Latvian CORS Time Series Analysis for 2011-2018

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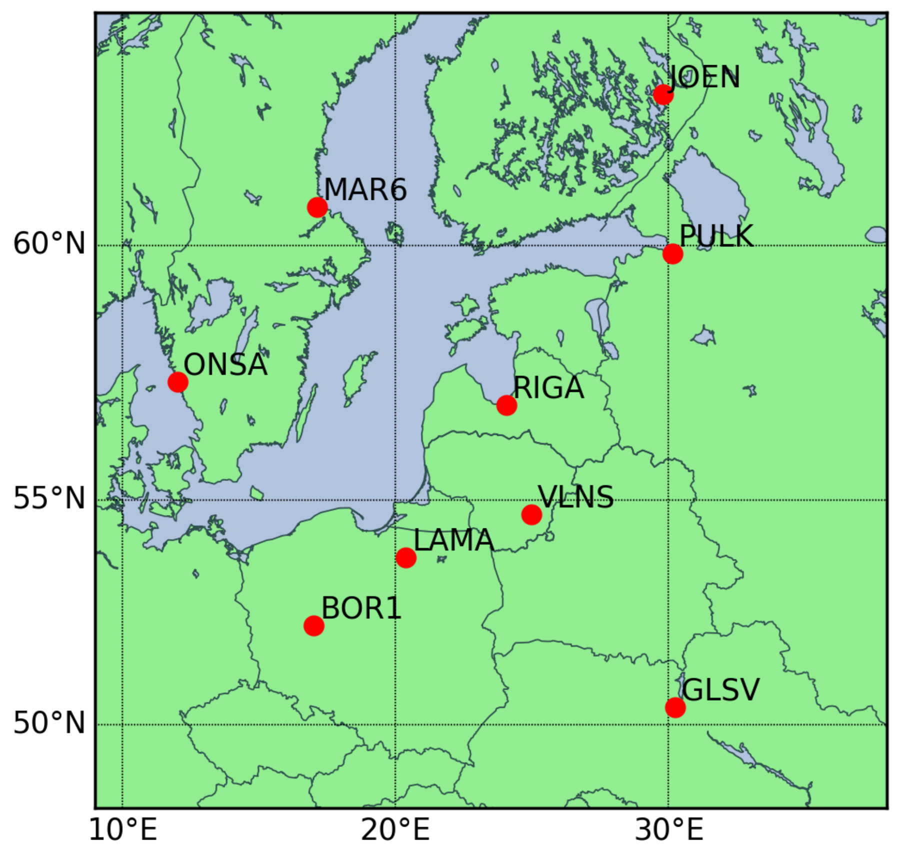
Introduction

The objective of this study is to obtain horizontal and vertical velocity fields of the continuously operating reference stations (CORS) in Latvia covering an eight-year time period: years 2011-2018. The velocities of the Latvian CORS were previously obtained for the period 2012-2017. Here both solutions are displayed.

