Eesti Maaülikool

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New 3D velocity model of Estonia from GNSS measurements

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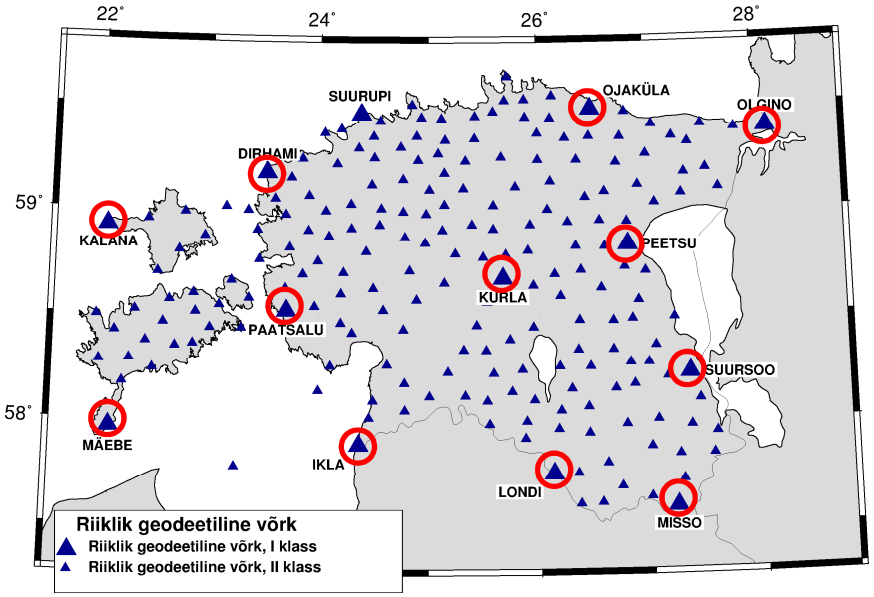
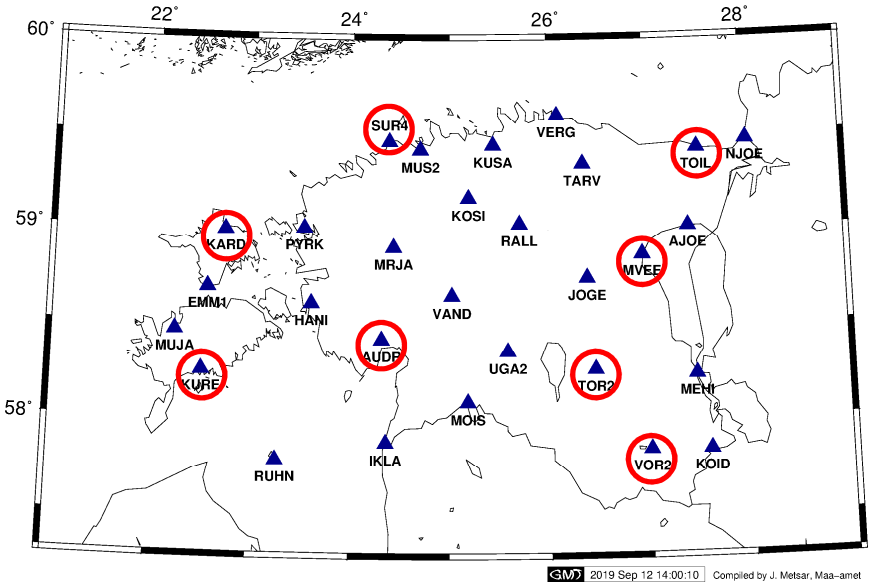
Outline

- Input data
- Modeling methods
- Results
- Comparison with the NKG_RF17VEL

Introduction

- Three GNSS campaigns in 1997, 2008 and 2017 on 12 1st order GRN points
- Eight stations from 29 CORS stations of ESTPOS GNSS network





