



Federal Agency for
Cartography and Geodesy



Status of the „FAMOS Finalization“ / BSCD2000 geoid

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with contributions by

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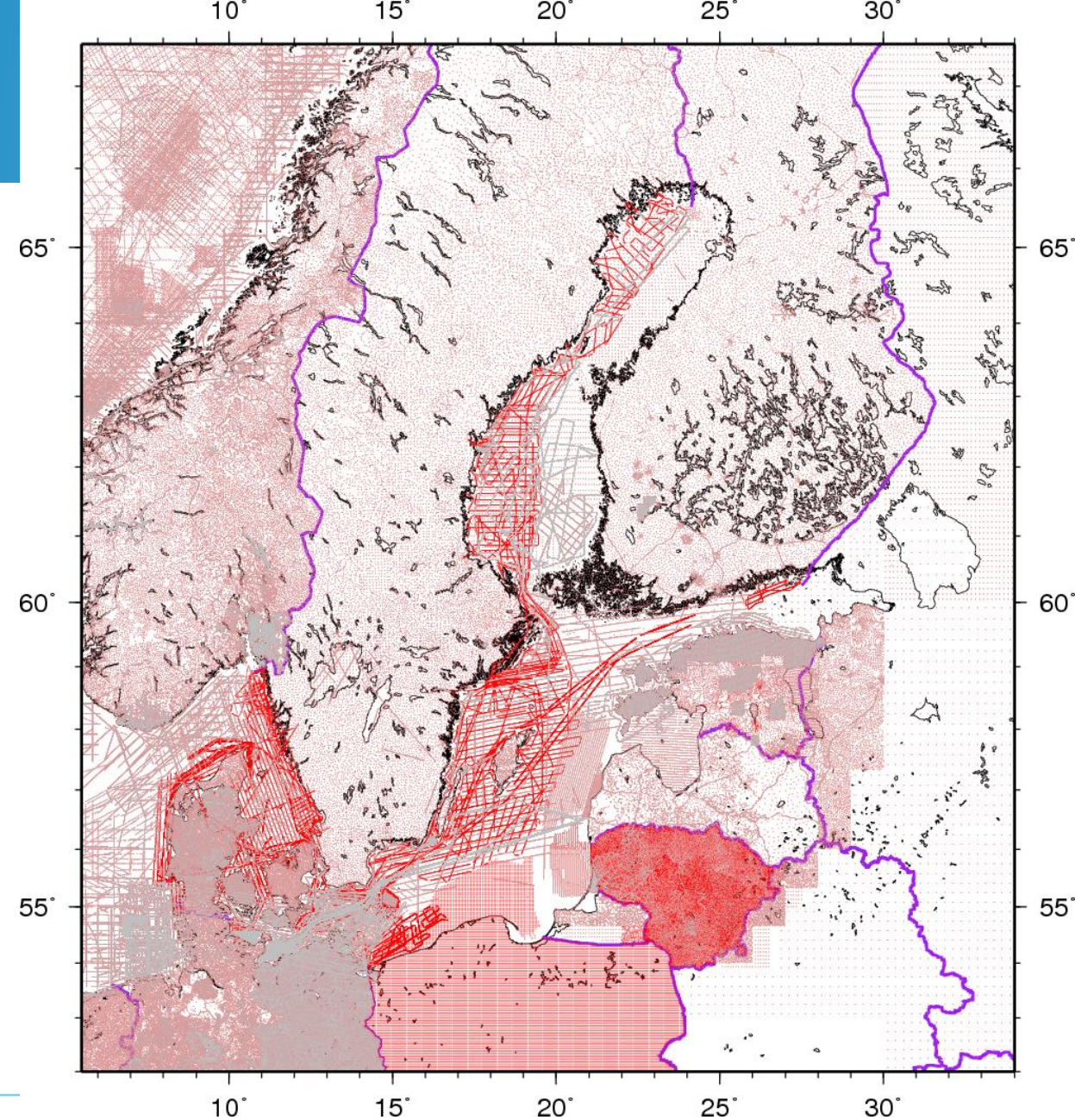
Review of CDWG12 regarding „FAMOS Finalization“

- Decision that CDWG should be responsible for the finalization of the FAMOS geoid model
 - Work plan
 - CDWG TOR (item 4) and List of actions
 - Notification of NKG
 - Draft of addendum to FAMOS license agreement (including opening clause to include also Poland)
- Addendum signed by all former FAMOS partners
- License papers signed by HOPN-GUT and IGiK (Poland)

- Report at NKG WGFHSG 15 Mar 2021
- GravDBv3 delivered 1 Jun 2021
- First round of geoid solutions received 31 Aug 2021
- Continued blending experiments to construct BSCD2000 geoid from interim gravimetric solutions, draft report (= proposal) just finished and ready to be distributed

FAMOS GravDB v3

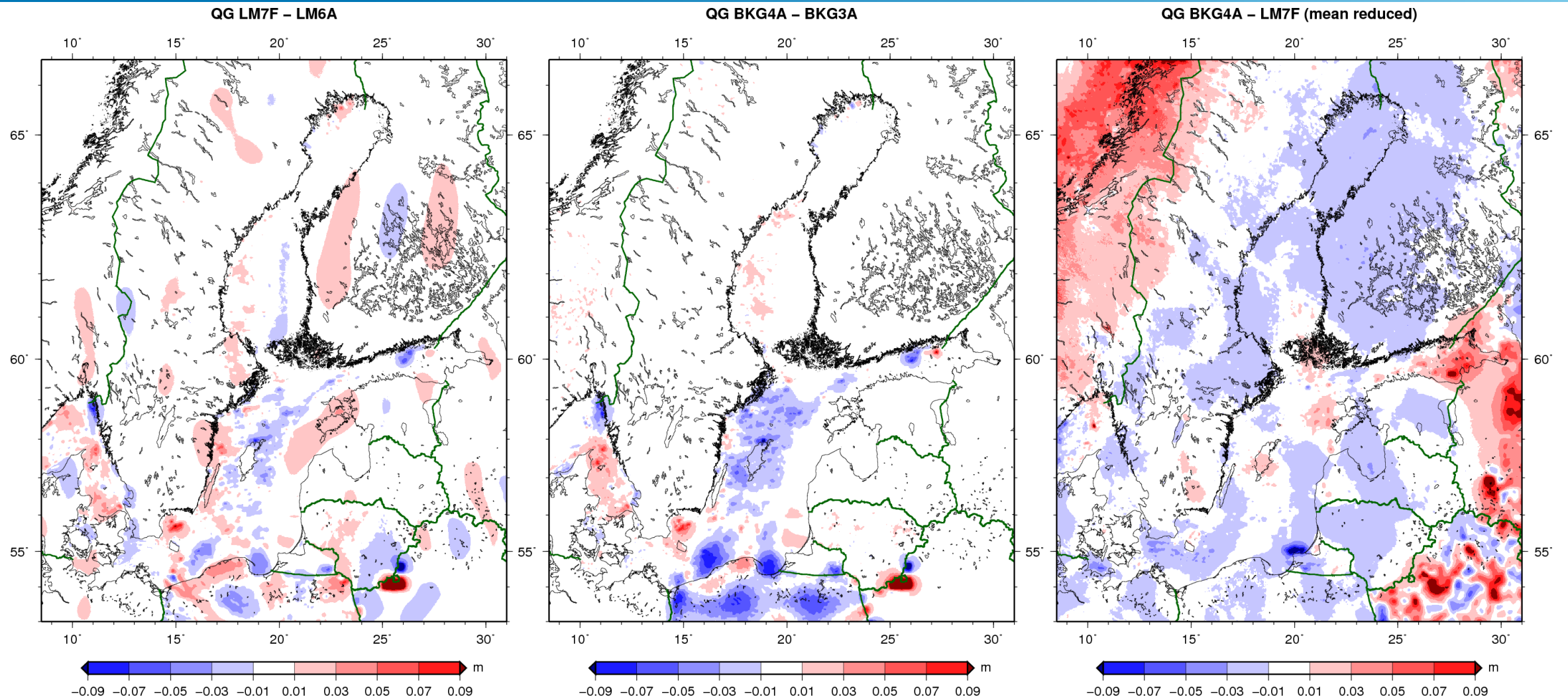
- Released 1 Jun 2021
- Includes
 - all shipborne FAMOS campaigns since autumn 2018
 - IGiK gravity grids for Poland (land and sea)
 - TU Gdansk shipborne data (2019)



