NEW HORIZONTAL INTRAPLATE VELOCITY MODEL FOR NORDIC AND BALTIC COUNTRIES

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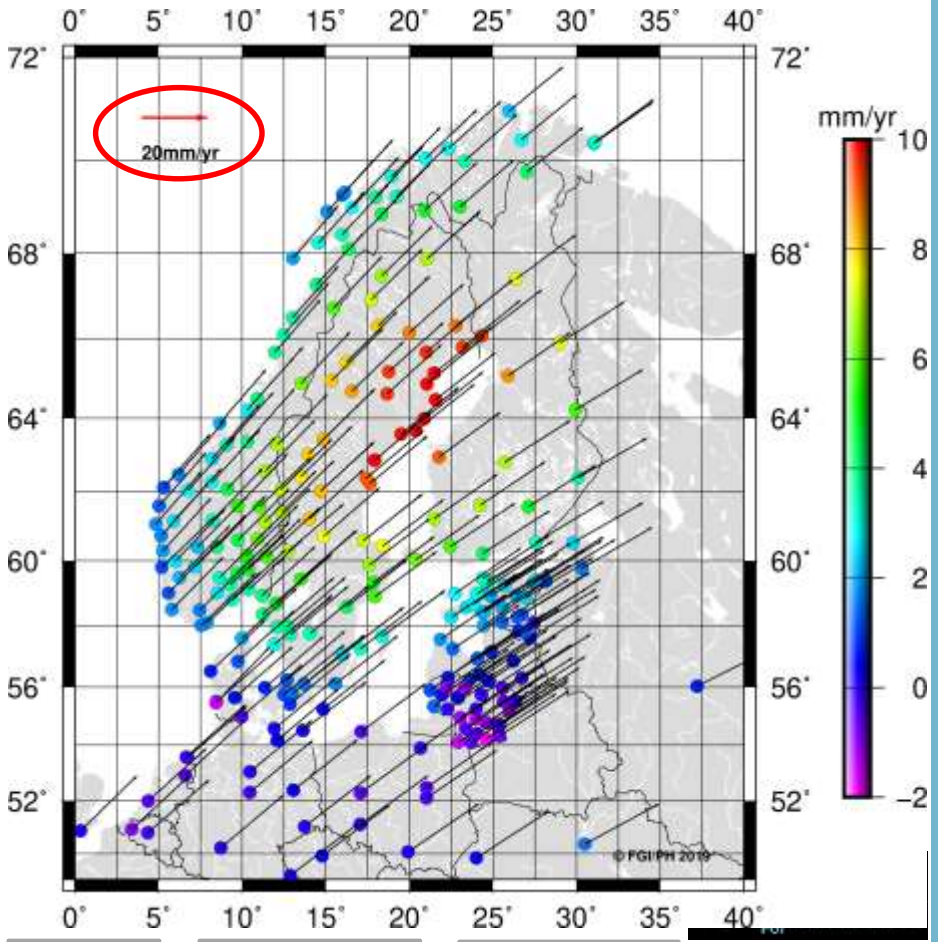
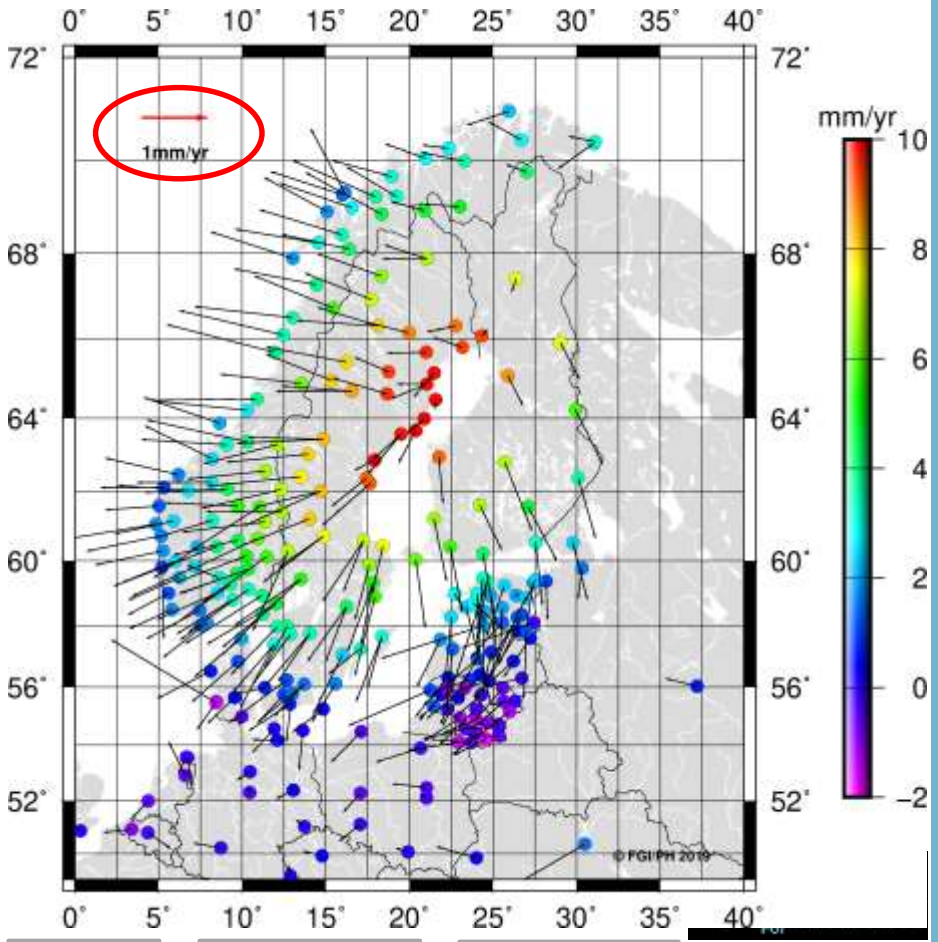
MOTIVATION

- Europe on Eurasian plate – horizontal motions ~20-25 mm/yr towards NE (black vectors, shown in ITRF2014)
- In Northern Europe also vertical motions due to Glacial Isostatic Adjustment (GIA) – up to ~10mm/yr (colored circles, ITRF2014)
- Pan-European European Terrestrial Reference System 1989 (ETRS89) defined to be co-moving with the Eurasian plate to minimize velocities / coordinate changes – rigid Eurasian plate motion removed



MOTIVATION

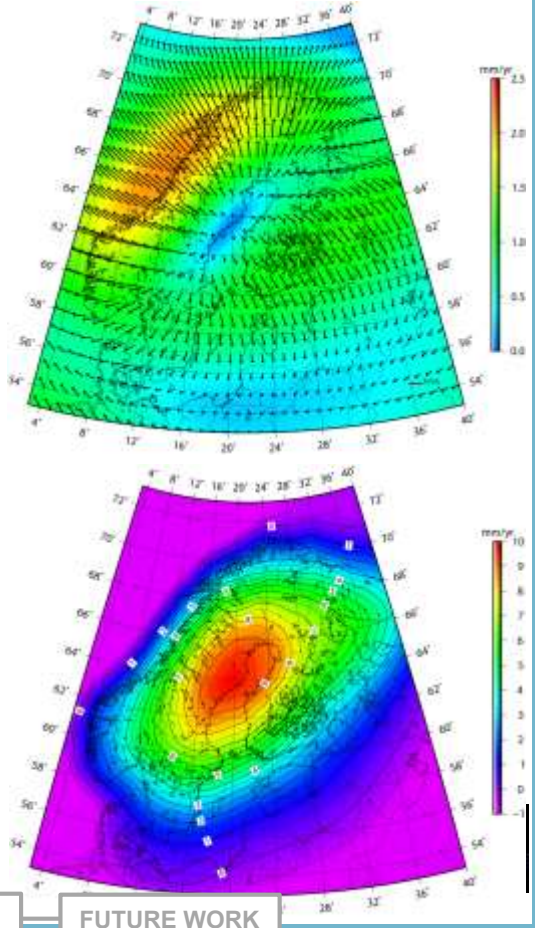
- Intraplate velocities by removing rigid Eurasian plate motion from ITRF2014 velocities (in ETRF2014)
  - Horizontal up to ~2-3 mm/yr
  - Vertical remain untouched (up to ~10 mm/yr)
- Together with time span from establishment of national ETRS89 realizations (mostly in the 90s) and intraplate (residual) velocities too large to be omitted in maintenance of the national ETRS89 realizations