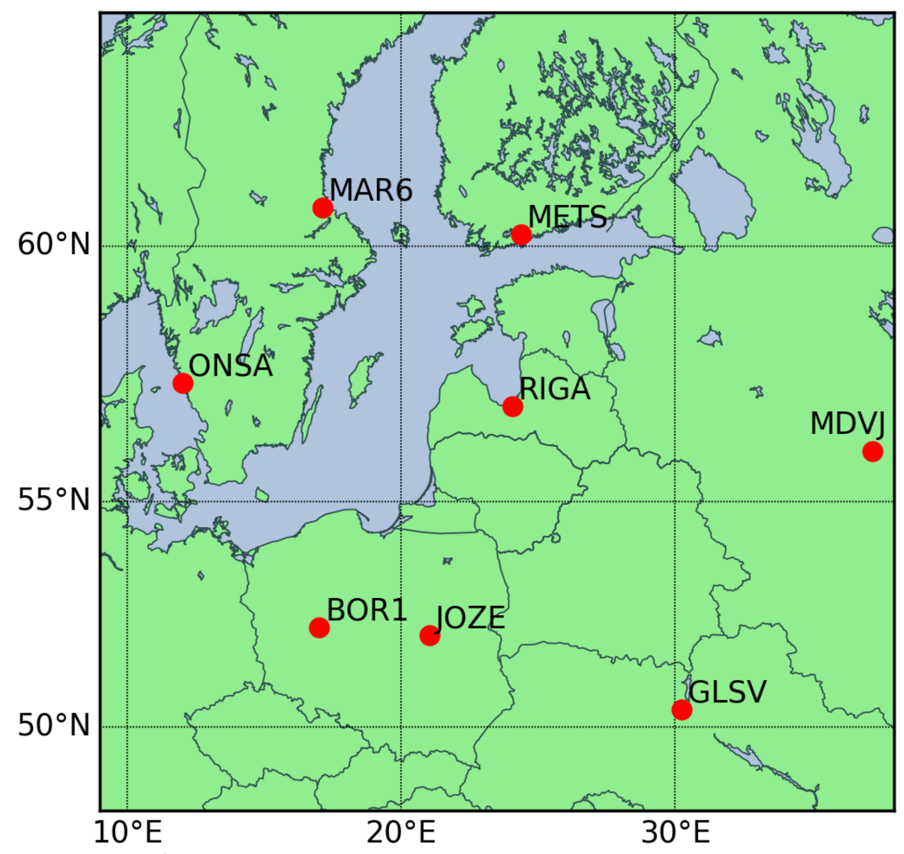
The raw observation data have been collected from the Latvian CORS of two permanent GNSS networks: LatPos (26 stations in 2018) and EUPOS®-Riga (5 stations). Bernese GNSS Software V5.2 was used in double-difference mode to obtain daily solutions. The final CODE precise orbits, Earth orientation and clock products, along with the CODE final ionosphere product, were used for GNSS data processing. The dry Global Mapping Function was used as the a priori troposphere model, while zenith path delay parameters were estimated using the wet Global Mapping Function; a cut-off elevation angle of 3° was selected. The positions of all stations were corrected for both solid Earth tide and ocean tide loading. 8-9 IGS/EPN reference stations were used to compute the coordinates of the Latvian CORS.

Daily coordinates are computed in IGb08 and IGS14 (since January 29, 2017). Obtained daily solutions are transformed to ETRF2000, Up coordinates are expressed also in ITRF2008.

The horizontal and vertical velocities of the daily solutions were computed for all LatPos and EUPOS®-Riga stations applying *Tsview* software. Outlier detection, offset identification, trend, seasonal variation, and uncertainty estimation was performed using it. The obtained velocity fields were compared to the models *NKG_RF03vel* and *NKG2016LU_abs* and the previous solution (2012-2017).