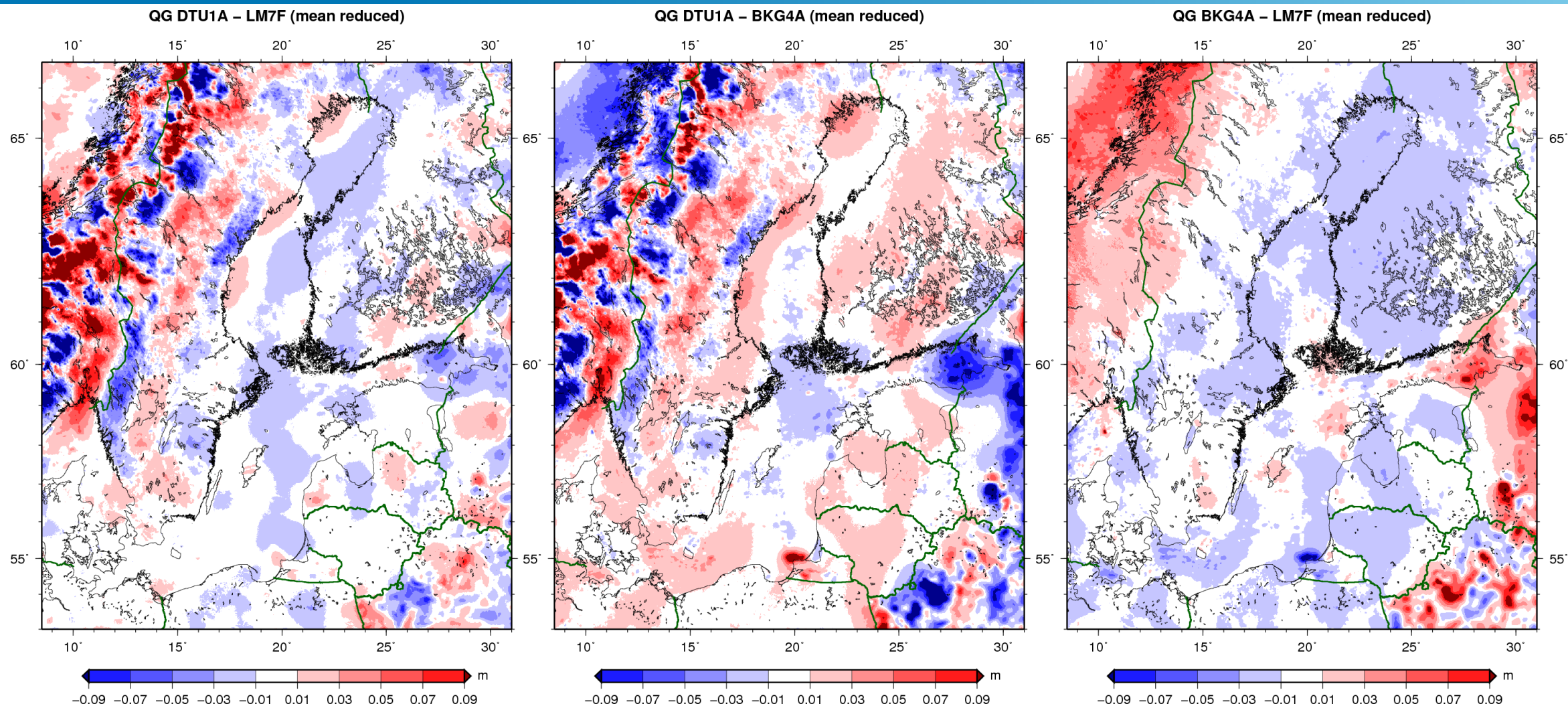
New GNSS/leveling data for LT, LV and PL → „DB v02“

- Lithuania
 - National quasigeoid model [LIT20G](#) based on new GNSS/leveling data (250 points, previously 546)
 - Kindly provided by Eimuntas Parseliunas (personal communication)
 - Drastically improved homogeneity (distribution, no more systematic effects, max-min 32 → 11 cm)
 - Even improves corrector surface residuals in Latvia
- Latvia
 - National quasigeoid model [LV'14](#) based on new [control points](#) (84 points, previously 54)
 - Also very consistent with new LT dataset (max-min 17 → 10 cm)
- Poland
 - [ASG-EUPOS dataset](#) freely available
- More details in draft report about blending experiments (Appendix A)
- Proposal: Use these data for combined FAMOS quasigeoid models and for validation
 - Formally not uplift epoch 2000.0 like NKG dataset, but no practical implications

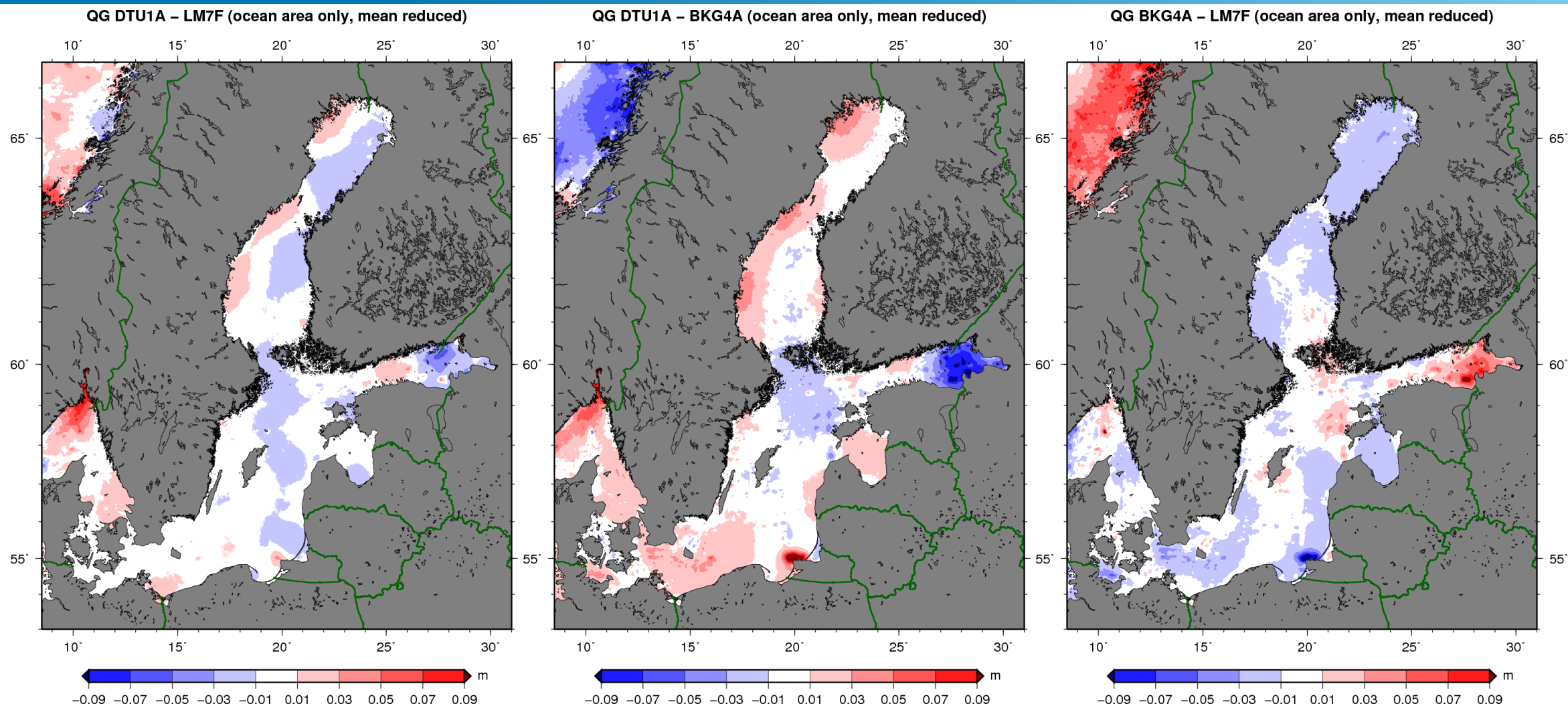
New interim gravimetric quasigeoid solutions (with GravDB v3)



