



Federal Agency for
Cartography and Geodesy



Status report for the EUREF Working Group “European Unified Height Reference”

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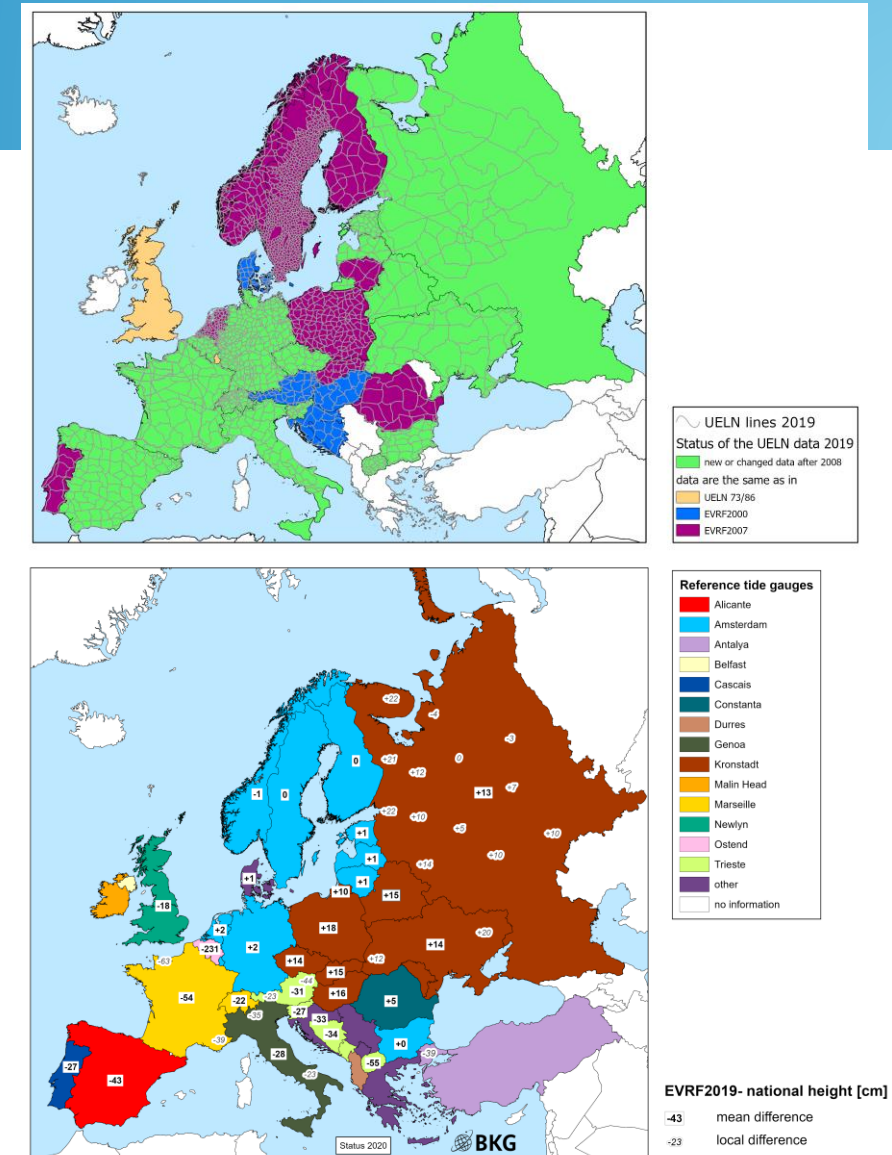
EUREF Symposium 2025, Covilhã, 25 June 2025

Introduction

Heights in Europe are not as unified as 3-D coordinates...*

- National height systems remain in use (with good reason)
- Official realization of the EVRS is based on the UELN
- Latest realization EVRF2019
- GNSS-based height determination in EVRF2019 requires fitted height reference surface (quasigeoid model) to transform ETRF20xx <> EVRF20xx seamlessly
- No such official product so far from EUREF

** cm ... sub-dm for ETRS89 datum ensemble!*



Working Group

- Established 2021 through EUREF Resolution No. 1/2021

Goals

- Provide comprehensive and easily accessible information about the national integrated spatial reference
- Improve interoperability of the national products of the height reference across borders
- Enable seamless GNSS-based height determination, thereby strengthen the importance of the EVRS
- Implement European height reference surface as an official realization of EVRS which is compatible to the latest realizations of ETRS89 and EVRS (= fulfill EUREF resolutions, e.g. No. 5/2009)

Actions

- **CRS-EU** Revised database with enhanced information on the vertical reference (geoid models)
- **EHRS_CP** New homogenized **GNSS/leveling dataset** in current ETRS89/EVRS realization
- **EHRS** Develop and provide **quasigeoid model fitted to ETRS89/EVRS realizations**
(cooperation with IAG SC2.4a European Geoid / European Geoid Project)

Inventory of national realizations (GNSS, heights, geoid models)

- Overview document of national realizations on EVRS website → <https://doi.org/10.71603/NatRefEurope>
- GNSS, heights, geoid models
- Initial version 2024-11-04 (small technical corrections since), based on countries' questionnaires
- Please check regularly and report updates if needed

Table 1 Overview of GNSS reference frames (national ETRS89 realizations) in Europe