NKG MODELS AND TRANSFORMATIONS

- Common interest for all Nordic and Baltic countries → co-operation under Nordic Geodetic Commission (NKG)
- 2005-2006: **intraplate models** NKG2005LU and NKG_RF03vel and **transformation** ITRF2000→Nat.ETRS89
  - NKG2005LU: vertical land uplift motions, used for data reductions e.g. in Nordic height systems (EVRS realisations)
  - NKG_RF03vel: 2D+1D model describing intraplate (land uplift) motions, vertical model equals with NKG2005LU_abs
- 2016: Updated **NKG**(2008) **transformation** between ITRFxx and national ETRS89 realizations
- 2016: NKG decided to release a new land uplift model package: **NKG2016LU_abs/lev, NKG_RF17vel and NKG2016LU_gdot**

NKG_RF03vel (NKG2005LU_abs)

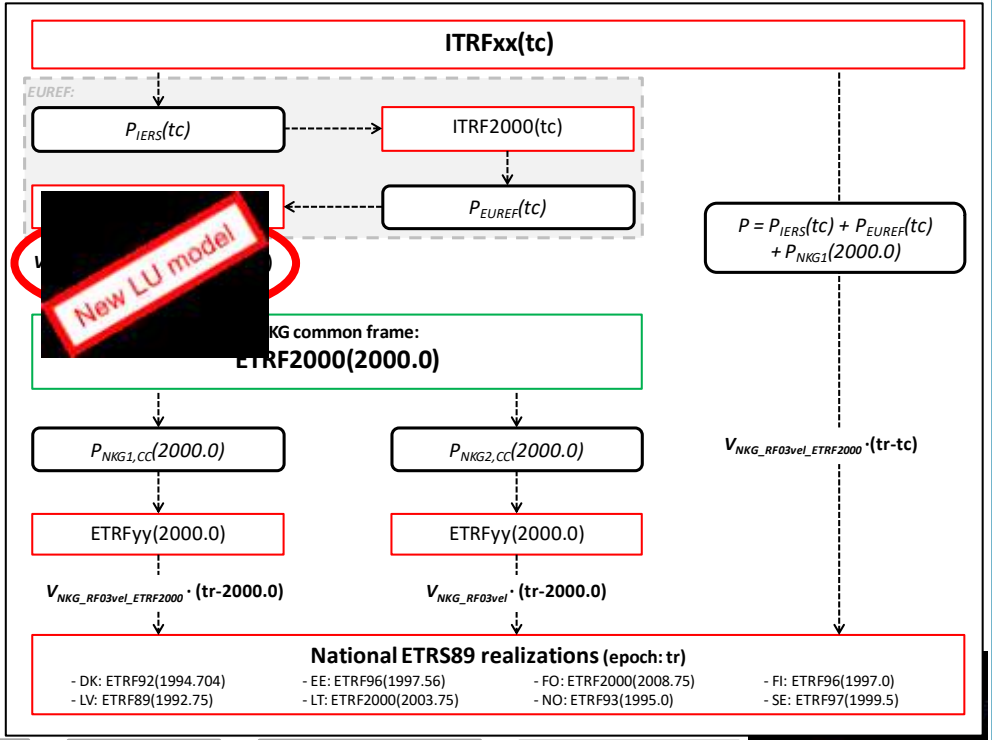


NKG TRANSFORMATION: ITRFXX←→NATIONAL ETRS89

How do we use the models?

- Latest NKG transformation released in 2016, see figure
  - Still utilizes the old NKG_RF03vel model
  - New vertical land uplift model NKG2016LU released in 2016
  - Horizontal model to be updated too

→ Topic of this talk: **horizontal** (land uplift) **intraplate velocities of the NKG_RF17vel model**



DATA FOR HORIZONTAL INTRAPLATE VELOCITIES

- Nordic land uplift models include observations from several measurement techniques and predictions from GIA models
- Horizontal model is a combination of **GNSS** and **GIA** velocities
- GNSS velocities based on Continuously Operating Reference Stations (CORS) and their sufficiently long observation time series
  - Through GNSS data enables absolute velocities in a global terrestrial reference frame (TRF) – used for reference frame alignment
  - CORS network however pretty sparse for describing local motions – to densify velocity field, can be complemented with:
    - more dense geodetic observation data (even other measurement techniques) – empirical model
    - geophysical data: for Fennoscandian land uplift glacial isostatic adjustment (GIA) model – semi-empirical model
- GIA models (along with chosen combination procedure) bring details to the GNSS velocity field (”fills the gaps”)