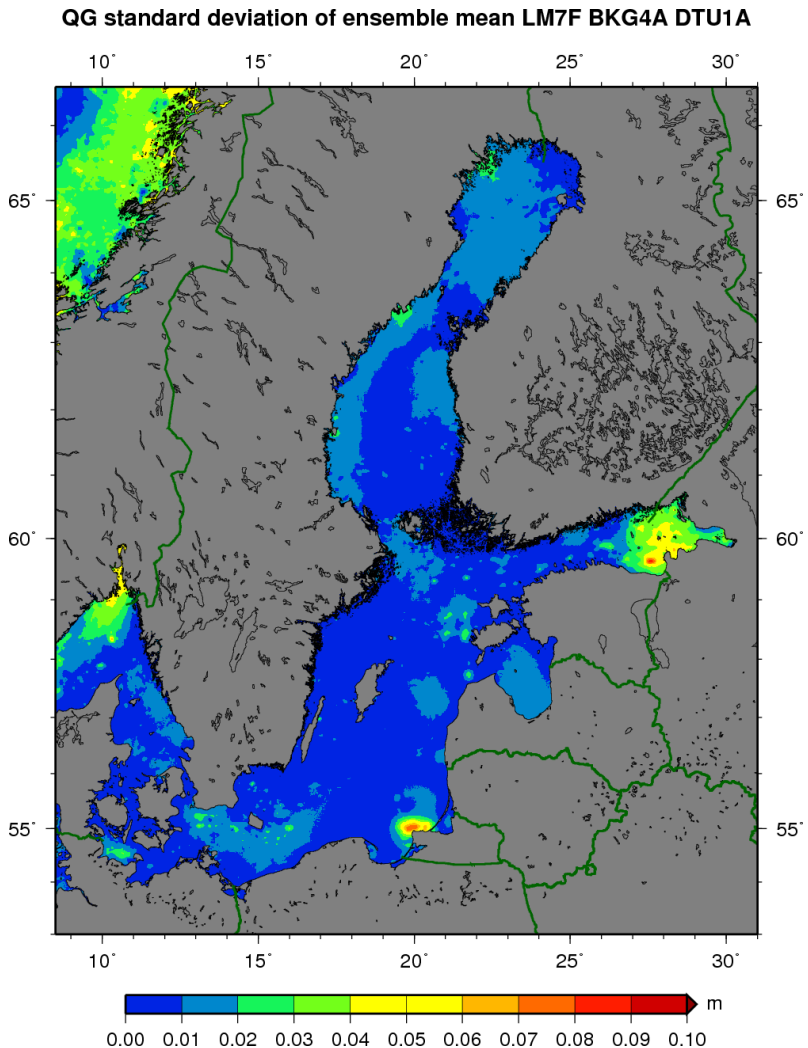
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New interim gravimetric quasigeoid solutions (with GravDB v3)



■ Model differences over ocean (m) **mean reduced*

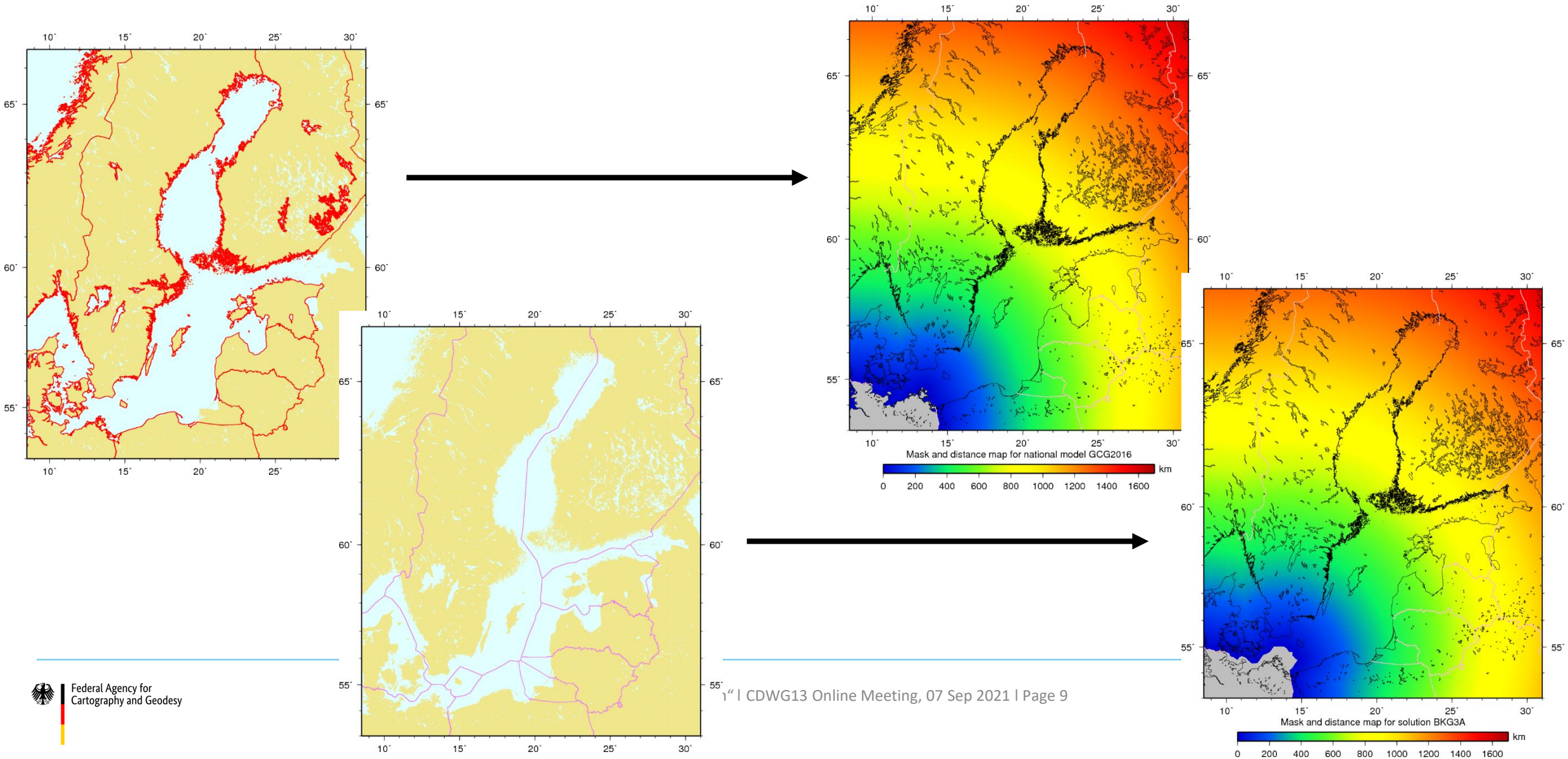
Models	Mean	Median	SD	Min.	Max.
LM7F – LM6A	+0.001	+0.002	0.008	–0.090	+0.095
BKG4A – BKG3A	–0.003	0.000	0.005	–0.123	+0.104
BKG4A – LM7F	0.000*	–0.006	0.013	–0.121	+0.167
DTU1A – LM7F	0.000*	–0.001	0.012	–0.308	+0.183
DTU1A – BKG4A	0.000*	+0.004	0.017	–0.348	+0.144

■ GNSS/leveling residuals (ITRF08, m) *except NO *mean per country reduced*

Models	Mean	Median	SD	Min.	Max.
LM6A (old)	0.000*	+0.002	0.020	–0.078	+0.066
BKG3A (old)	0.000*	+0.001	0.018	–0.073	+0.062
TUT1A (old)	0.000*	–0.002	0.020	–0.104	+0.073
LM7F	0.000*	0.000	0.019	–0.066	+0.061
BKG4A	0.000*	0.000	0.017	–0.069	+0.079
DTU1A	0.000*	+0.001	0.020	–0.102	+0.099