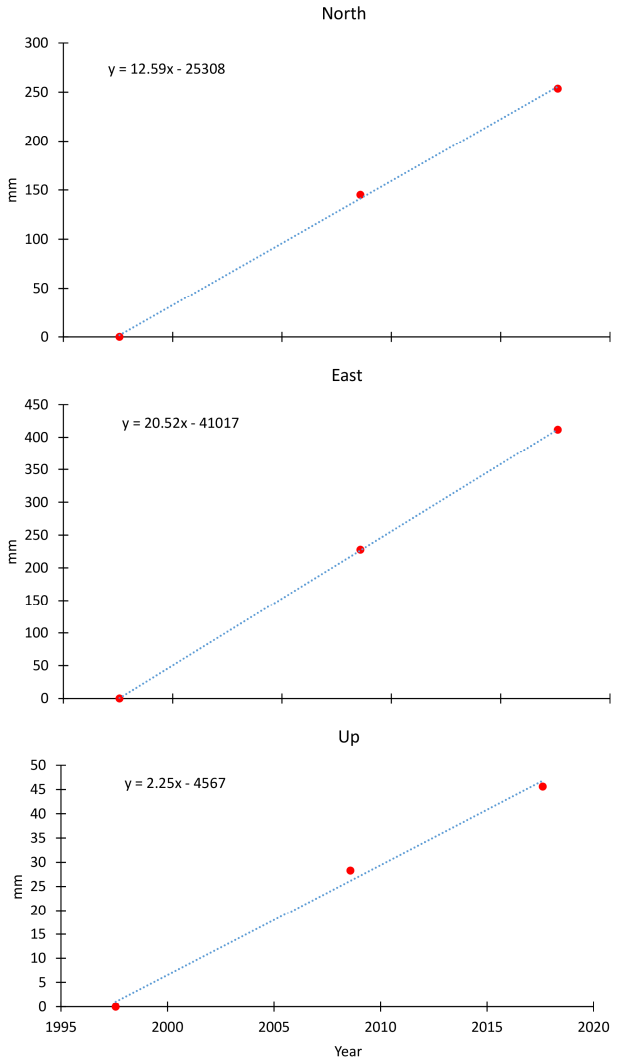
Pictures: Maa-amet

GIPSY-OASIS PPP calculations

Parameter	Value
Observations	Only GPS
Input file format	RINEX
Coordinate calculation method	PPP
Reference frame	ITRF2008 (Altamimi et al. 2011)
Ambiguity fixing	Yes
Earth orientation parameters	IERS 2010 standards (Petit & Luzum 2010)
Orbit and clock product	JPL final orbit and clock parameters (Bertiger et al. 2020)
Antenna cut-off angle	10°
Observation interval	30 s
Antenna calibrations	File igs08.atx (Rebischung et al. 2012)
Observations weighting	Depending on signal elevation angle
Troposphere mapping function	VMF1 (Böhm et al. 2006)
Ionosphere correction	Ionosphere-free linear combination and 2nd-order ionosphere correction
Ocean loading correction	Model FES2014b (Carrere et al. 2016)