Background colors: **Grey** No longer in use

CC	Country	Date of info	Valid from	Valid until	Name of realization	Target frame	Epoch [yr]	Tx [mm]	Ty [mm]	Tz [mm]	D [ppb]	Rx [mas]	Ry [mas]	Rz [mas]	Re- marks	EPSG
AT	Austria	2022-04-29	unknown	unknown	ETRS89 Austria 2002	ETRF2000	2002.56									
BE	Belgium	2022-05-23	unknown	unknown	BEREF (Belgian Reference Frame)	ETRF2000	2002.73									
BG	Bulgaria	2022-04-12	unknown	unknown	BGS2005 (Bulgarian Geodetic System 2005)	ETRF2000	2005.0									7797
CH	Switzerland	2021-08-24	unknown	unknown	CHTRF95	ETRF93	1993.0								[1]	4933
CZ	Czech Republic	2022-06-15	unknown	unknown		ETRF2000	2007.0									
DE	Germany	2022-04-29	ca. 2003	2016-11-30	ETRS89/DREF91 Realization 2002	ETRF2000	2002.79	63.9	-93.9	53.2	-10.9	-2.400	-0.800	2.300		
		2022-04-29	2016-01-12	unknown	ETRS89/DREF91 Realization 2016	ETRF2000	2008.46	0.0	0.0	0.0	0.0	0.658	-0.208	0.755		10283

Inventory of national realizations

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Table 2 Overview of national height reference surfaces (geoid models). For more details on the GNSS realizations, please refer to Table 1.

Height types: NH Normal heights, NOH Normal-orthometric heights, OH Orthometric heights (Helmert heights not precluded), OH(H) Helmert orthometric heights (confirmed), U Uncorrected for gravity

Background colors: **Yellow** CRS of grid is not ETRS89 geographic (longitude, latitude) → projected coordinates nmd/or other datum, **Grey** No longer in use

Standard CRS of interpolation grids: "ETRS89 geographic" (i.e., any ETRFxxxx) assumed as EPSG:4258, "WGS84 geographic" (i.e., any ITRFxxxx) assumed as EPSG:4326

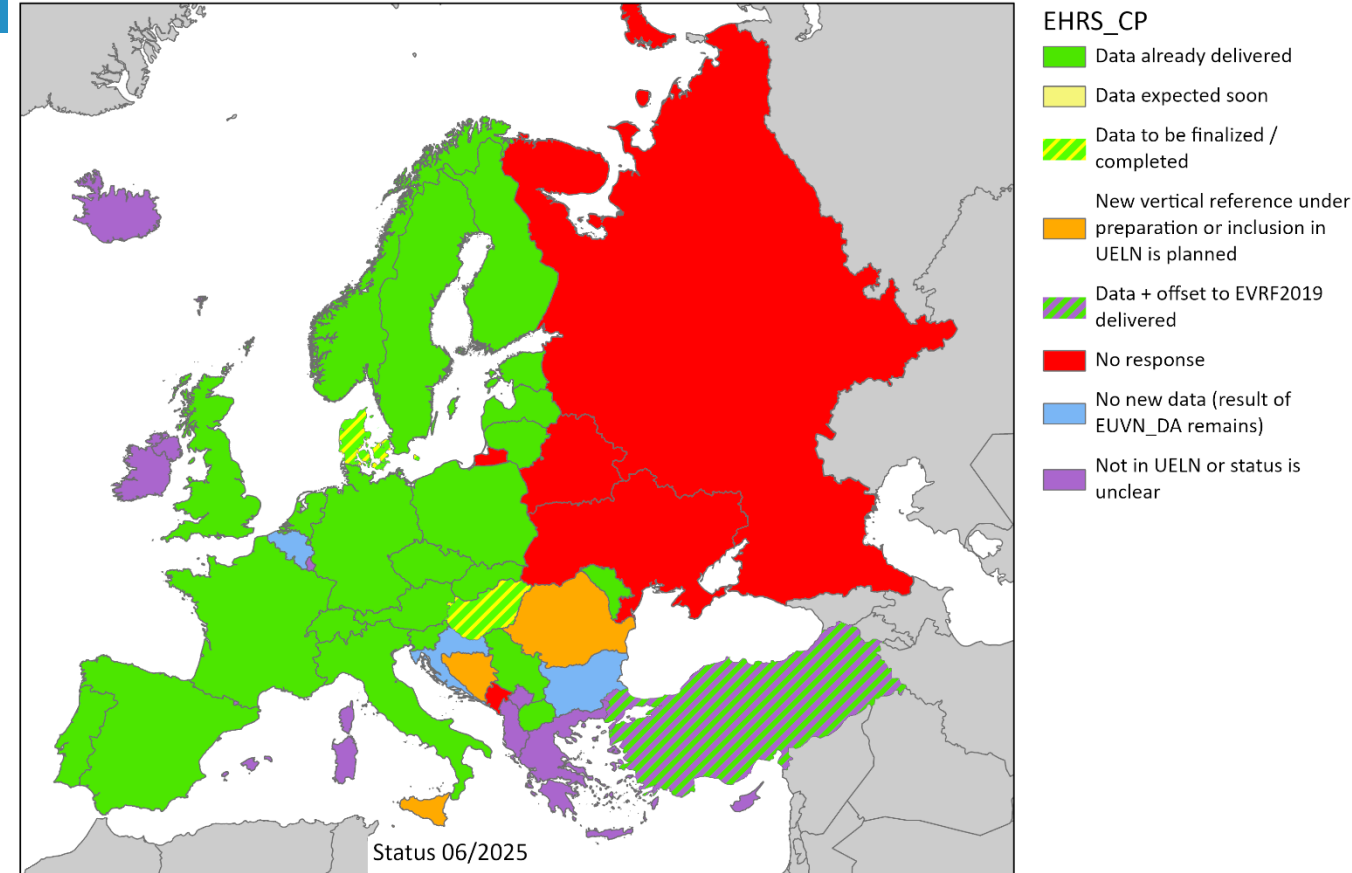
CC	Country	Subregion	HRS grid	Valid from	Valid until	CRS of grid	GNSS realization of ellipsoidal height	ETRS89 datum?	Ell. height linked to	Height realization	Height datum	Height type	Re- marks	Link
AT	Austria		Austrian Geoid 2008 (GRS80) (EPSG:9276)	2008-01-01		ETRS89 geographic	ETRS89 with GRS80 ellipsoid (EPSG:4937)	yes	ETRF2000 (2002.56)	EVRF2000 Austria (EPSG:9274)	Amsterdam (NAP)	OH	[1] [2]	Info ZIP
AT	Austria		Austrian Geoid 2008 (Bessel) (EPSG:9277)	2008-01-01		MGI geogr. with Bessel (EPSG:4312)	MGI with Bessel ellipsoid (EPSG:9267)	no	ETRF2000 (2002.56) by transf.	EVRF2000 Austria (EPSG:9274)	Amsterdam (NAP)	OH	[1] [2]	Info ZIP
AT	Austria		Höhen-Grid plus Geoid (EPSG:9499)	2013-11-08		MGI geogr. with Bessel (EPSG:4312)	ETRS89 with GRS80 ellipsoid (EPSG:4937)	(yes)	ETRF2000 (2002.56)	GHA height (EPSG:5778)	Triest (MGI/Adria)	NOH	[2]	Info ZIP
BE	Belgium		hbG18	2018-08-01		ETRS89 geographic	BEREF (EPSG:4937)	yes	ETRF2000 (2002.73)	TAW/DNG height (EPSG:5710)	Ostende	U		ISG