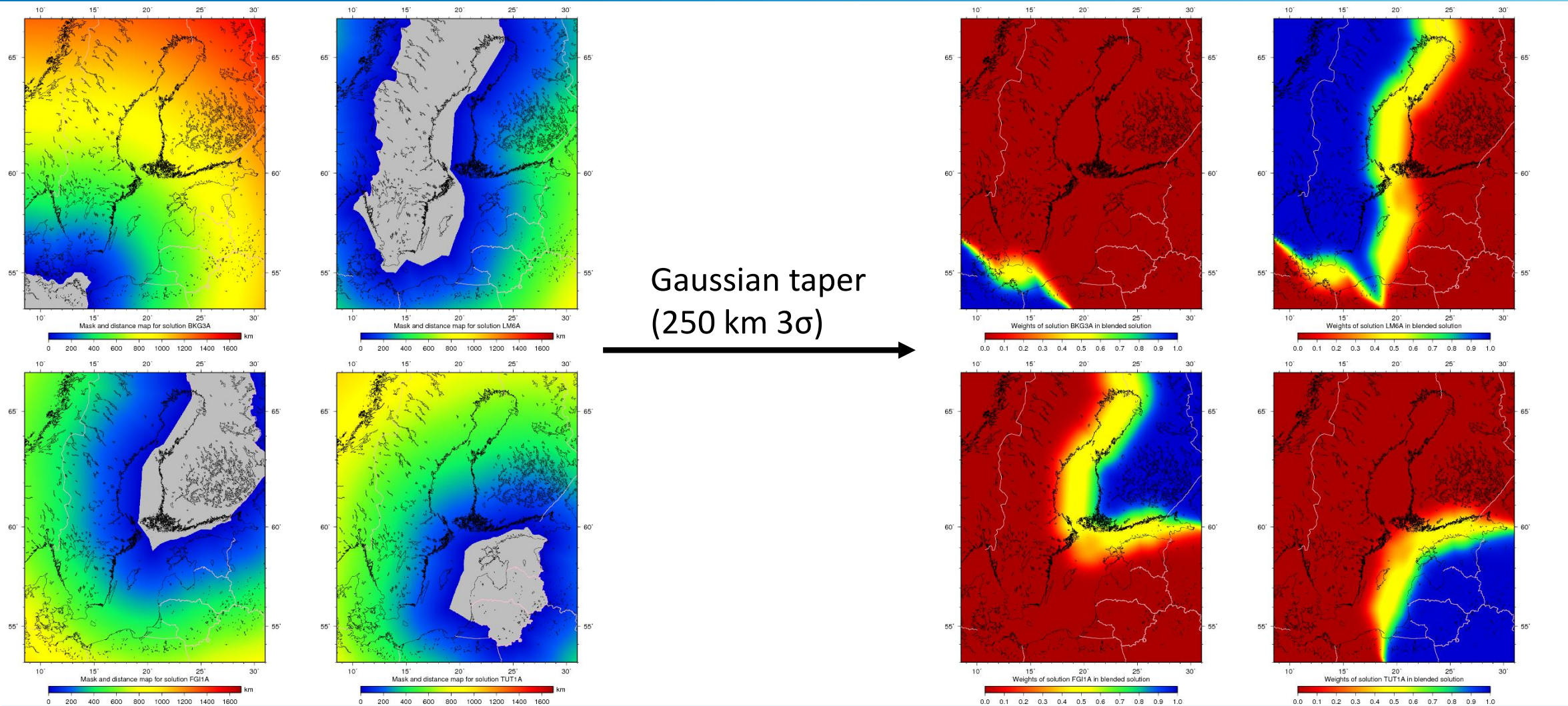
Blending experiments based on 1st-gen geoid solutions (= GravDB v2)

► Coastlines and boundaries → mask grids and distance maps



Blending experiments based on 1st-gen geoid solutions (= GravDB v2)

► Blending of FAMOS solutions (after corrector surface): 1 model → 1 influence zone



Blending experiments based on 1st-gen geoid solutions (= GravDB v2)

► Draft report (proposal) for construction of BSCD2000 grid

Proposal to construct the FAMOS/BSCD2000 geoid by blending various gravimetric geoid solutions based on location-dependent weighting

Joachim Schwabe (Federal Agency for Cartography and Geodesy, BKG)

September 6, 2021

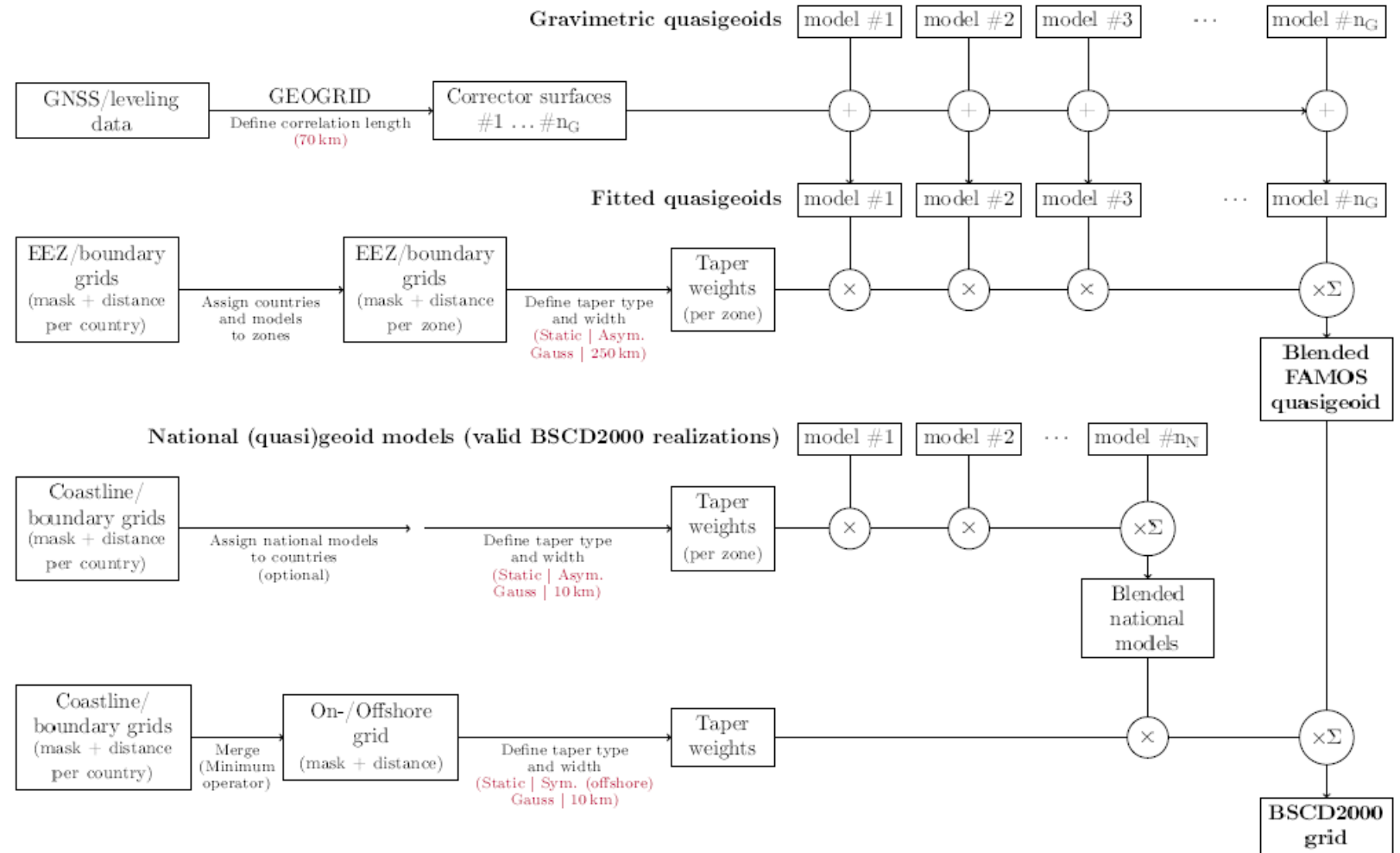
1 Introduction

This work is related to the project FAMOS (“Finalizing Surveys for the Baltic Motorways of the Sea”; <http://www.famosproject.eu>); co-funded by the European Commission between 2015 and 2018 under the TEN-T program “Motorways of the Sea” and the upcoming unified chart datum for the Baltic Sea, BSCD2000 (Baltic Sea Chart Datum 2000, Schwabe et al. (2020)). One major work package within the FAMOS project was the computation of an improved quasigeoid model which is supposed to be adopted as the official height reference surface for the BSCD2000 by 2023. The activities are supervised by the Chart Datum Working Group (CDWG; <http://www.bshc.pro/working-groups/cdwg/>) of the Baltic Sea Hydrographic Commission (BSHC; <http://www.bshc.pro>).

