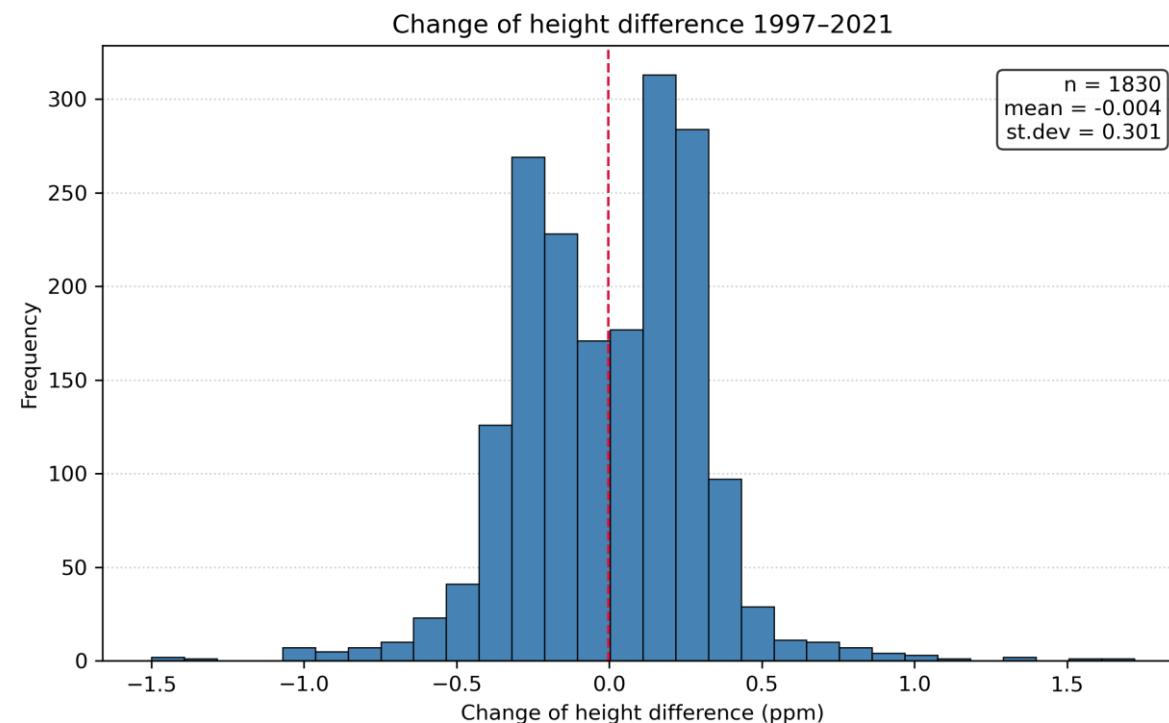
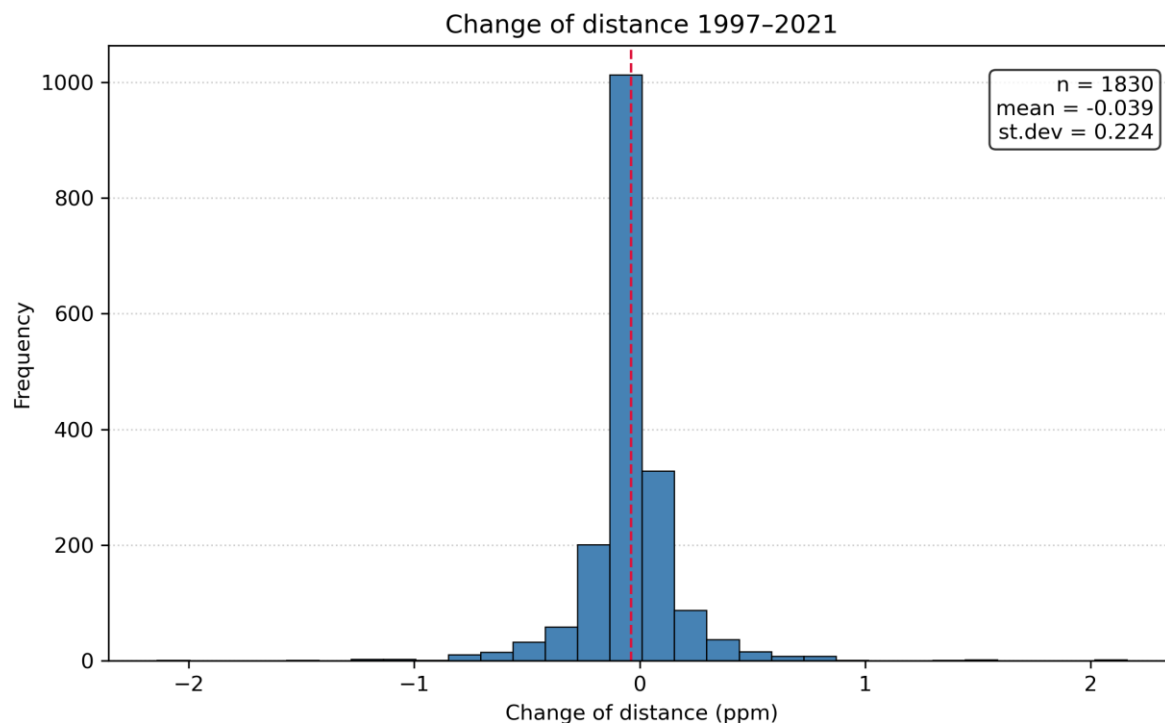