New set of GNSS/leveling control points (CP) for the European Height Reference Surface (EHRP)

- Homogenization of GNSS heights (ETRF2020)
 - *see presentation EUREF Symposium 2024*
- EVRS heights (EVRF2019)

Status

- Data provided by most UELN countries
- New or updated countries in UELN
 - *see previous talk by M. Sacher*
- New data (e.g. DK, PT, RS), some to be processed



The border of Kosovo is used without prejudice to positions on status and is in line with UNSC 1244 and the ICJ Opinion on the Kosovo declaration of independence.

Test computations of corrector surface with EHRS_CP dataset

Contribution of S. Varbla (TalTech, now TUM)

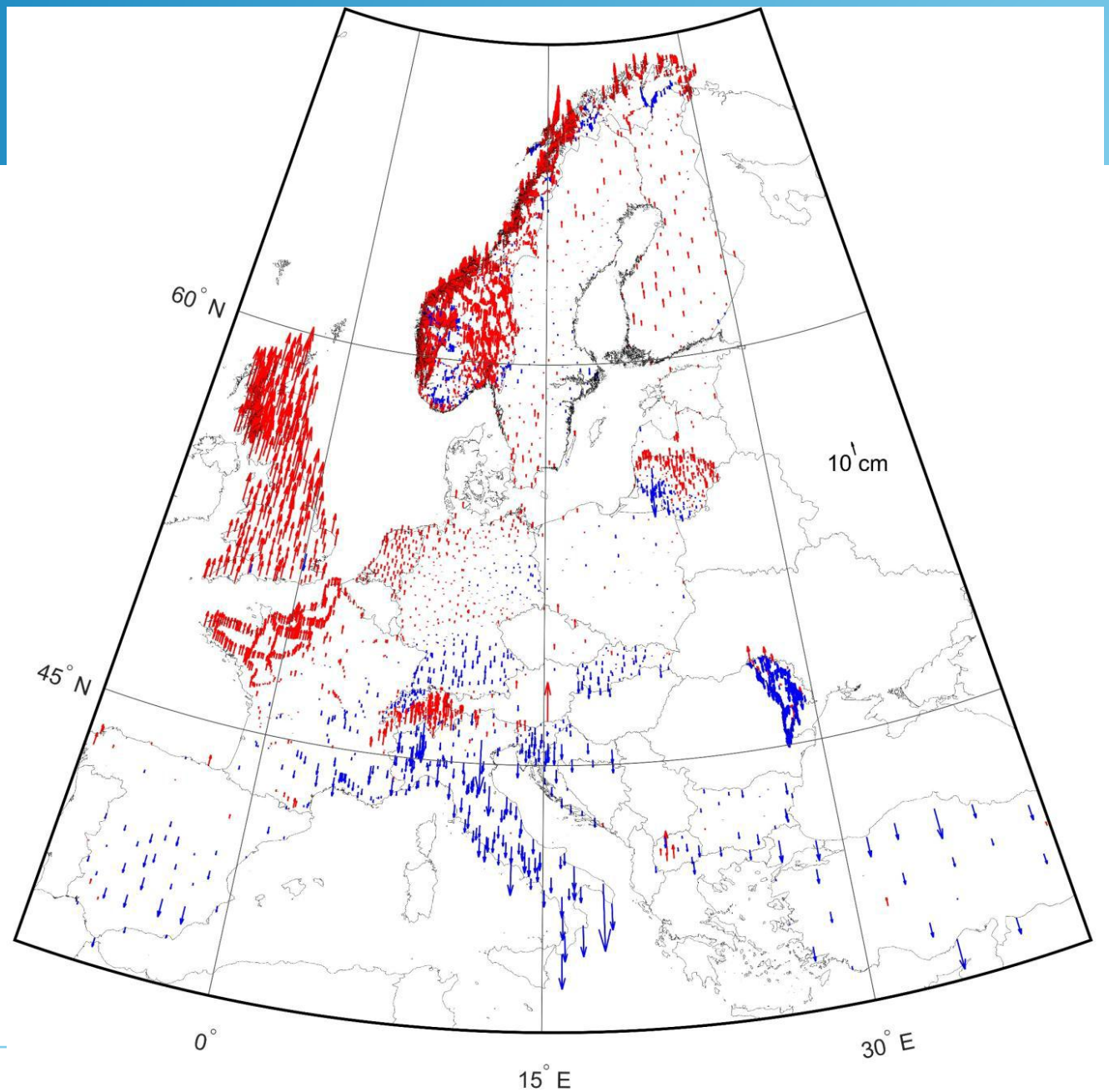
Based on:

**Preliminary GNSS/leveling dataset
(status 2024)**

EGG2015 quasigeoid model

**2nd-order Gauss Markov interpolation with
locally adapted covariance model**

GNSS/leveling – quasigeoid differences ►



Test computations of corrector surface with EHRS_CP dataset

Contribution of S. Varbla (TalTech, now TUM)

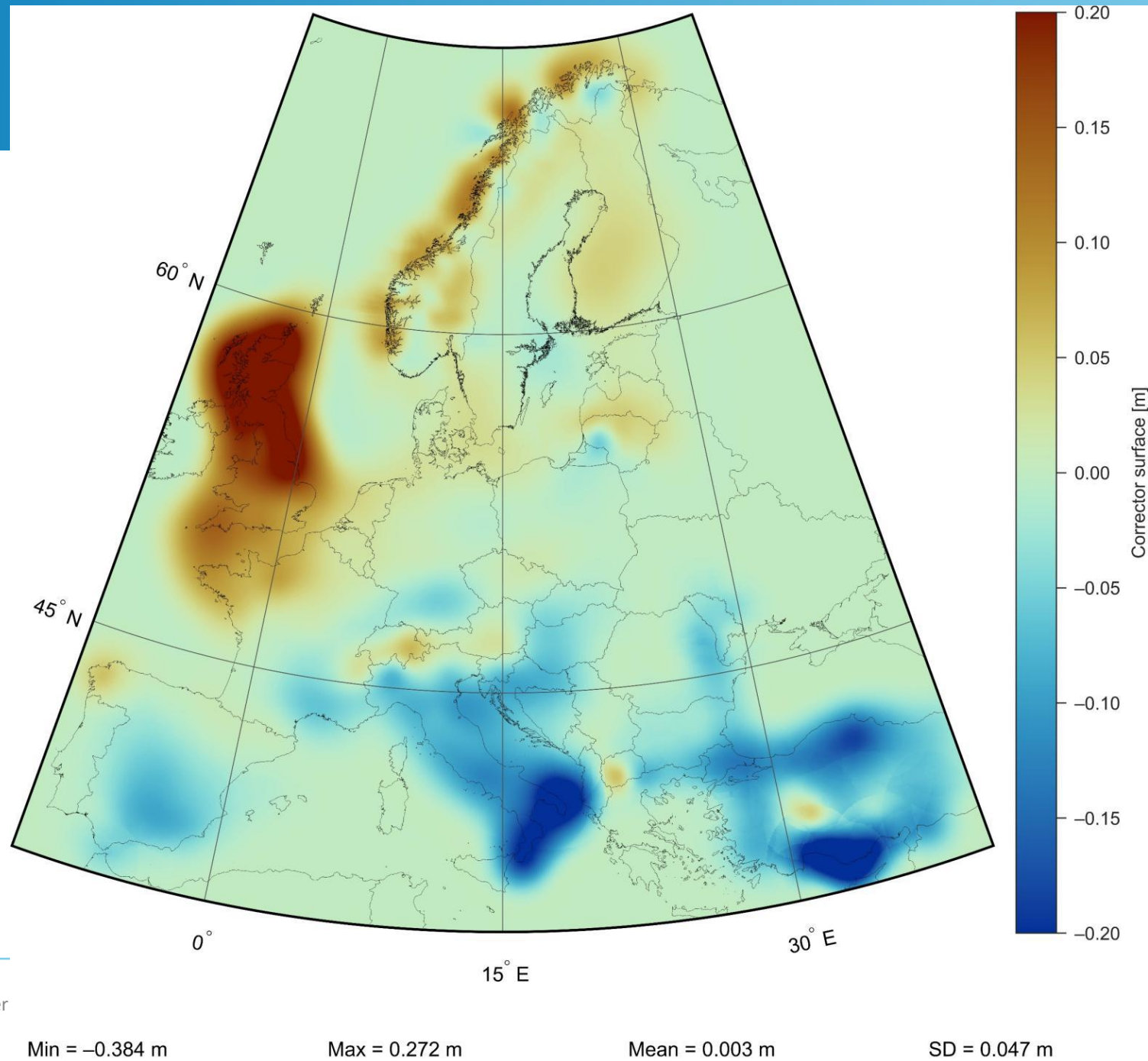
Based on:

**Preliminary GNSS/leveling dataset
(status 2024)**

EGG2015 quasigeoid model

**2nd-order Gauss Markov interpolation with
locally adapted covariance model**

Corrector surface ►



Test computations of corrector surface with EHRS_CP dataset

Contribution of S. Varbla (TalTech, now TUM)