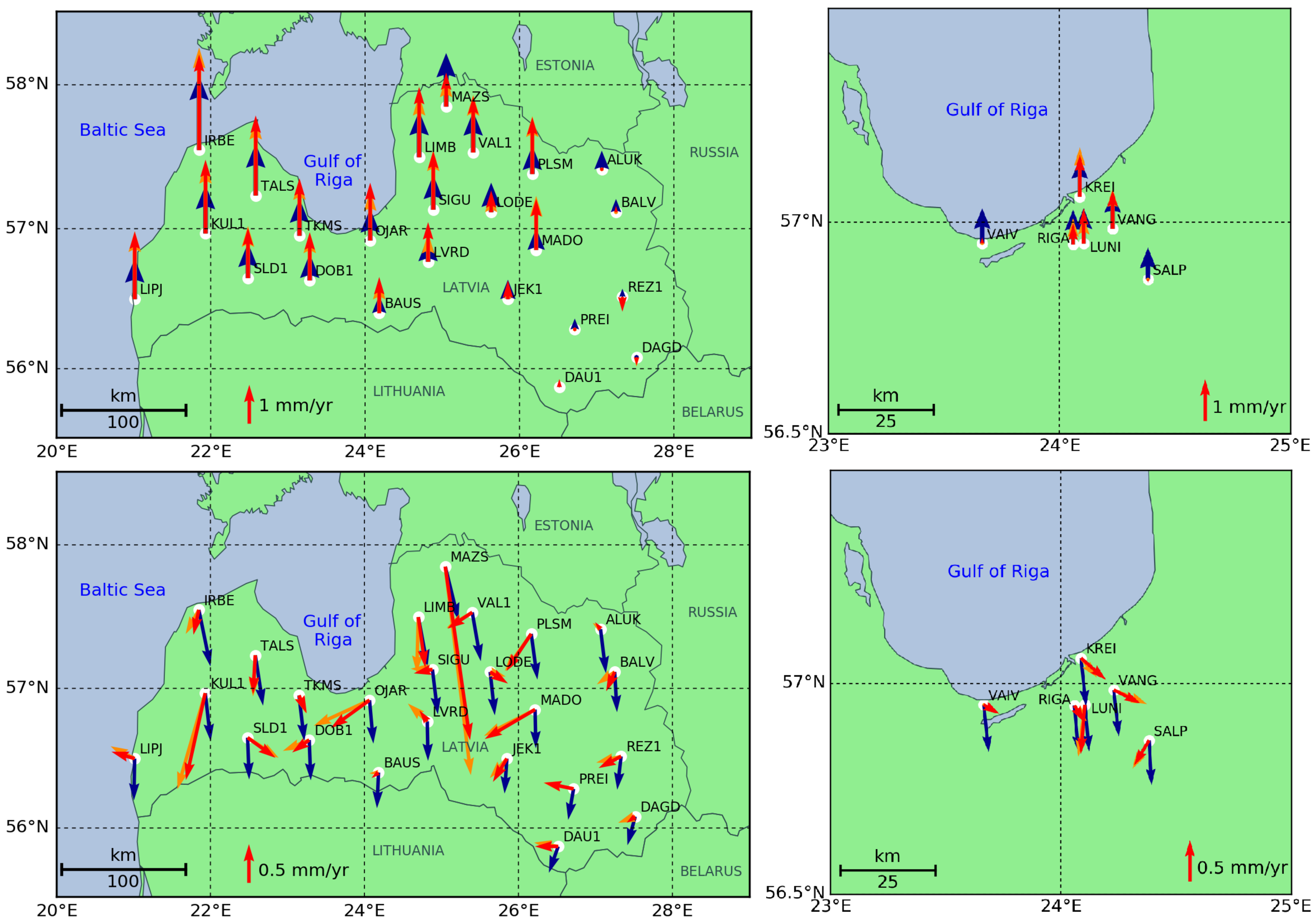
9 IGS/EPN stations used as fiducial stations in the reference frame IGb08.



8 IGS/EPN stations used as fiducial stations in the reference frame IGS14.

Stations	Velocities (mm/yr)			Uncertainties (mm/yr)			Offsets				Seasonal signal (>1mm)	Unmodelled signal
	Up ITRF2008	North ETRF2000	East ETRF2000	Up	North	East	A/R	GLO	IGS14	U		
ALUK	-0.07	0.09	-0.07	0.20	0.08	0.06		X	X			N
BALV	0.16	-0.25	-0.11	**0.23**	0.06	0.08	X		X		E	
BAUS	0.93	-0.07	-0.09	0.12	0.06	0.07	X	X	X			
DAGD	-0.21	-0.08	-0.11	**0.21**	0.08	0.05	X	X	X	X	U	
DAU1	0.21	0.00	-0.30	0.11	0.05	0.03			X			
DOB1	1.24	-0.16	-0.22	0.04	0.02	0.05			X			
IRBE	2.46	-0.32	-0.07	**0.21**	0.04	0.05		X	X			
JEK1	0.48	-0.30	-0.18	0.20	0.07	0.05		X	X			
KUL1	1.90	-1.12	-0.25	**0.25**	0.06	0.09				X	N U	
LIMB	1.81	-0.65	0.09	0.10	0.06	0.05			X			N
LIPJ	1.74	0.09	-0.30	0.09	0.07	0.04			X			
LODE	0.56	-0.15	0.23	0.15	**0.11**	0.07	X		X	X		N
LVRD	1.02	0.14	-0.10	**0.22**	**0.16**	**0.12**	X	X	X			N E
MADO	1.31	-0.38	-0.65	0.10	0.05	0.05			X			
MAZS	0.88	-2.24	0.32	0.11	**0.27**	0.07			X		N U	N E U
OJAR	1.49	-0.36	-0.50	0.20	**0.16**	**0.21**	X	X	X			N E
PLSM	1.46	-0.48	-0.32	0.12	0.05	0.06	X		X		N	
PREI	0.06	0.08	-0.38	0.20	0.08	0.07		X	X	X	E U	
REZ1	-0.38	-0.15	-0.29	**0.21**	0.08	0.04		X	X		N U	N
SIGU	1.51	-0.05	-0.24	0.09	0.04	0.04			X		U	
SLD1	1.29	-0.26	0.36	0.15	0.09	**0.27**		X	X		E	E
TALS	2.06	-0.50	-0.03	0.14	0.06	0.05		X	X			
TKMS	1.48	-0.23	0.10	0.13	0.06	0.09		X	X		N	
VAL1	1.44	-0.21	-0.32	0.07	0.03	0.03			X			
KREI	1.01	-0.26	0.30	**0.23**	0.05	**0.11**		X	X			E
LUNI	0.84	-0.59	-0.05	0.15	0.06	**0.14**		X	X			E
SALP	-0.08	-0.30	-0.18	**0.43**	**0.13**	0.09		X	X		N E U	N U
VAIV	0.16	-0.11	0.19	**0.24**	0.08	**0.13**		X	X			E
VANG	0.93	-0.16	0.32	0.18	0.06	**0.13**		X	X		U	E
RIGA	0.50	-0.20	0.12	0.12	0.05	0.08	X		X			