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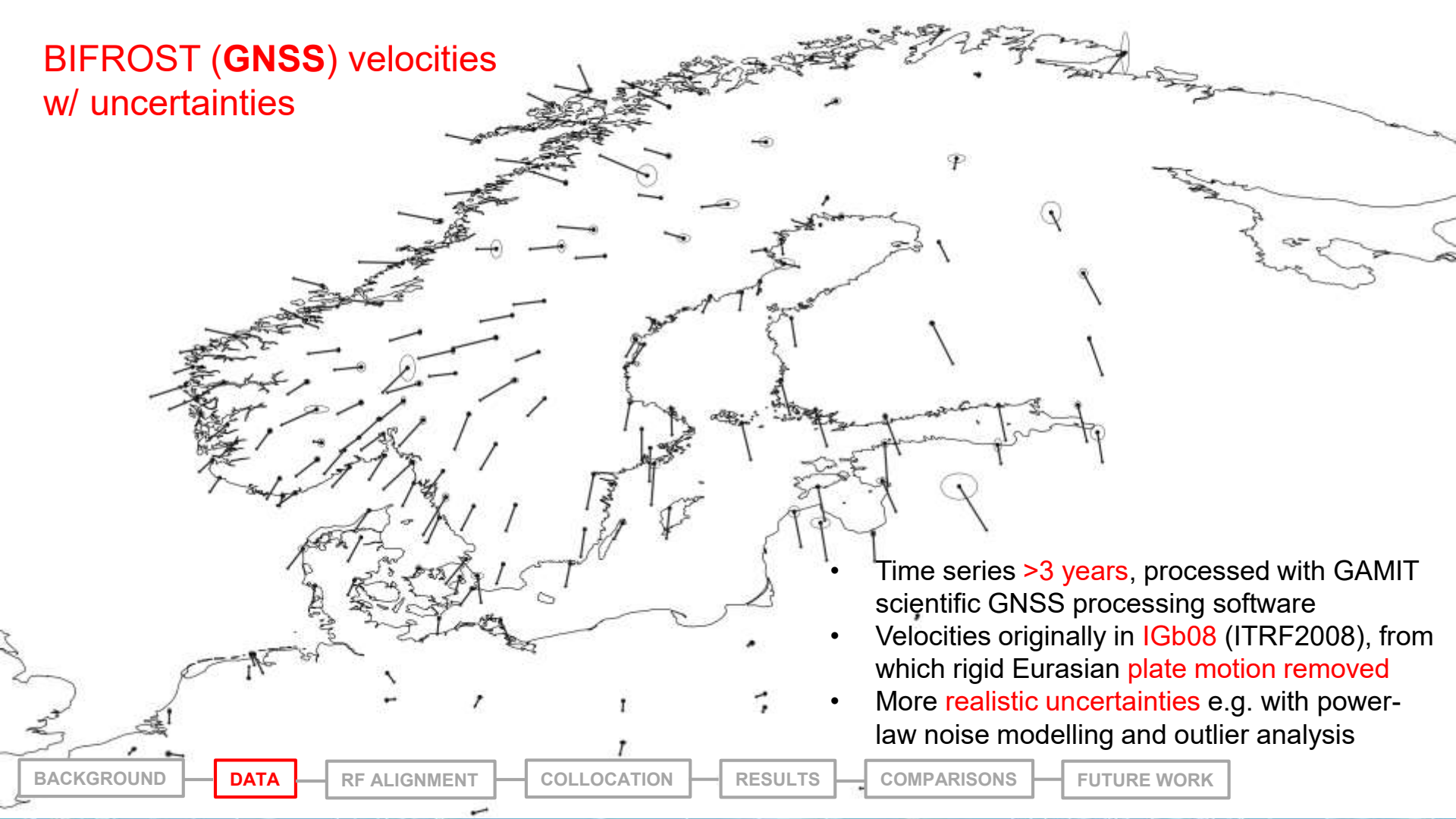
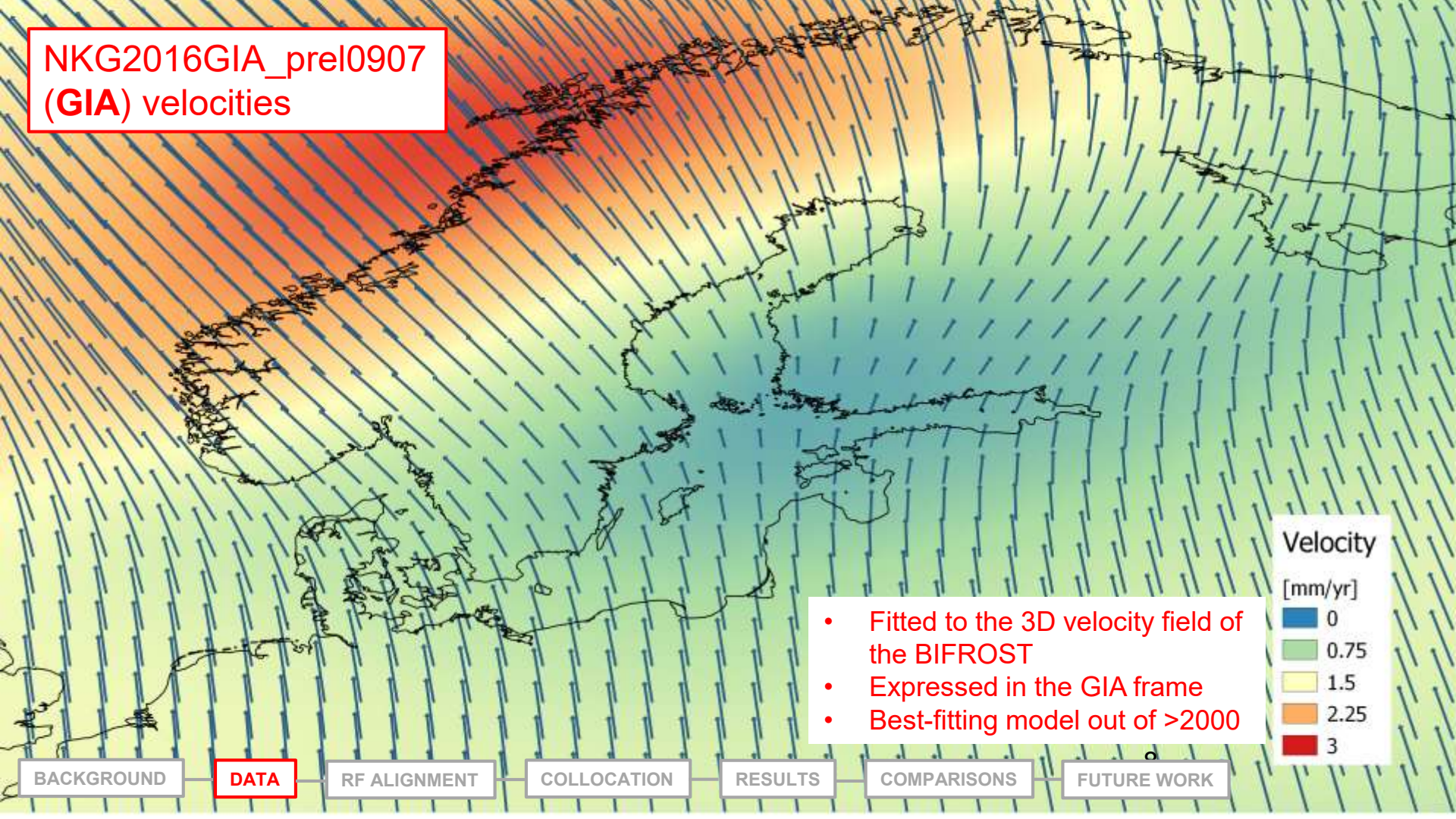
BIFROST (**GNSS**) velocities w/ uncertainties



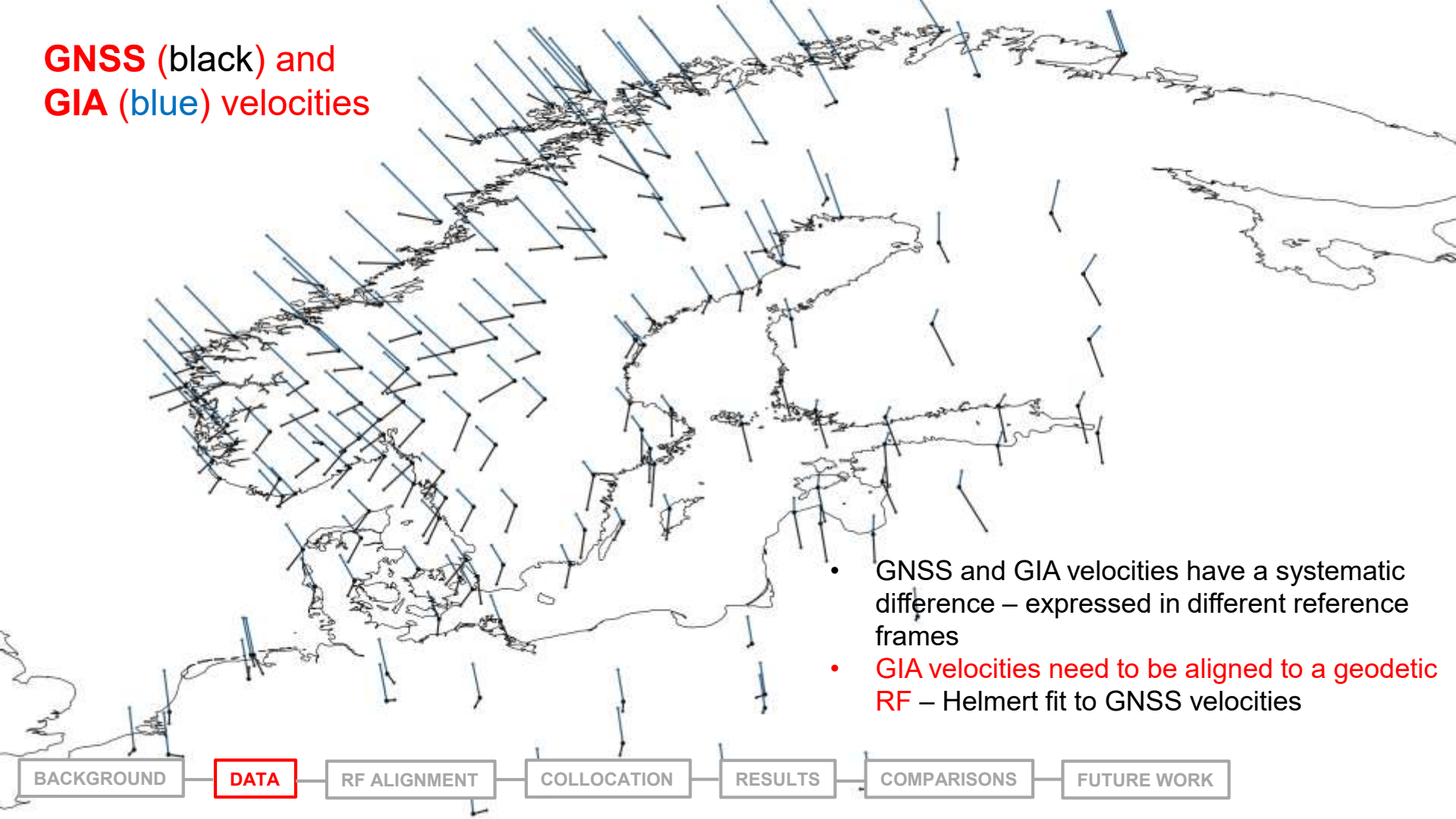
- Time series >3 years, processed with GAMIT scientific GNSS processing software
- Velocities originally in IGb08 (ITRF2008), from which rigid Eurasian plate motion removed
- More realistic uncertainties e.g. with power-law noise modelling and outlier analysis