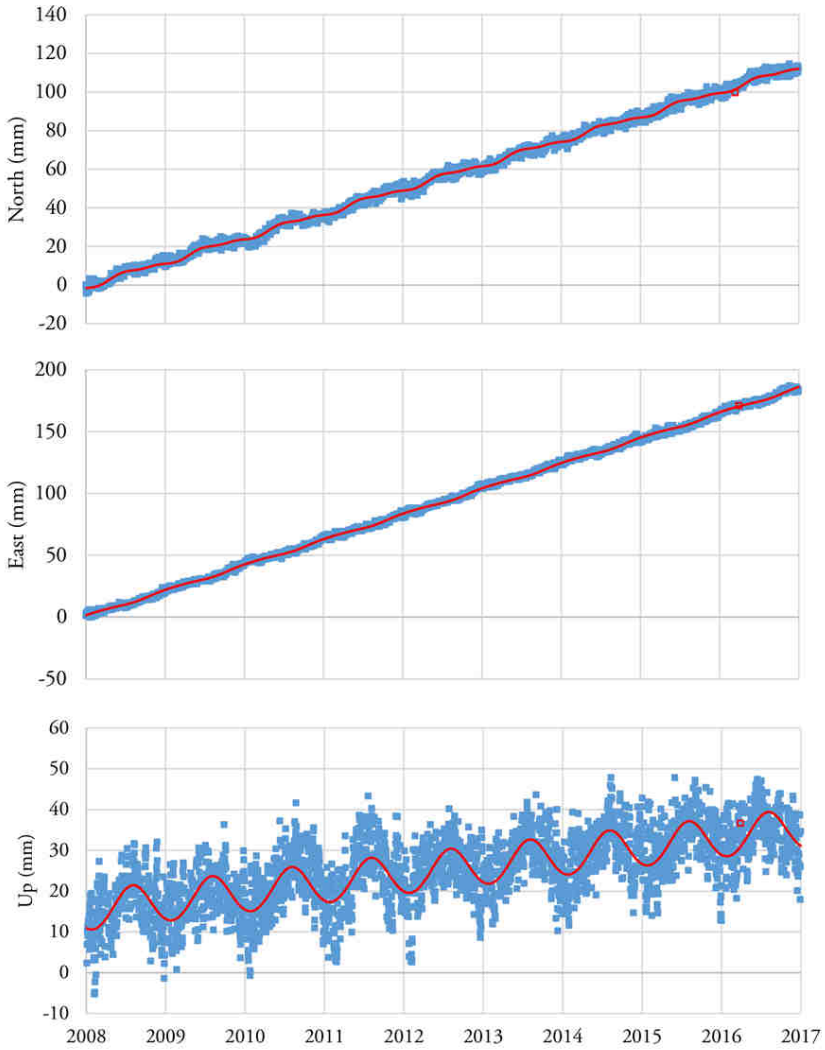
Velocity calculation of GRN points

- Software TSAnalyzer
- Linear weighted least squares method
- Weights were found based on the standard deviations of PPP coordinates