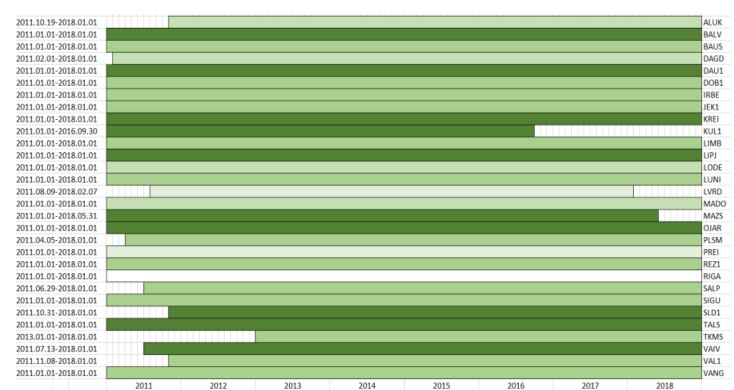
Latvian CORS station velocities and their uncertainties (mm/yr) for Up, North and East components (2011-2018); offsets due to antenna or receiver change (A/R), introduction of GLONASS in 2015 (GLO), switch to IGS14 in 2017 (IGS14), and other reasons (U); coordinate components influenced by seasonal signals with amplitudes larger than 1 mm and coordinate components with unmodelled signal left after detrending and removing seasonal signals.