During the funding period, several so-called *interim gravimetric quasigeoid models* have been computed by various computation centers based on the available gravity data. Unfortunately, the third phase of the FAMOS project initially planned for 2019/2020 could not be funded, one reason being the delayed call for the TEN-T programme due to political circumstances at that time. At the 13th CDWG meeting on March 2nd, 2020, an agreement was drafted and subsequently signed by the former FAMOS partners to extend the licensing period of the necessary data (gravity data, GNSS/leveling data and digital elevation model) for a “FAMOS finalization” action. On this basis, the former FAMOS computation centers have agreed to finalize the geoid computations without funding on a voluntary basis. The author was designated as the leader of the activities and was delegated to the CDWG as an observer.

In fact, from the geodesists point of view, BSCD2000 is just a special realization of the European geodetic height reference system EVRS (normal heights in the mean sea level of the Normaal Amsterdam Peil) with some specifications regarding the epoch of the Fennoscandian land uplift model. By now, the geodetic authorities of all Baltic states (except Russia) have established or are in the process of establishing their height reference compatible with EVRS. Therefore, according to the BSCD2000 specifications (Agren et al. 2019), the national height reference frame realizations and associated national (quasi)geoid models are valid realizations of BSCD2000 and are already now being used in the transition phase to implement BSCD2000 in updated national nautical charts (e.g., BSCD2000^{BHNS2016} for Germany).

It is therefore common sense that, in order to ensure interoperability, the final BSCD2000 height reference grid should provide a smooth transition to the geodetic infrastructure along the coast and on land. There, the BSCD2000 grid should reproduce the national geoid models as far as possible, i.e., apart from resampling effects and minor deviations in transition zones along the land borders. In particular, mariners will expect no differences between the models in the ports. This implies the task to construct the final BSCD2000 grid by blending the best FAMOS geoid (in the marine areas) with the official national (quasi)geoid models on land. This document is intended to demonstrate a pragmatic blending approach based on location-dependent weighting, i.e., distance grids for coastlines and national land and sea boundaries. Furthermore, a proposal is made in



Final steps towards BSCD2000 grid

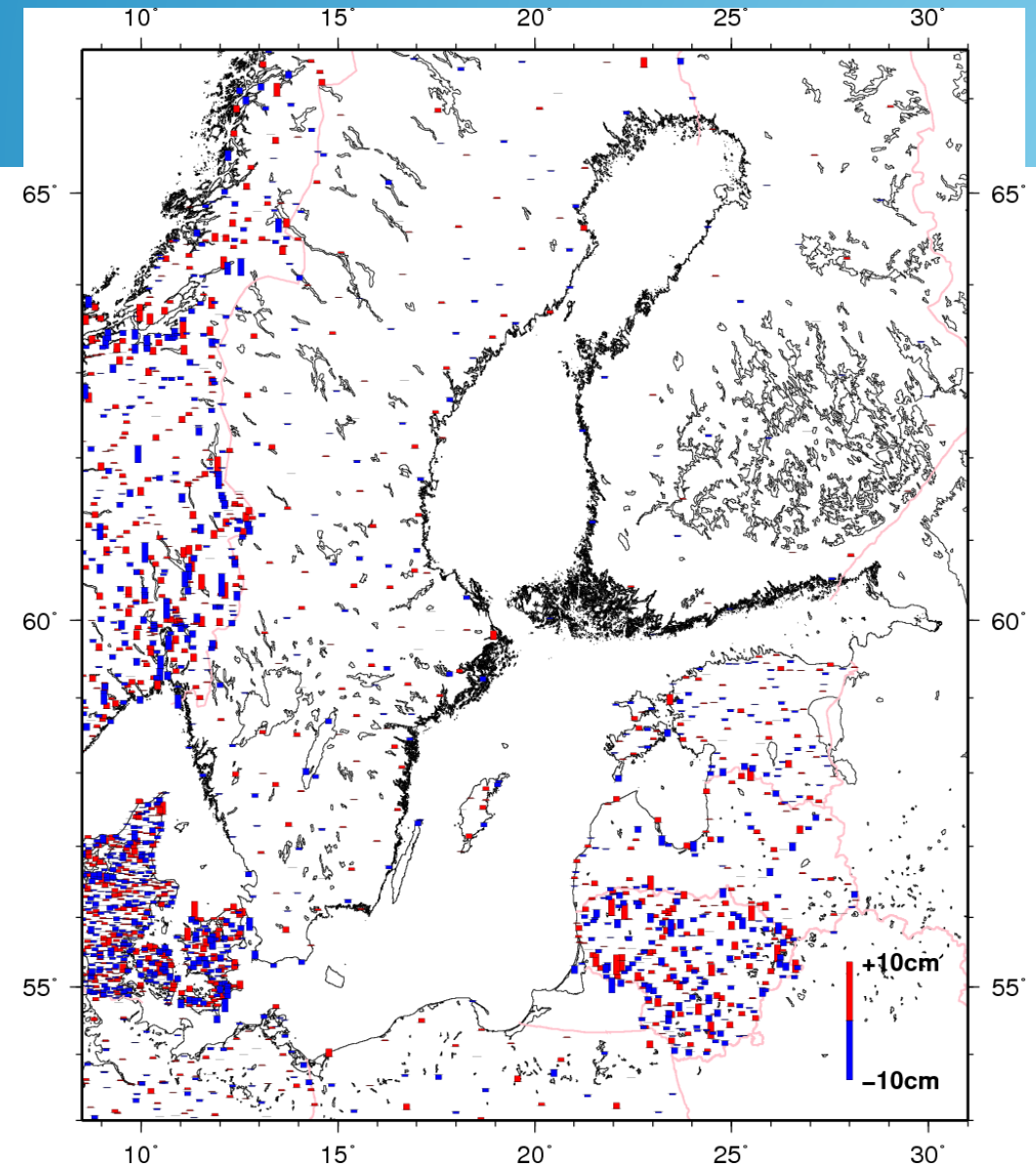
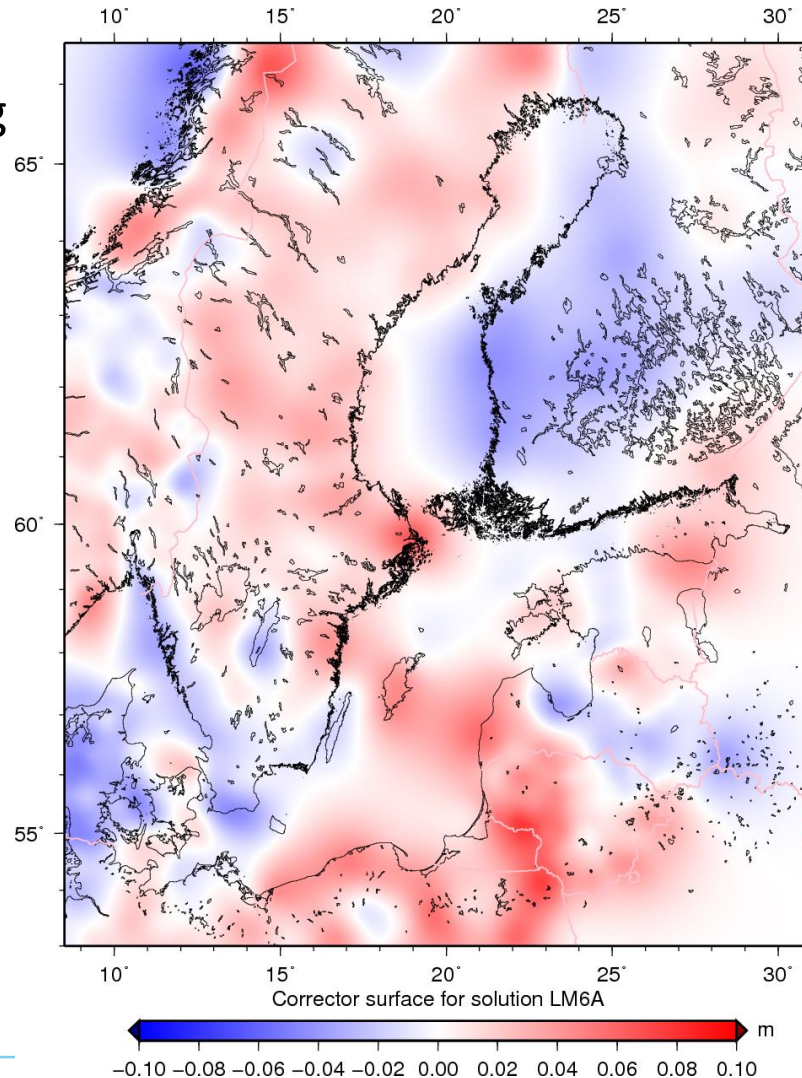
- Complete and refine 2nd-gen interim geoid models with GravDB v3
- Discuss and finalize draft „recipe“ for construction of BSCD2000 grid
- **Final update/add-on of databases**
 - Potential last-minute marine data (PL HOPN/TU Gdansk, LT?)?
 - Ditto for GNSS/leveling data (Sweden, Finland)
 - Proposed deadline to submit data: **17 Dec 2021**
- **Final iterations of gravimetric quasigeoid solutions**
 - Proposed deadline to submit grids: **28 Feb 2022**
- Construction of **BSCD2000 release candidate** according to „recipe“ until CDWG14 (Apr 2022?)
- **Decision** on BSCD2000 grid at CDWG14
- Wrap-up work and implementation (documentation, reports, notification of users, PR)
- Explore opportunities for funding to continue/join work on BSCD2000 geoid
 - e.g. EU [Interreg Baltic Sea 2021-2027](#), Info event 28 Sep 2021