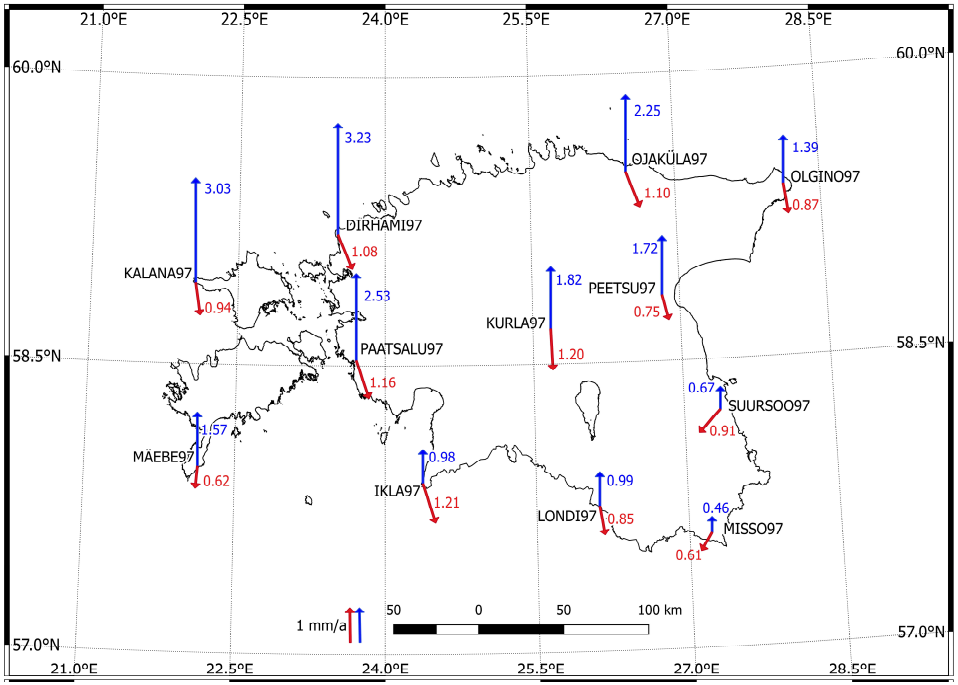


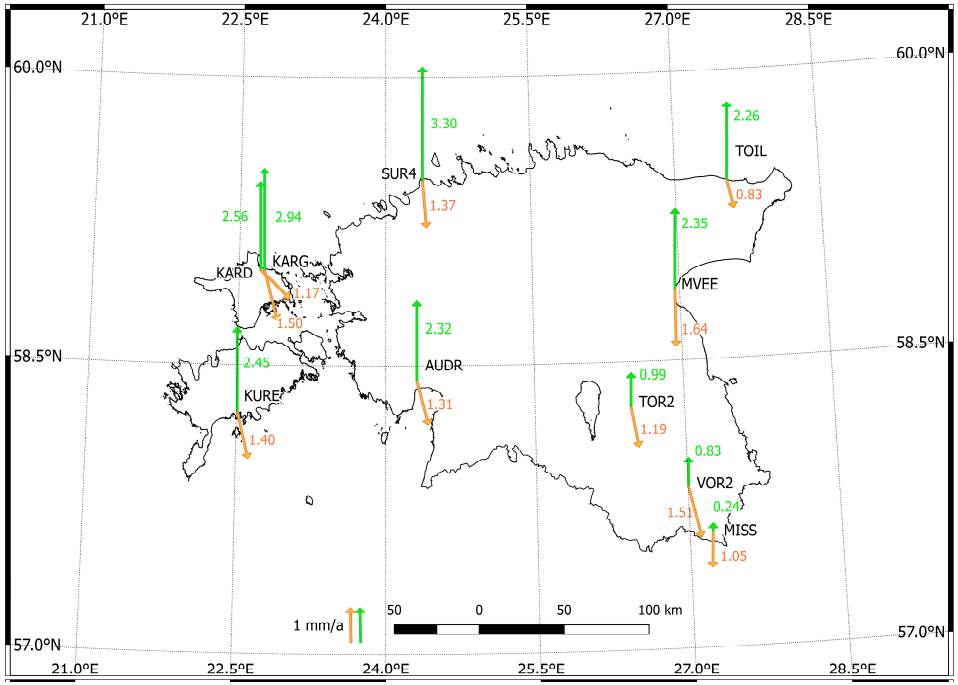
Velocities of CORS stations

- 10 stations with operating period from 2008 to 2016
  - Eight ESTPOS stations
  - Two Trimble VRSNow stations
- Software Hector
- Linear trend + annual and semiannual periods
- Flicker noise + White noise
- Published in journal „Geosciences"
  - https://doi.org/10.3390/geosciences9050233



Set of intraplate velocities





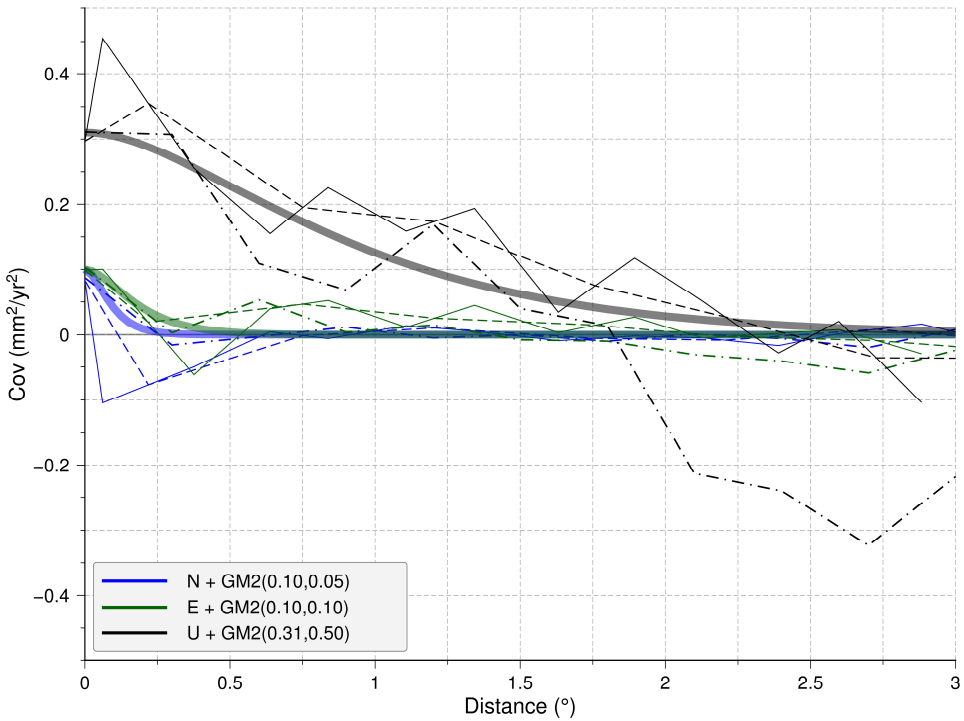
$$v = v_{obs} - v_{ITRF2008-PPM}$$

Method

- Remove-compute-restore
- NKG2016GIA as a reference model
  - $v_{res} = v_{obs} - v_{ITRF2008-PPM} - v_{GIA}$
- Residual analysis:
  - Variograms
  - Autocovariance plots
- Modeling the residual surface