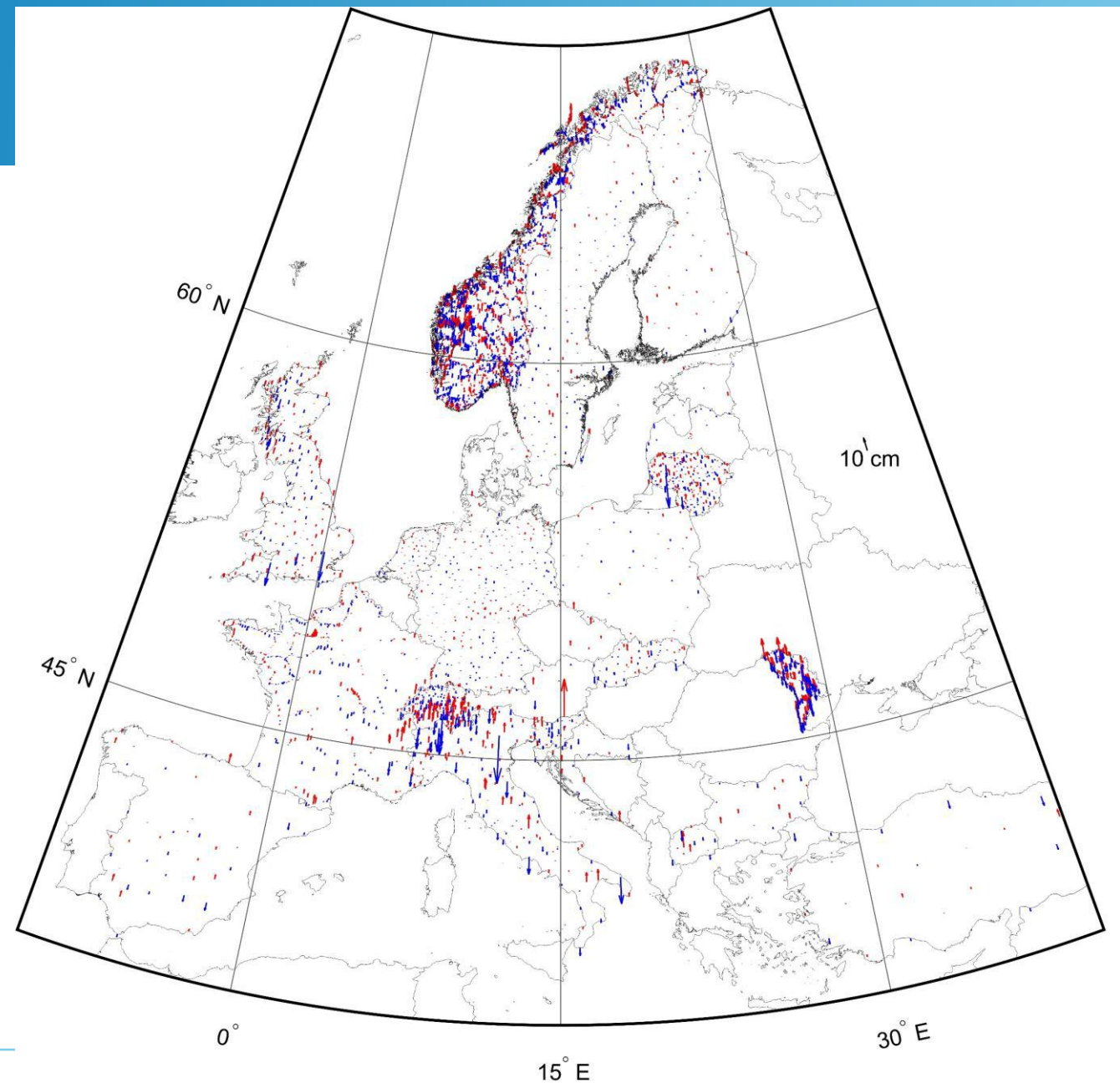
Based on:

**Preliminary GNSS/leveling dataset
(status 2024)**

EGG2015 quasigeoid model

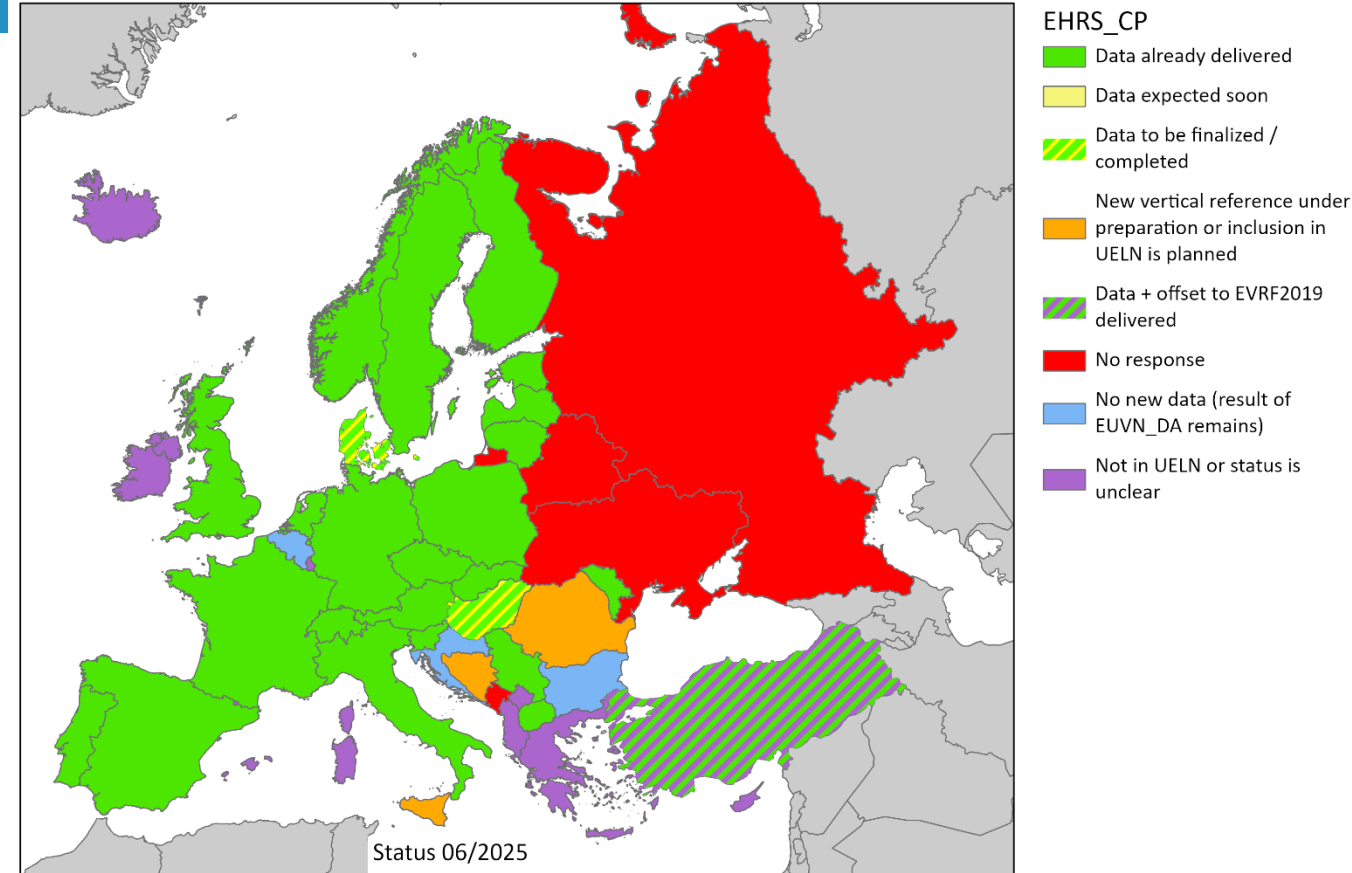
**2nd-order Gauss Markov interpolation with
locally adapted covariance model**