Intraplate deformations





Inner deformation of the network

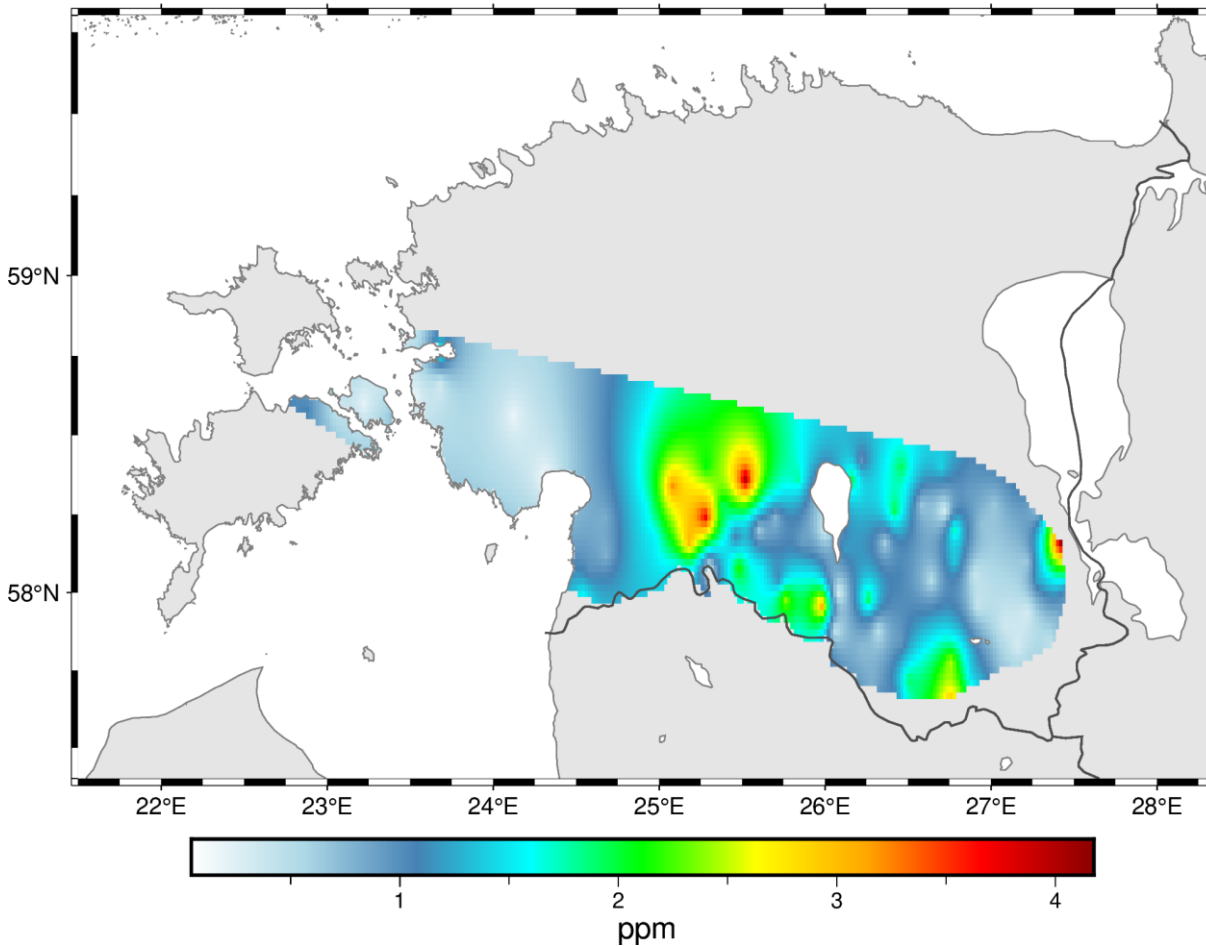


Parameter	Mean	Std.Dev	Min	Max
Change of distance (ppm)	-0.039	0.224	-2.14	2.16
Change of height difference (ppm)	-0.004	0.301	-1.50	1.72