Residual velocities of GRN 1st order points (mm/year)	N	E	U
MEAN	−0.79	−0.31	−0.34
STDEV	0.19	0.32	0.48
Residual velocities of CORS (mm/year)			
MEAN	−1.11	−0.10	−0.21
STDEV	0.31	0.30	0.65

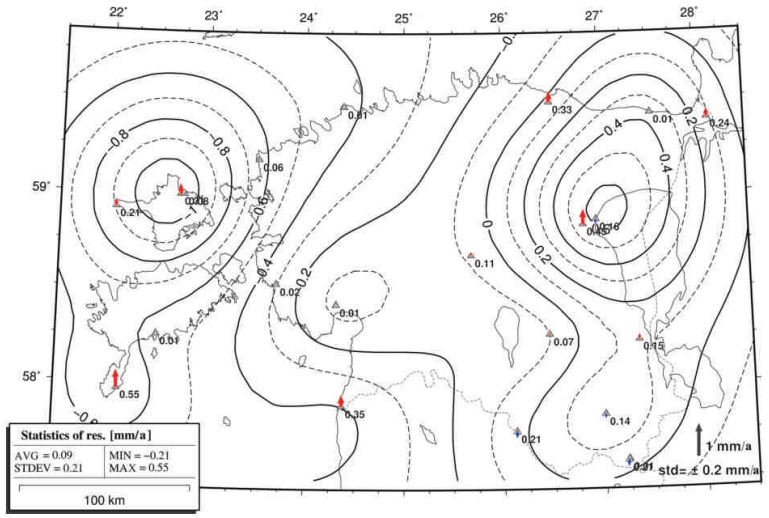
Autocovariance plot



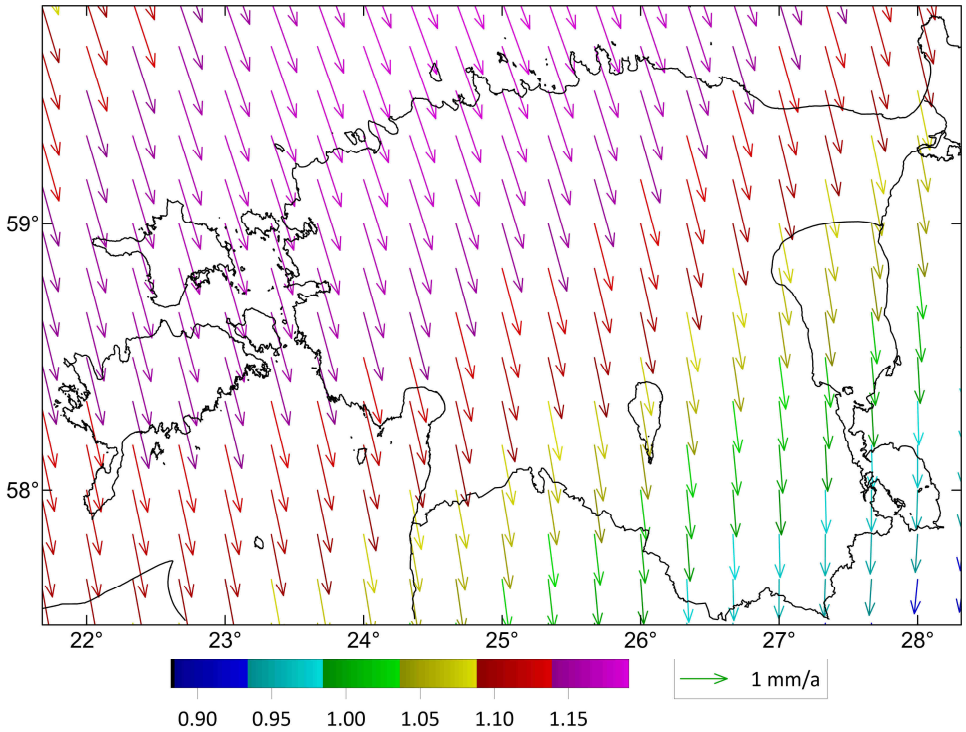
- Different empirical curves were estimated by using different interval width dl values from 0.25° to 0.5° and software (gstat, cov_func_comp)
- The isotropic Gauss-Markov 2nd-order model (GM2) $Cov = C(l)$ as a function of interval l between points with two unknown parameters was fitted with empirical curves