Back-up slides

Corrector surfaces to gravimetric quasigeoids

This example: LM6A

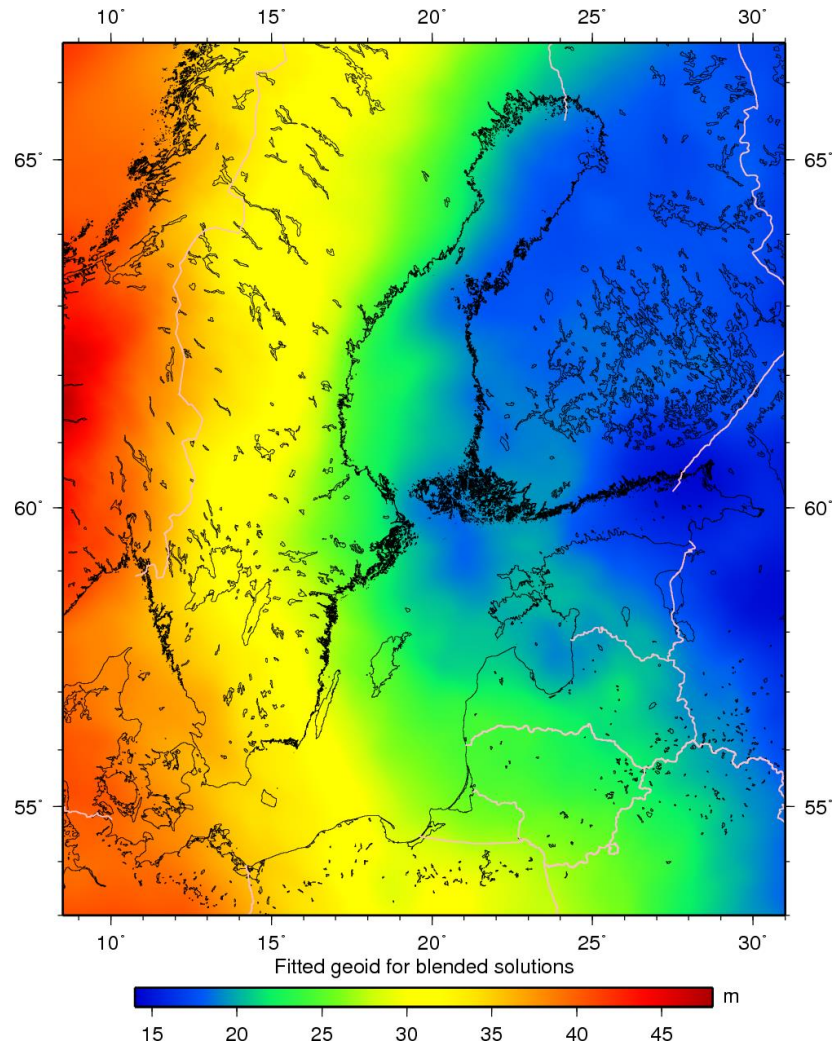
- Computed using FAMOS GNSS/leveling DB „List C“ (national realizations)
- GRAVSOFT GEOGRID
- Simple collocation mode, correlation length 70 km
- a-priori SD 1 cm



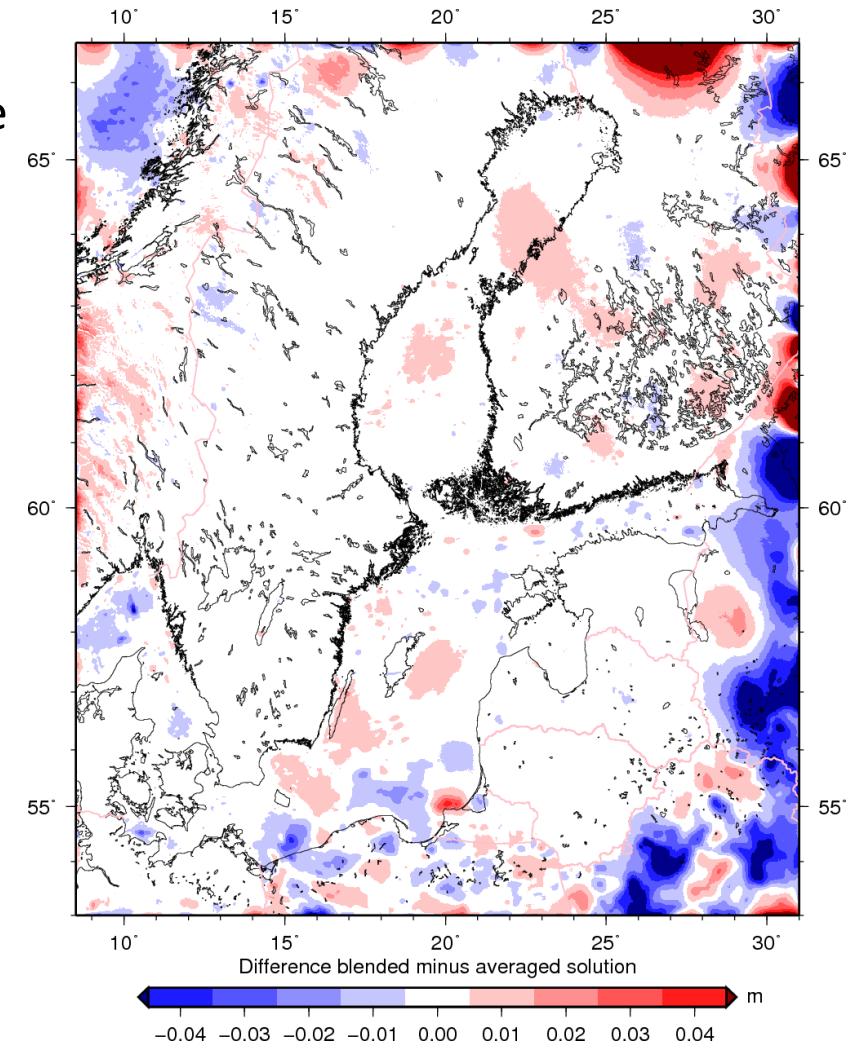
Blending experiments based on 1st-gen geoid solutions (= GravDB v2)