NKG2016GIA_prel0907 (**GIA**) velocities



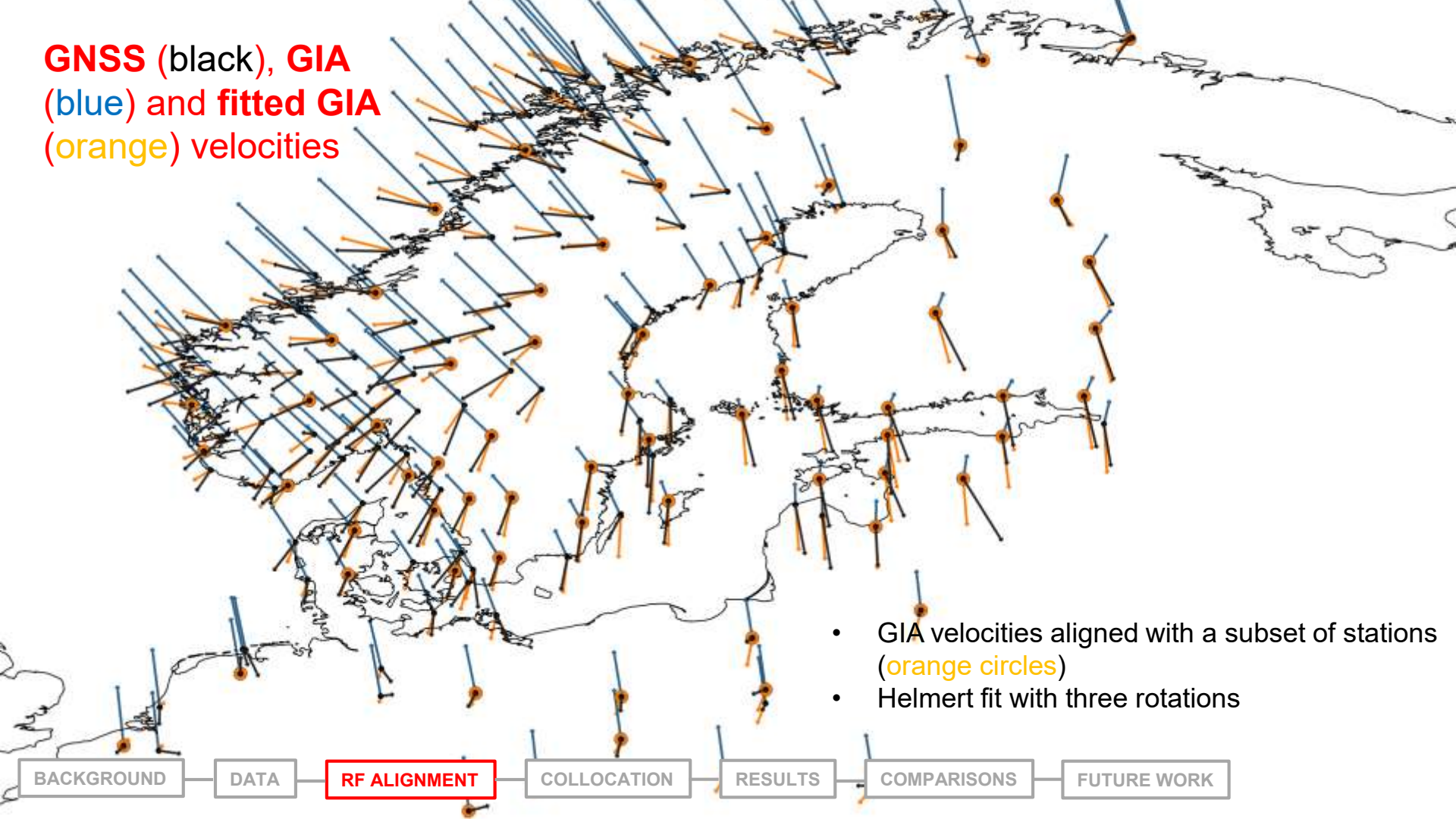
- Fitted to the 3D velocity field of the BIFROST
- Expressed in the GIA frame
- Best-fitting model out of >2000