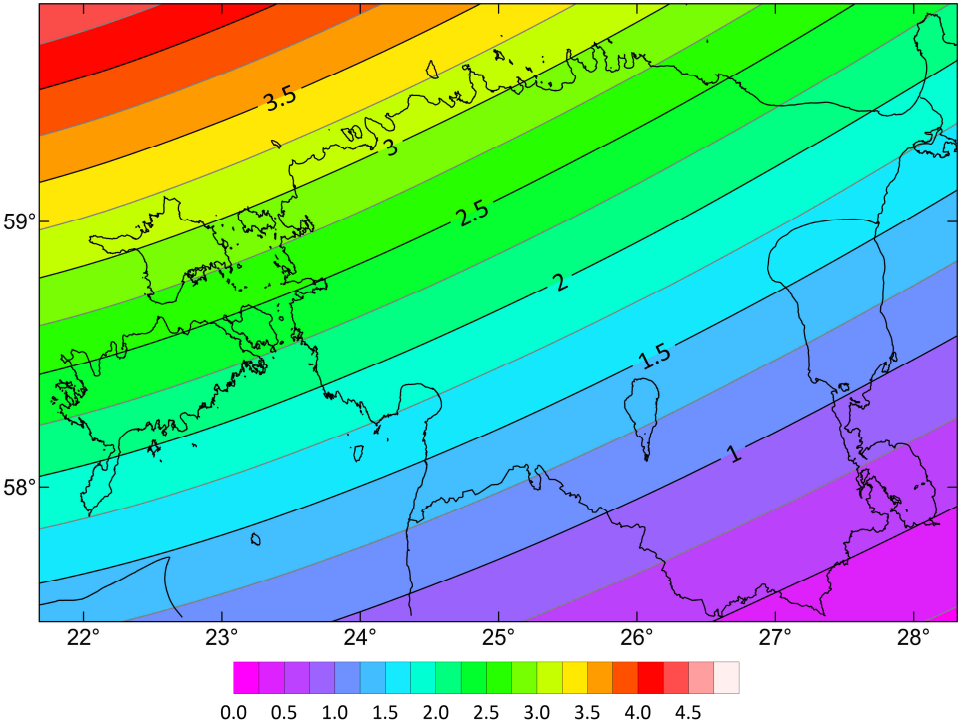
Fit of the different surfaces to the residuals

Model	N			E			U		
	MEAN	STDEV	RMS	MEAN	STDEV	RMS	MEAN	STDEV	RMS
Kriging	0.00	0.29	0.28	0.03	0.22	0.21	0.00	0.30	0.29
LSC	–0.25	0.27	0.36	–0.06	0.10	0.11	–0.12	0.23	0.25
Slope plane	0.00	0.29	0.28	0.00	0.22	0.21	0.00	0.30	0.29
GIA-model + const. (–0.94)	0.12	0.34	0.36	-	-	-	-	-	-



Restored surfaces in ITRF2008, model EST2020VEL





Comparison with NKG_RF17VEL ETRF2014 (mm/year)

Component	Mean	Min	Max	STDEV	RMS
North	−0.17	−0.25	−0.01	0.07	0.18
East	0.04	−0.04	0.08	0.02	0.05
Up	−0.20	−0.68	0.05	0.13	0.24

Conclusions

- Estonian model fits with NKG models very well
  - The fact that a simple slope plane was sufficient to model surfaces of residual velocities (for the N component, almost equivalent would be to apply a constant shift) suggests a very good fit of the reference GIA model to the empirical GNSS data
- Uncertainty of the EST2020VEL is estimated at approximately ±0.30 for the horizontal component and ±0.45 mm/a for the vertical component
- Results will be published in *Estonian Journal of Earth Sciences*, paper accepted
  - https://doi.org/10.3176/earth.2021.08
- We thank Maa-amet and Karin Kollo for GNSS data used in this study


THANK YOU!