Residuals ►



Next steps

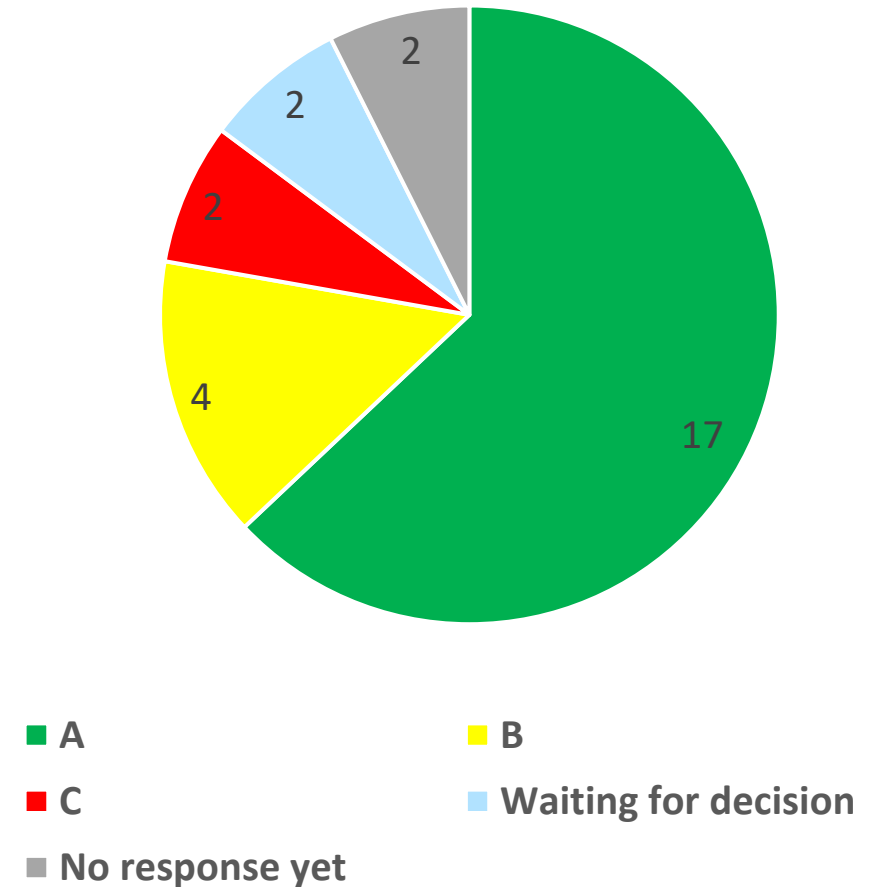
- Advancements in UELN/EVRF, but new EVRF version postponed
→ *see previous talk by M. Sacher*
- Preliminary GNSS/leveling dataset for most of Europe ready or to be finalized
- Progress regarding test computations of corrector surface with EGG2015 → *see prev. slide*
- **Goal: Publication of first EHRP „beta“ version until EUREF2026**
- **Publish GNSS/leveling points as well (with permission) for validation, research etc.**
 - **h_ETRF2020** (uplift epoch 2000.0 for NKG)
 - **H_EVRF2019** (zero-tide, mean-tide)



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- Application for approval to publish the data sent out to data providers
- 3 options regarding distribution and license
 - A. Make available on EVRS website with DOI as open data (CC-BY 4.0)
 - B. Make available by email after request to WG chair (yearly report of requests via EUREF Newsletter)
Terms of use: non-commercial use only, no further distribution, attribution
 - C. No publication
(possibly direct application to national point of contact)

Turnout
(as of 24 June 2026)



News from regional geoid initiatives

■ **European Alps Geoid project (since 2022)**

- Data pooling finished (dedicated gravity field campaigns finished or ongoing)
- Geoid test computations in Zugspitze region (DE/AT)
- Preliminary results validated with astrogeodetic measurements (accuracy 1-3 mm/km) → *IAG 2025*
- Airborne gravity dataset of Italy expected summer 2026
- Computation of pan-Alpine geoid model now scheduled for 2027

■ **Nordic Geodetic Commission (NKG) geoid**

- Computation of new version envisaged for 2026-2027
- Extension of model area under consideration (Iceland, Faroe Islands, ...)

■ **IAG Subcommittee 2.4a – Gravity and Geoid in Europe (~ European Gravimetric Geoid)**

- **See next presentation**

Summary and outlook

- Overview document of the national integrated geodetic reference (GNSS, heights, geoid) published on EVRS website → <https://doi.org/10.71603/NatRefEurope>
- First version of homogenized GNSS/leveling dataset (EHR_S_CP) to be finalized
- Refined test computations for geoid corrector surface ongoing
- First „beta“ version of EHR_S envisaged for 2026
 - ETRF2020 + land uplift epoch 2000 in Scandinavia | EVRF2019 (for the time being)
 - Including publication of GNSS/leveling dataset
- New regional gravimetric quasigeoid solutions envisaged for 2026/2027 (NKG, Alps, Germany, Italy, ...) as further cornerstones on the (long) way towards a new European Gravimetric Quasigeoid (EGG) and updates of the EHR_S