GNSS (black) and
GIA (blue) velocities



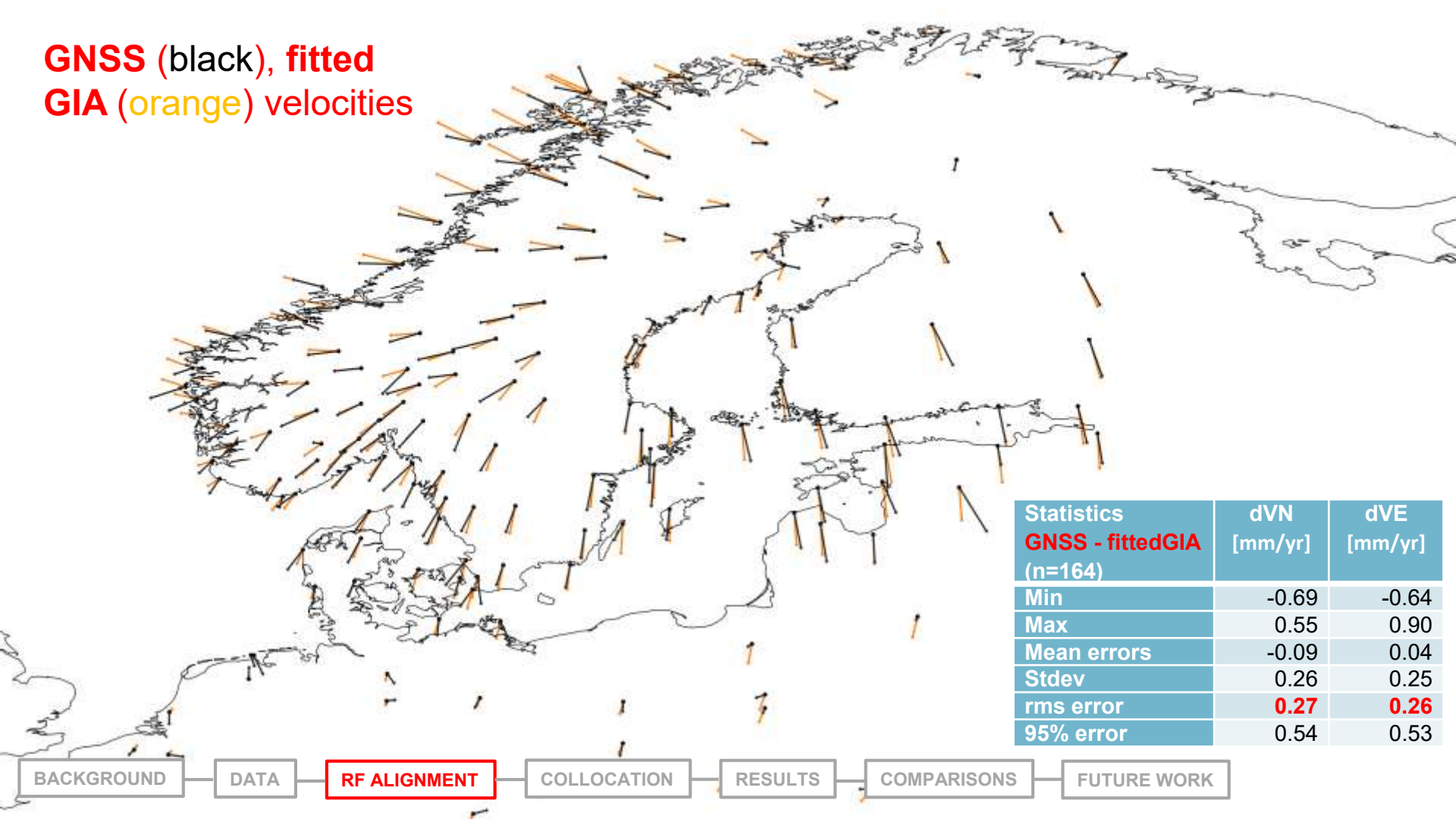
- GNSS and GIA velocities have a systematic difference – expressed in different reference frames
- GIA velocities need to be aligned to a geodetic RF – Helmert fit to GNSS velocities

GNSS (black), **GIA** (blue) and **fitted GIA** (orange) velocities



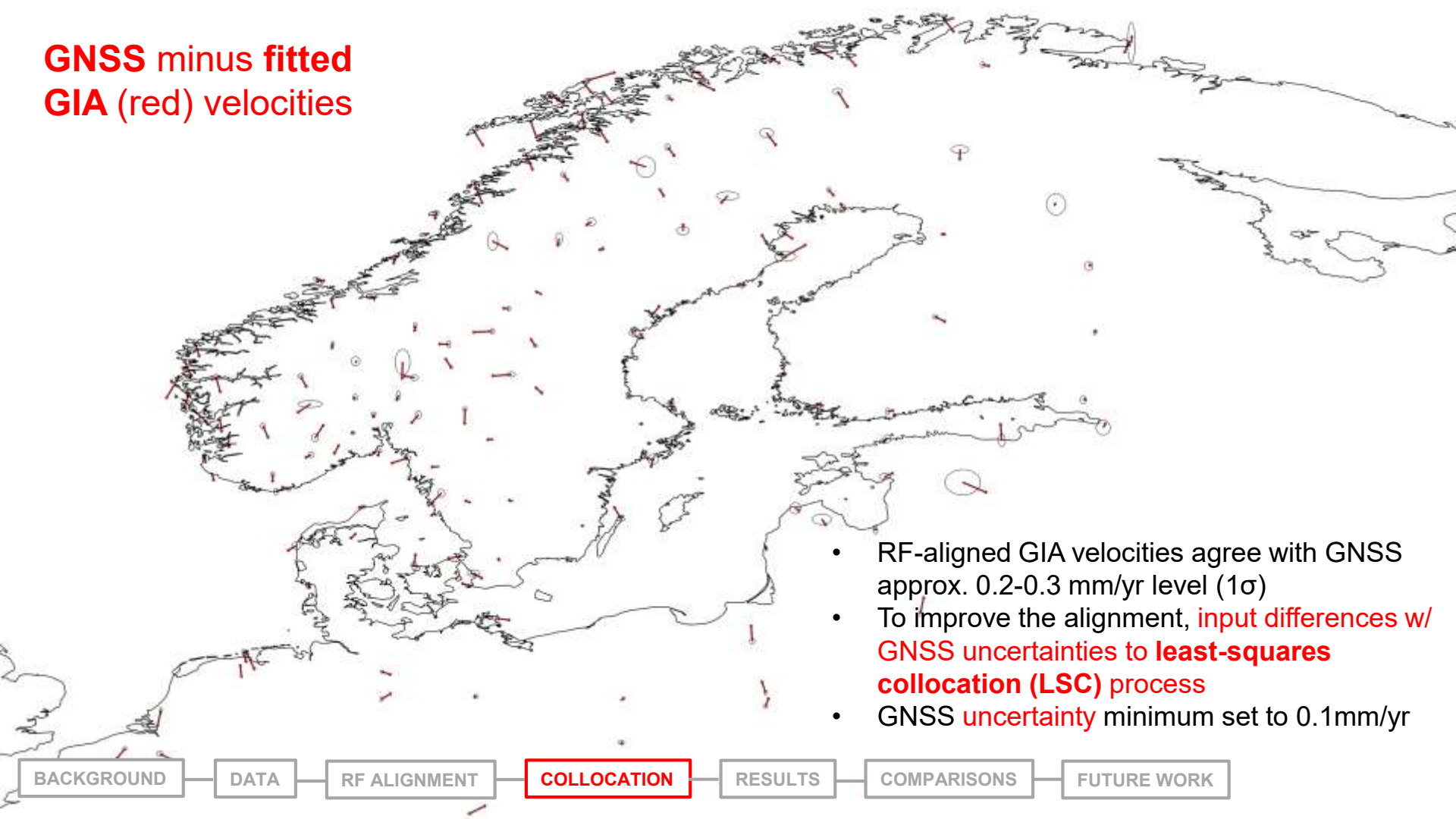
- GIA velocities aligned with a subset of stations (orange circles)
- Helmert fit with three rotations