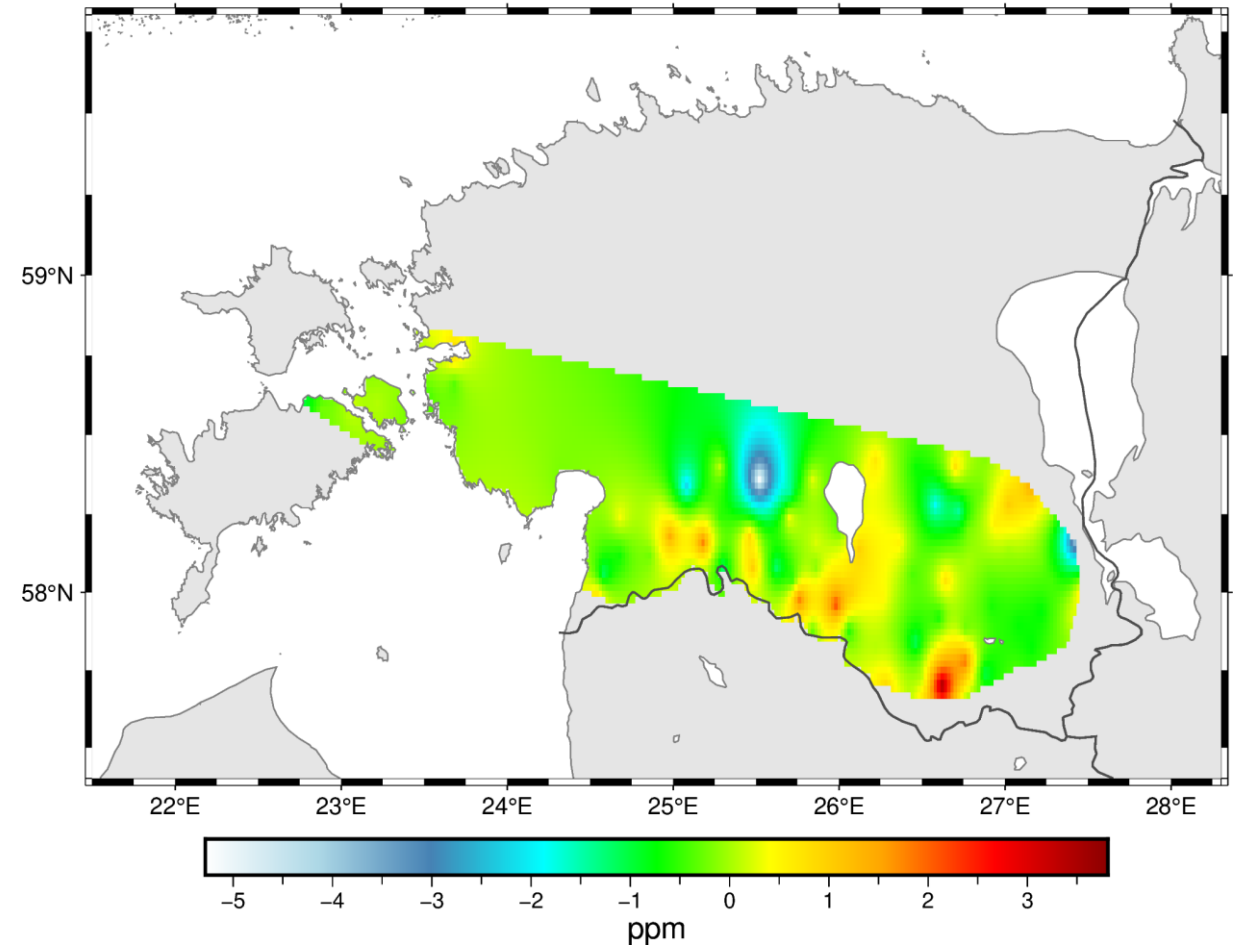


Inner deformation of the network

Shear Strain



Dilatation





Conclusions

- **Transformation Suitability:** Both the newly estimated parameters and the official NKG2020 model achieve cm-level accuracy. The NKG2020 transformation is fully applicable for Southern Estonia without needing a separate regional model.
- **Methodological Insight:** Due to the ill-conditioning of Helmert transformations for small networks, transformations should be evaluated by their effect on coordinates rather than by comparing highly correlated individual parameters.
- **Horizontal Stability:** The internal horizontal geometry of the network has remained highly stable over 24 years (~ 0.2 ppm), fulfilling ordinary surveying requirements without requiring an immediate realization update.
- **Vertical Deformation:** Accumulated vertical land uplift (up to ~ 5 cm over 24 years) is significant for high-accuracy tasks and aligns well with the NKG2016LU model.
- **Future Outlook:** Localized deformation extremes likely indicate individual station stability issues rather than regional crustal movements. Continuing with a semi-dynamic, NKG2020-based approach and refining crustal models is recommended for long-term stability.



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Aitäh! Thank You!