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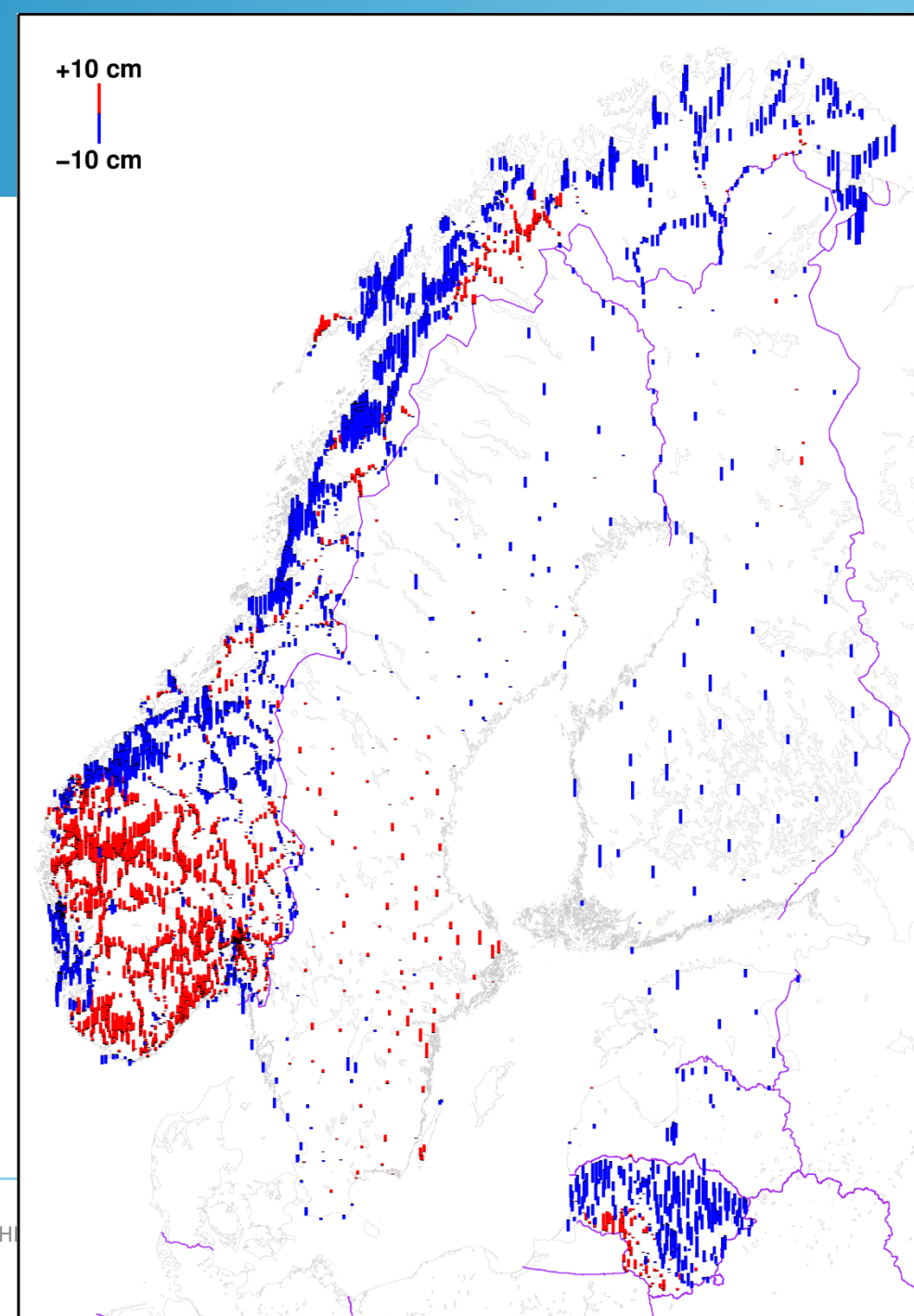
Thank you for your kind attention!