GNSS (black), **fitted**
GIA (orange) velocities



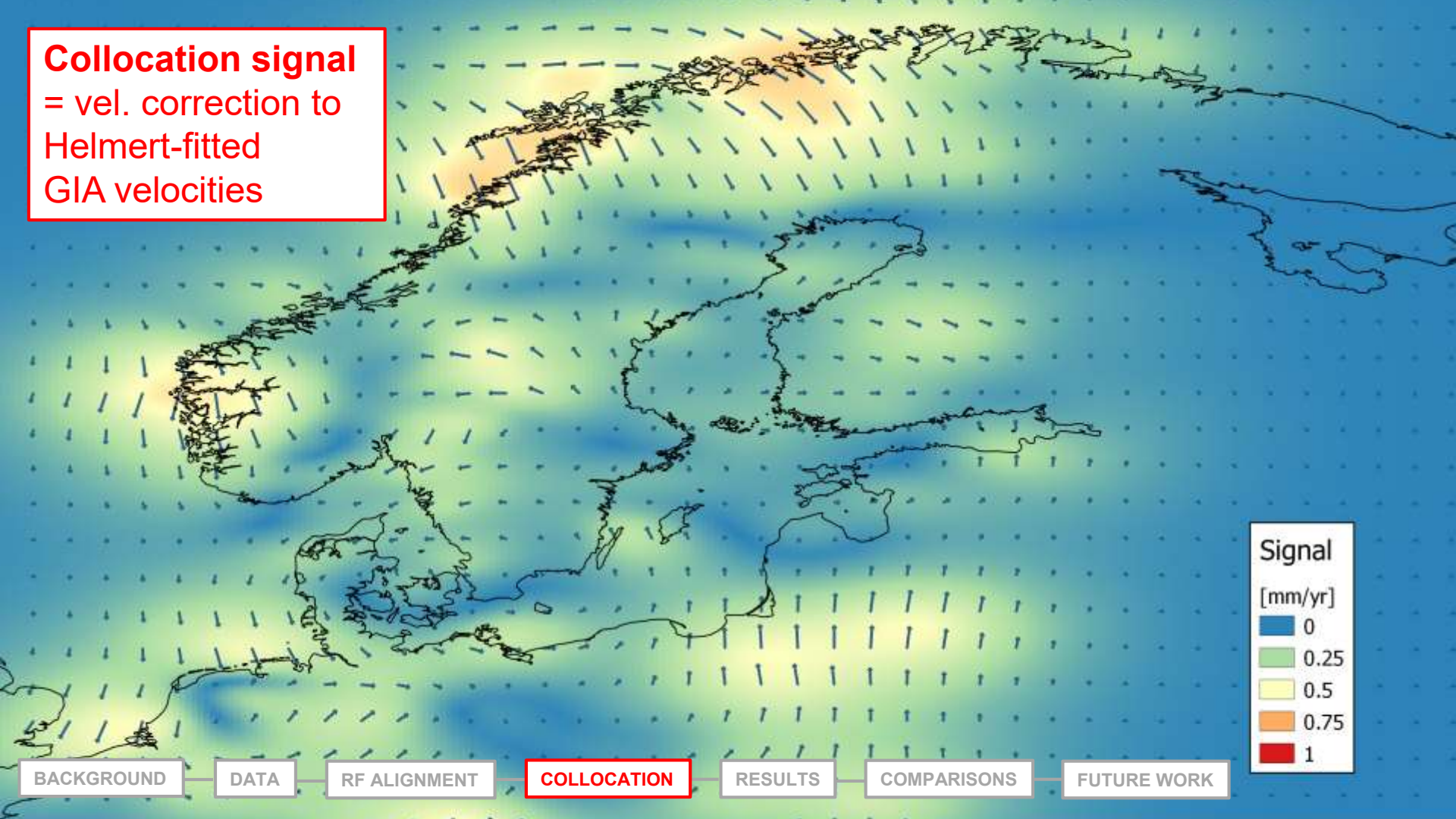
Statistics GNSS - fittedGIA (n=164)	dVN [mm/yr]	dVE [mm/yr]
Min	-0.69	-0.64
Max	0.55	0.90
Mean errors	-0.09	0.04
Stdev	0.26	0.25
rms error	**0.27**	**0.26**
95% error	0.54	0.53

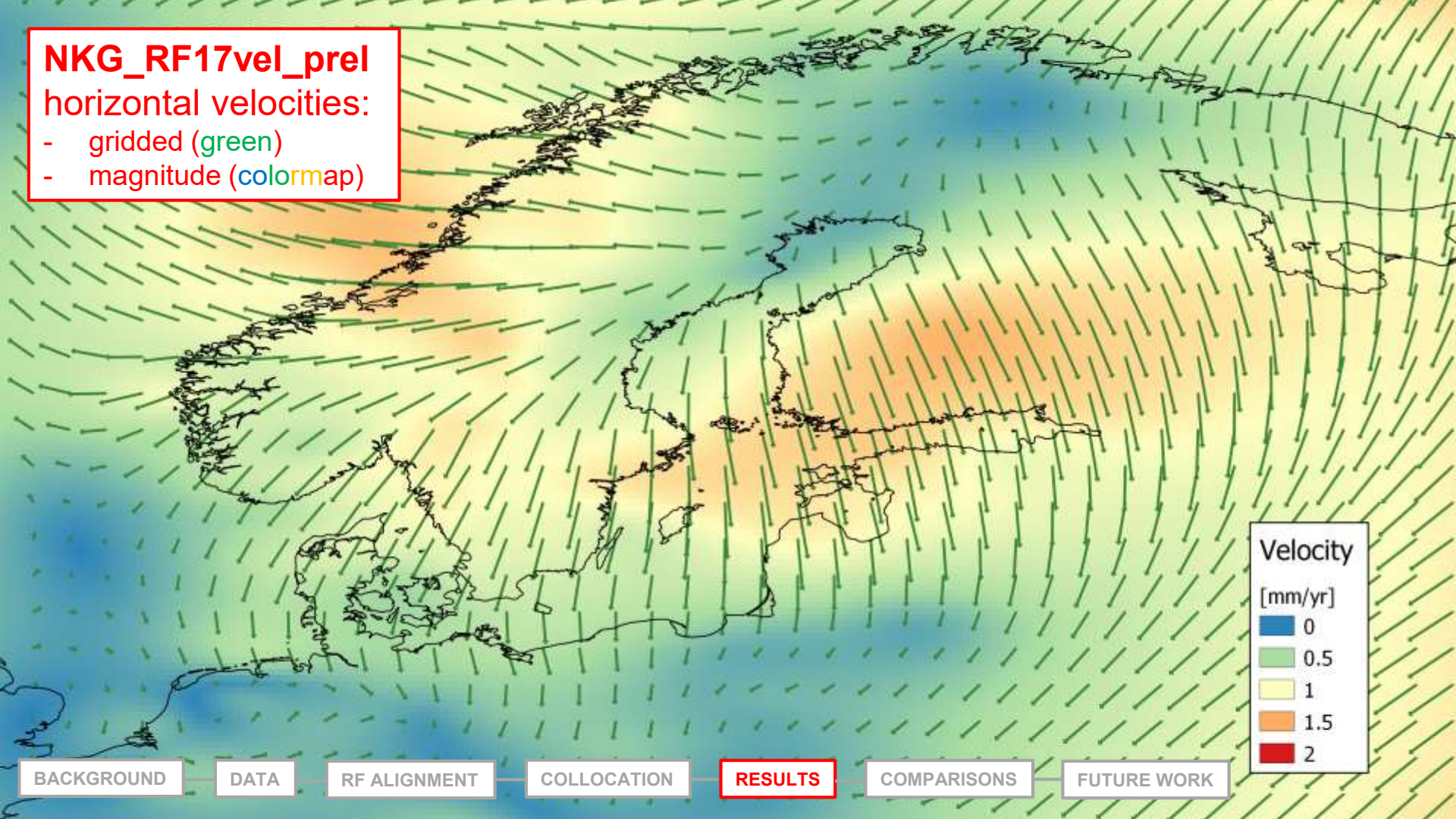
GNSS minus **fitted**
GIA (red) velocities