► „FAMOS geoid“

- Blended „FAMOS geoid“

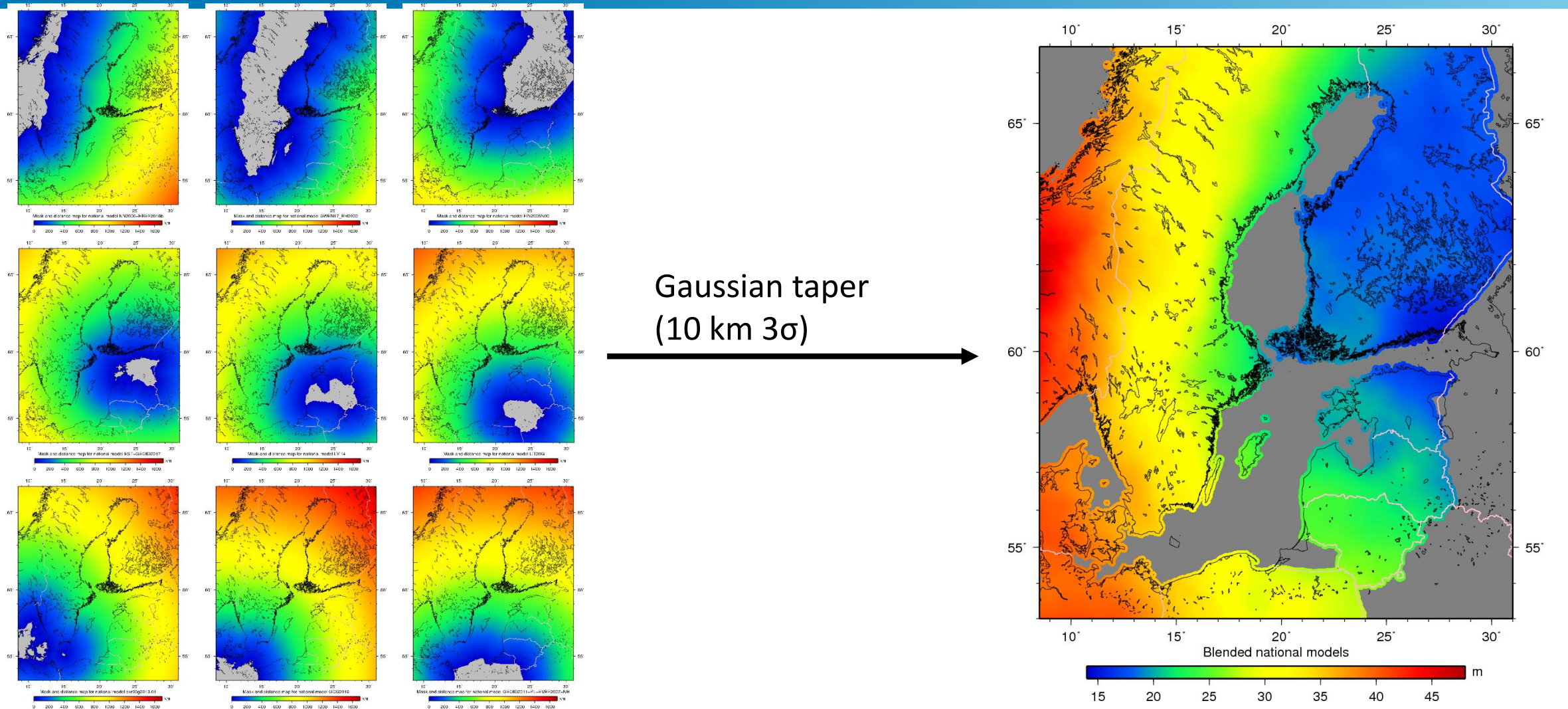


- Difference against simple average



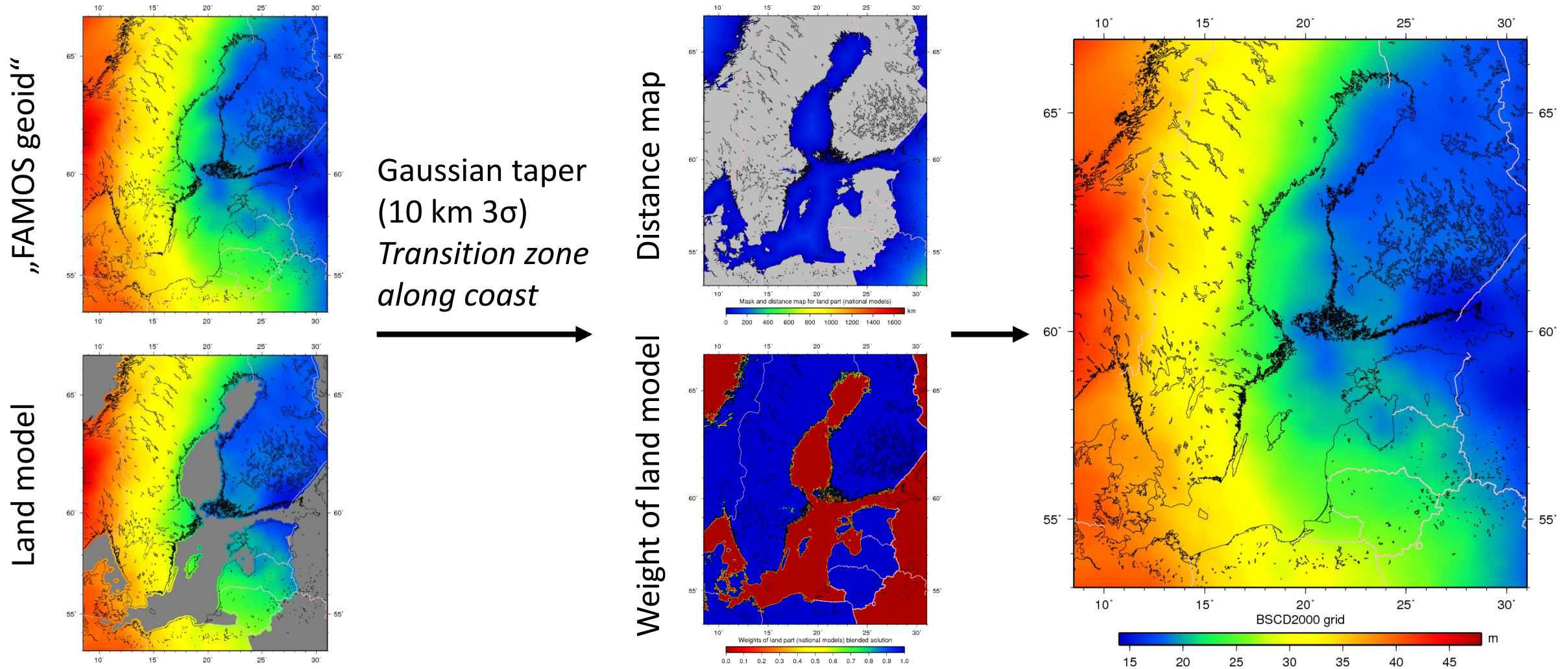
Blending experiments based on 1st-gen geoid solutions (= GravDB v2)