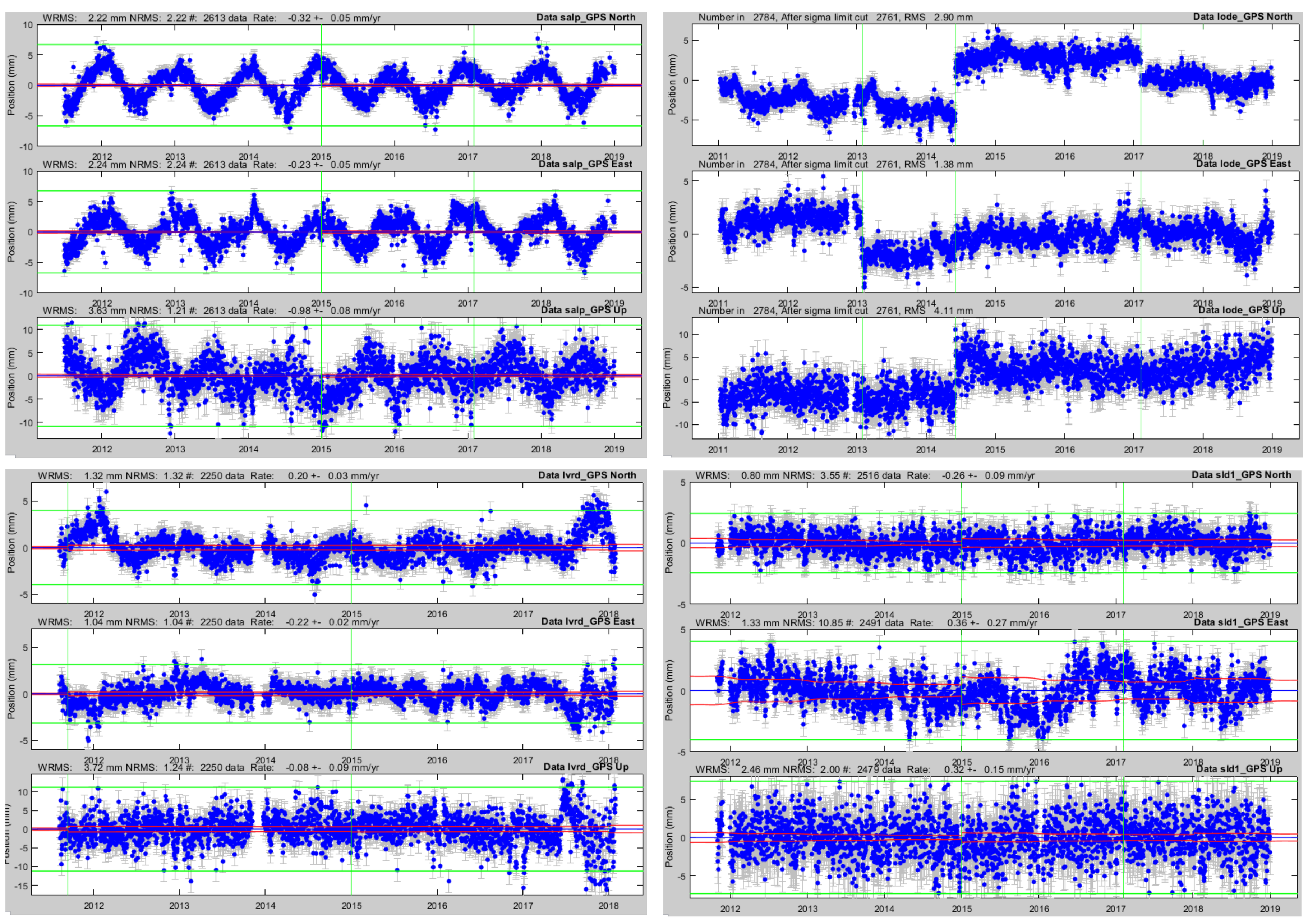
EUPOS®-Riga (right) and LATPOS (left) CORS station vertical (top) and horizontal (bottom) movements obtained from the daily solutions (2011–2018: red; 2012-2017: yellow); vertical and horizontal velocities from *NKG_RF03vel* and *NKG2016LU_abs* models (blue).

	Solution 2011-2018			Solution 2012-2017		
	NKG_RF03vel		*NKG2016LU_abs*	*NKG_RF03vel*		*NKG2016LU_abs*
	North	East	Up	North	East	Up
Mean	0.30	-0.14	0.17	0.32	-0.19	0.14
STDV	0.23	0.24	0.48	0.27	0.26	0.49
RMS	0.38	0.27	0.50	0.42	0.32	0.50

Mean, STDV and RMS of differences (mm/yr) between estimated velocities of both (2011-2018 and 2012-2017) solutions and the deformation models *NKG_RF03vel* (North, East) and *NKG2016LU_abs* (Up), station MAZS excluded.



Data coverage of Latvian CORS.



Examples of Latvian CORS affected by various factors: SALP station affected by seasonality (top left); LODE station – break introduction (top right); LVRD – human intervention, installation of ventilation system near antenna in 2017 (bottom left); SLD1 – unmodelled signals after detrending and estimation of seasonal signal (bottom right).

Conclusions

- ✓ Horizontal and vertical velocity fields of all CORS in Latvia were obtained for the eight-year time period: 2011-2018 using *Tsview* software.
- ✓ Solution reveals the effect of the Fennoscandian rebound in the territory of Latvia. LatPos and EUPOS®-Riga station vertical velocity vectors have maximum values in the north-western part of Latvia and minimum values in the south-eastern part of the country.
- ✓ The highest velocity differences in Up component between the obtained results and *NKG2016LU_abs* model have been observed in the north-western part of Latvia, as well as in the middle-eastern part of Latvia. The velocities of this solution correspond well to the *NKG2016LU_abs* model in the eastern part of Latvia.
- ✓ Several problems exist: too many offset breaks, human intervention, unmodelled signals in time series.
- ✓ Future work: better understanding of station site-specific effects and time series noise characteristics; reprocessing 2011-2014 using both GPS and GLONASS observations to avoid offsets due to GLONASS introduction; extending length of the time series – reprocessing of the earlier data: 2007-2010; testing other time series analysis software.