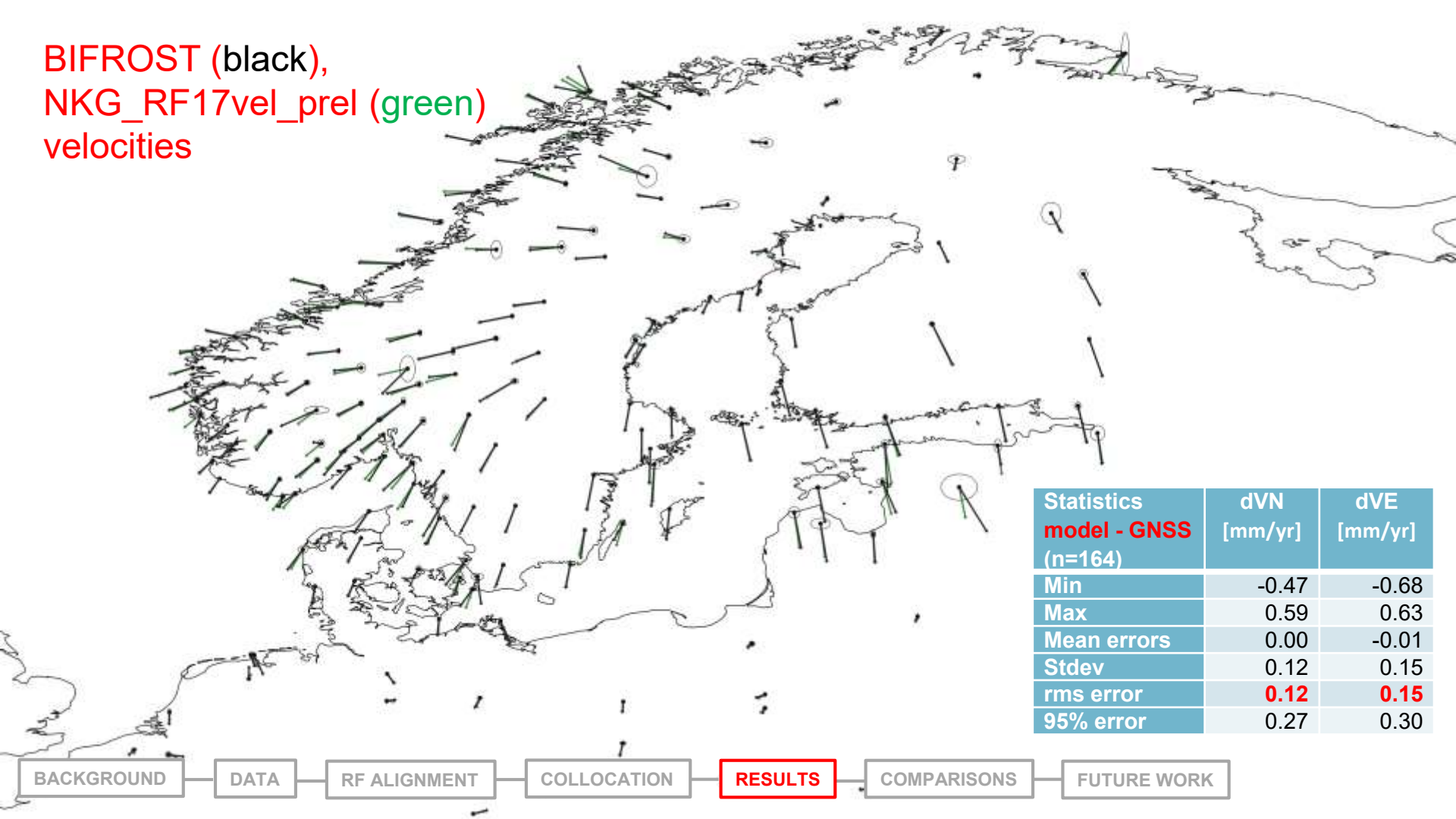
- RF-aligned GIA velocities agree with GNSS approx. 0.2-0.3 mm/yr level (1σ)
- To improve the alignment, input differences w/ GNSS uncertainties to **least-squares collocation (LSC)** process
- GNSS uncertainty minimum set to 0.1mm/yr

Collocation signal
= vel. correction to Helmert-fitted GIA velocities




NKG_RF17vel_prel
horizontal velocities:
- gridded (green)
- magnitude (colormap)
Velocity
[mm/yr]
0
0.5
1
1.5
2
BACKGROUND
DATA
RF ALIGNMENT
COLLOCATION
RESULTS
COMPARISONS
FUTURE WORK

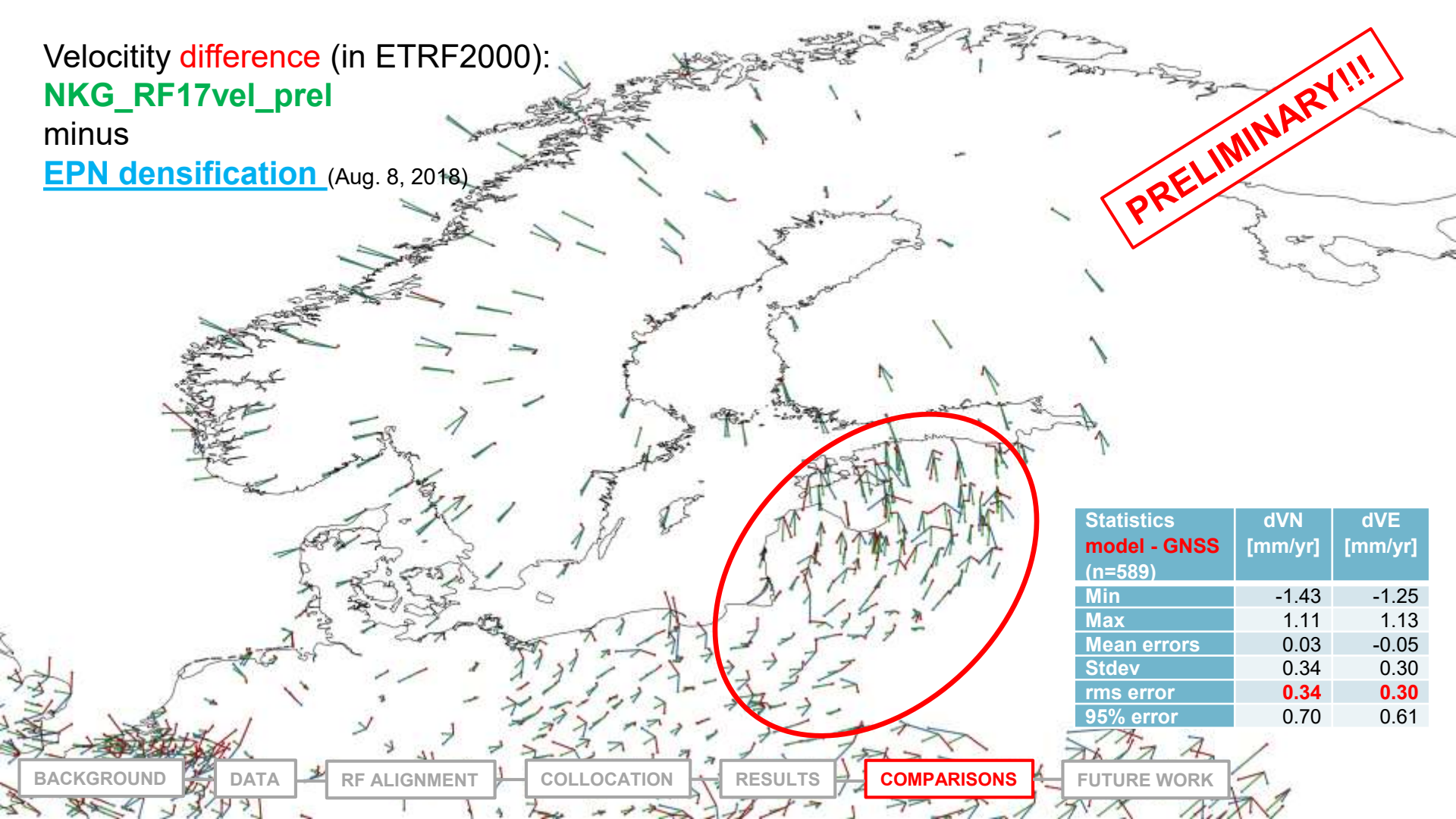
BIFROST (black),
NKG_RF17vel_prel (green)
velocities



Statistics model - GNSS (n=164)	dVN [mm/yr]	dVE [mm/yr]
Min	-0.47	-0.68
Max	0.59	0.63
Mean errors	0.00	-0.01
Stdev	0.12	0.15
rms error	**0.12**	**0.15**
95% error	0.27	0.30