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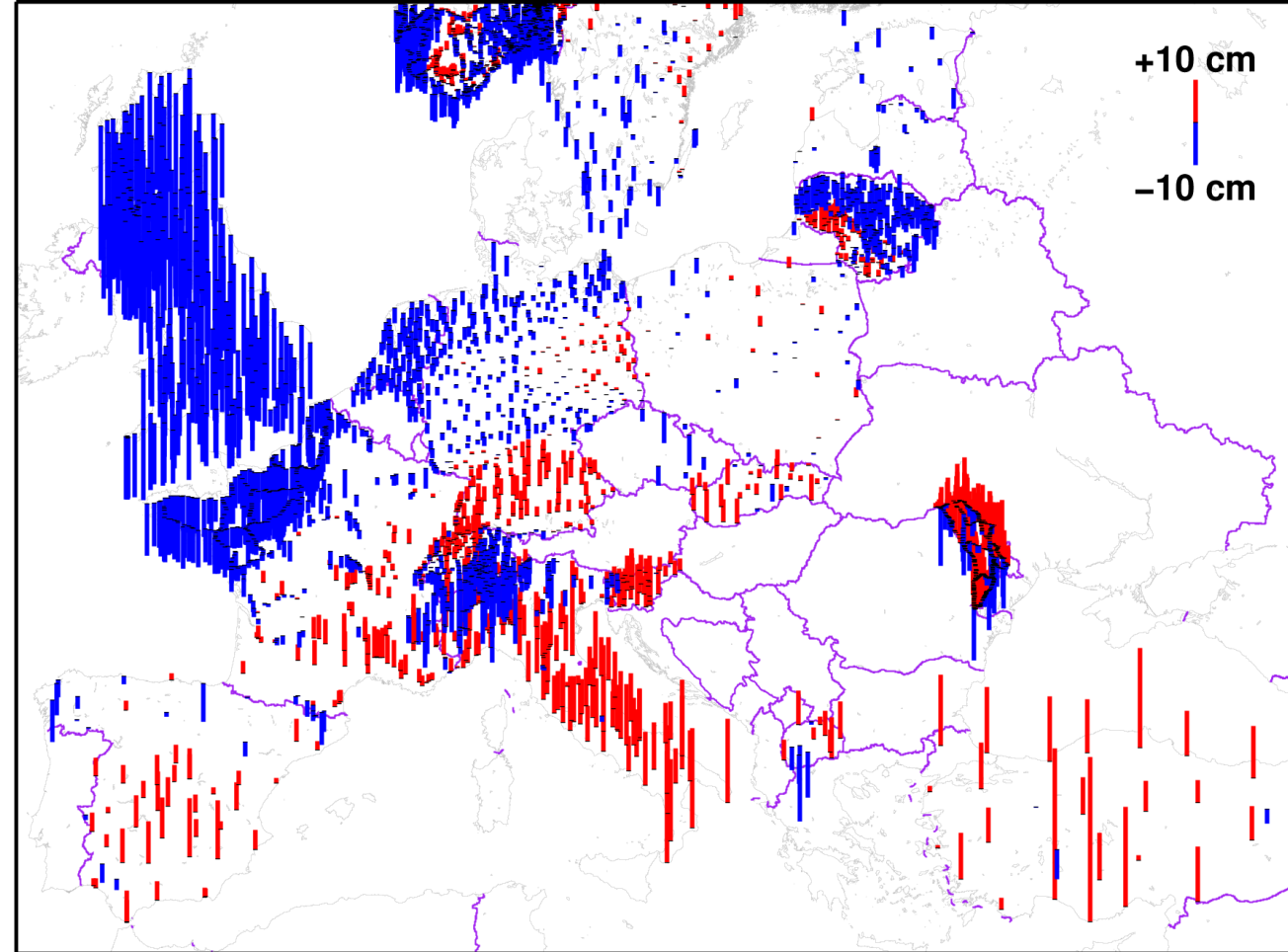
Comparison with NKG2015 (updated)

CC	#	#out	Mean	Med.	STD (mean)	Max. (mean)	STD (plane)	Max. (plane)
EE	11		-7.0	-6.7	1.5	3.8	1.3	2.9
FI	74		-6.9	-7.0	1.9	5.2	1.8	4.4
LT	241	4	-7.0	-7.4	3.2	9.1	2.3	6.4
LV	18		-7.3	-7.3	1.9	3.3	1.4	3.0
NO	3224		-5.0	-4.6	3.5	16.9	3.0	13.6
SE	185		-4.4	-4.3	1.9	4.9	1.8	5.2



Comparison with EGG2015 (updated)

CC	#	#out	Mean	Med.	STD (mean)	Max. (mean)	STD (plane)	Max. (plane)
CH	208	1	-2.4	-1.4	4.8	17.3	4.3	14.4
CZ	6		-4.3	-3.7	2.4	3.0	2.1	2.4
DE	359		-0.3	-0.8	2.2	6.4	1.5	4.7
ES	53		+2.7	+2.8	4.9	12.5	3.9	8.5
FR	463		-3.6	-4.4	4.5	17.1	2.8	15.4
GB	241	3	-19.5	-20.4	6.0	17.7	3.7	12.7
IT	148	2	+6.9	+7.1	6.7	20.8	5.0	18.7
MD	405		+3.3	+3.6	4.3	17.7	4.2	17.2
MK	13		+0.4	+2.8	8.3	18.2	7.2	15.2
NL	82		-3.6	-3.6	0.9	2.9	0.8	2.5
PL	38		-0.3	-0.4	1.5	3.4	1.5	2.9
SI	46	1	+3.8	+3.2	4.1	9.9	2.4	5.6
SK	29		+2.4	+2.0	2.7	6.5	2.2	5.9
TR	26		+10.8	+10.6	10.6	27.9	10.5	24.5



Comparison with NKG2015 / EGG2015 (updated)

CC	#	#out	Mean	Med.	STD (mean)	Max. (mean)	STD (plane)	Max. (plane)
EE	11		-2.4	-2.3	1.3	2.7	1.3	3.0
FI	74		-1.0	-1.0	2.1	6.3	1.8	5.3
LT	241	4	-3.5	-3.8	3.1	8.4	2.2	6.5
LV	18		-4.1	-3.6	1.7	3.2	1.3	2.6
NO	3224		-2.6	-1.9	4.0	24.4	3.7	21.7
SE	185		0.0	+0.2	2.2	7.2	2.2	7.1

EGG2015 (RTM without HC for quasigeoid)

CC	#	#out	Mean	Med.	STD (mean)	Max. (mean)	STD (plane)	Max. (plane)
EE	11		-7.0	-6.7	1.5	3.8	1.3	2.9
FI	74		-6.9	-7.0	1.9	5.2	1.8	4.4
LT	241	4	-7.0	-7.4	3.2	9.1	2.3	6.4
LV	18		-7.3	-7.3	1.9	3.3	1.4	3.0
NO	3224		-5.0	-4.6	3.5	16.9	3.0	13.6
SE	185		-4.4	+4.3	1.9	4.9	1.8	5.2

NKG2015 (KTH method with different approach)

Comparison with EGG2015 (updated)

CC	#	#out	Mean	Med.	STD (mean)	Max. (mean)	STD (plane)	Max. (plane)
EE	11		-2.4	-2.3	1.3	2.7	1.3	3.0
FI	74		-1.0	-1.0	2.1	6.3	1.8	5.3
LT	241	4	-3.5	-3.8	3.1	8.4	2.2	6.5
LV	18		-4.1	-3.6	1.7	3.2	1.3	2.6
NO	3224		-2.6	-1.9	4.0	24.4	3.7	21.7
SE	185		0.0	+0.2	2.2	7.2	2.2	7.1