Velocitity difference (in ETRF2000):
NKG_RF17vel_prel
minus
EPN densification (Aug. 8, 2018)

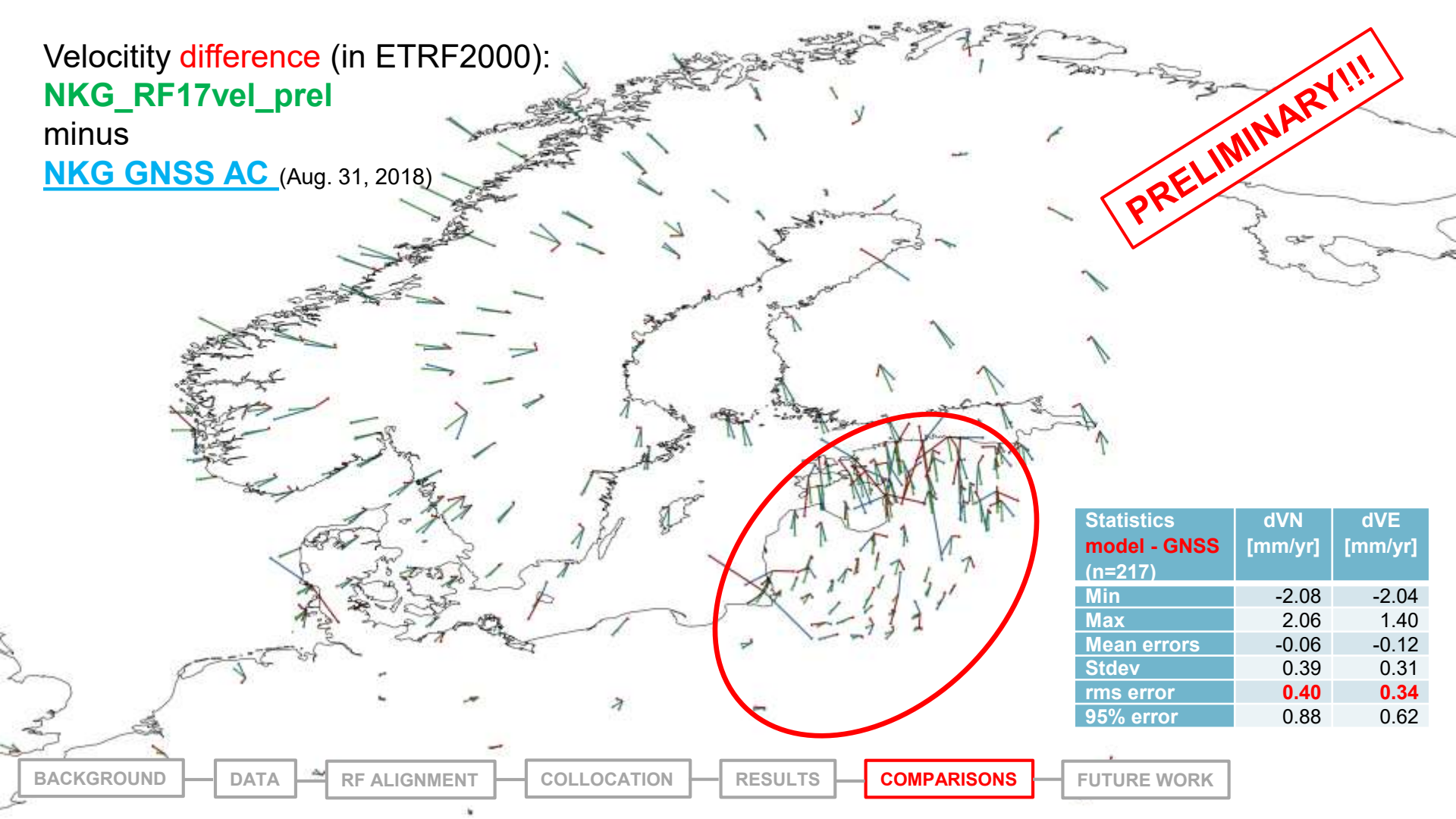
PRELIMINARY!!!



Statistics model - GNSS (n=589)	dVN [mm/yr]	dVE [mm/yr]
Min	-1.43	-1.25
Max	1.11	1.13
Mean errors	0.03	-0.05
Stdev	0.34	0.30
rms error	**0.34**	**0.30**
95% error	0.70	0.61

Velocitity difference (in ETRF2000):
NKG_RF17vel_prel
minus
NKG GNSS AC (Aug. 31, 2018)

PRELIMINARY!!!



Statistics model - GNSS (n=217)	dVN [mm/yr]	dVE [mm/yr]
Min	-2.08	-2.04
Max	2.06	1.40
Mean errors	-0.06	-0.12
Stdev	0.39	0.31
rms error	**0.40**	**0.34**
95% error	0.88	0.62

CONCLUSIONS AND FUTURE WORK

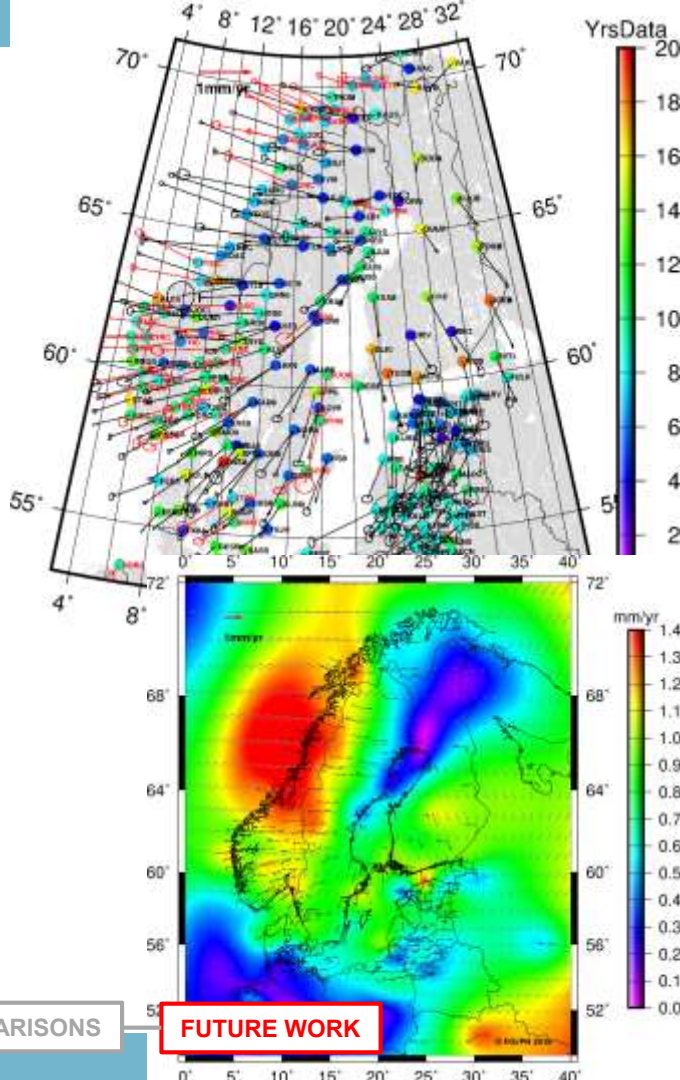
- Methodology works but Baltic area could be improved

→ Model presented here only a **preliminary** model

→ Use new NKG repro1 velocities

  - Longer time span
  - More data in Baltic
  - Careful pre-analysis of the time series
  - Spatial correlation for velocities from CATREF

- Evaluate/analyse/tune remaining details e.g.:
  - Clean GNSS data
  - Correlation length



THANK YOU!