► Intermediate land model: First merge national quasigeoid models on land



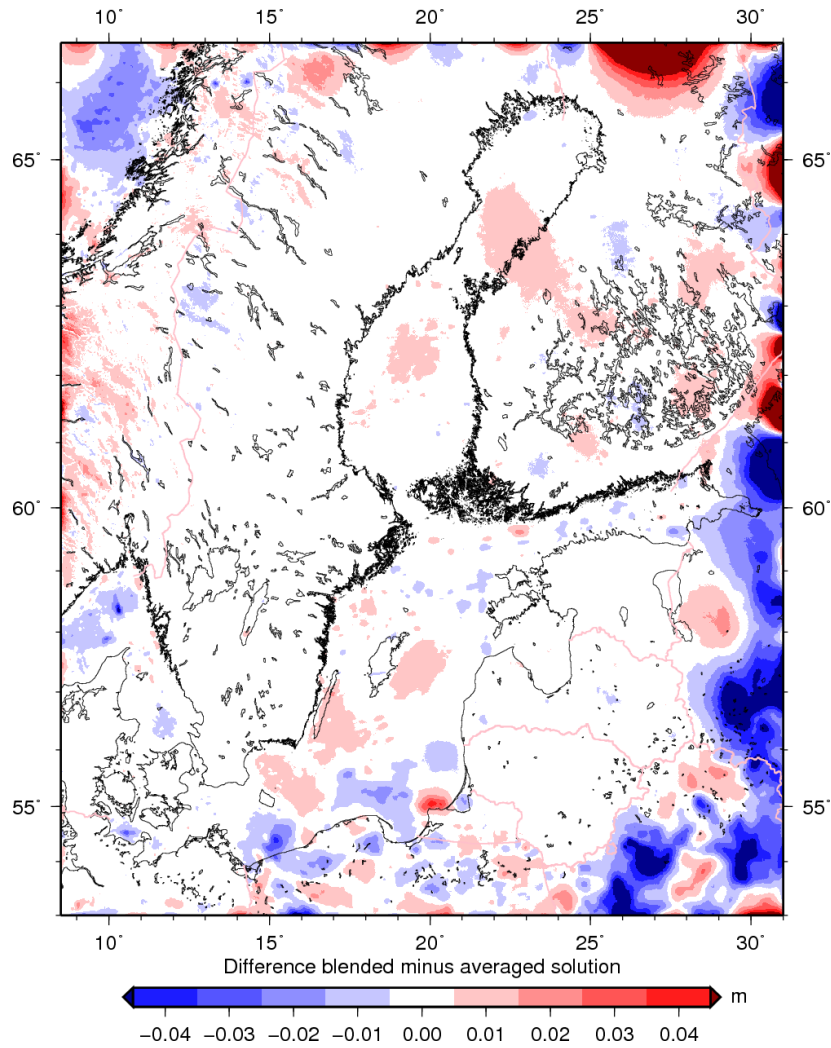
Blending experiments based on 1st-gen geoid solutions (= GravDB v2)

- BSCD2000-like grid („FAMOS geoid“ at sea, nat. models on land)

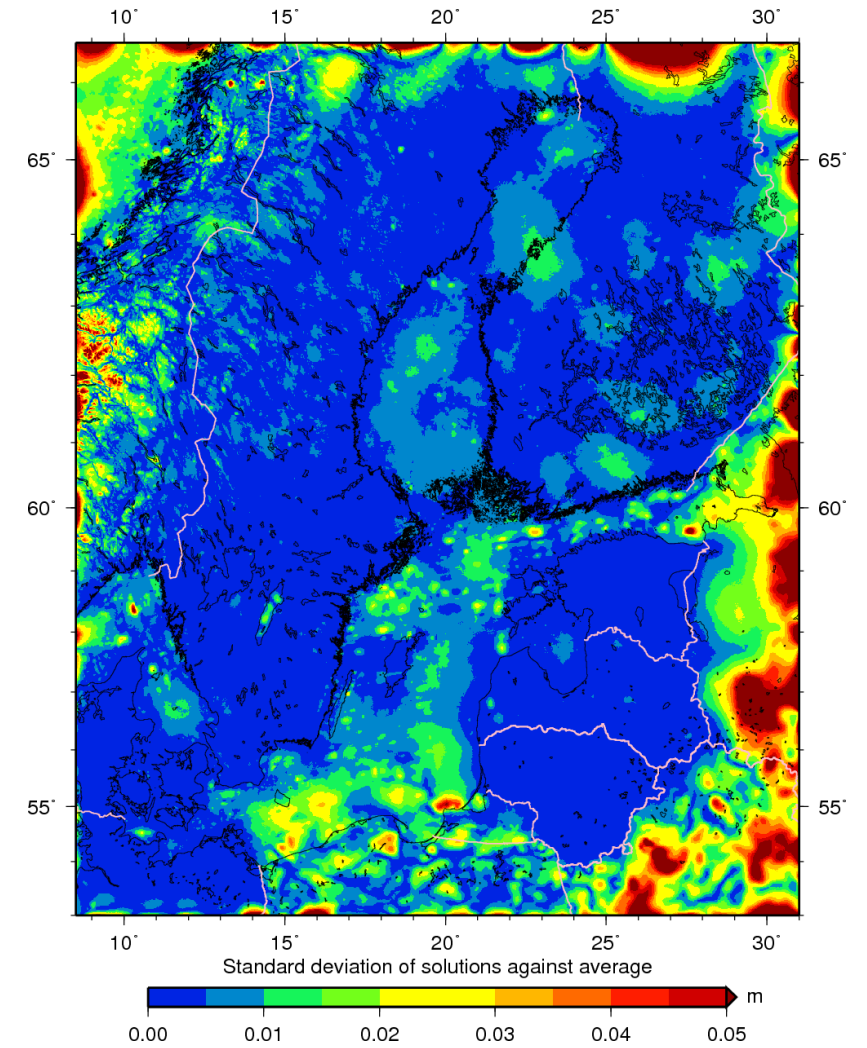


Blending experiments based on 1st-gen geoid solutions (= GravDB v2)

- Difference blend minus average

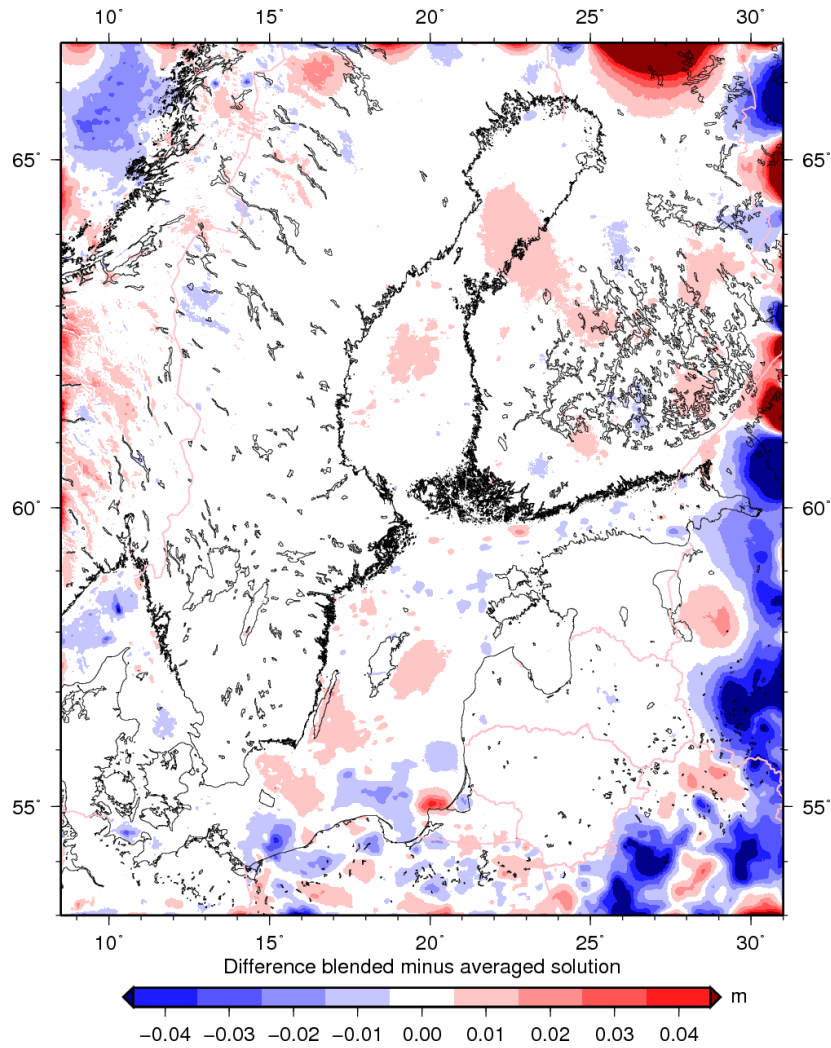


- st.dev. of combined solutions

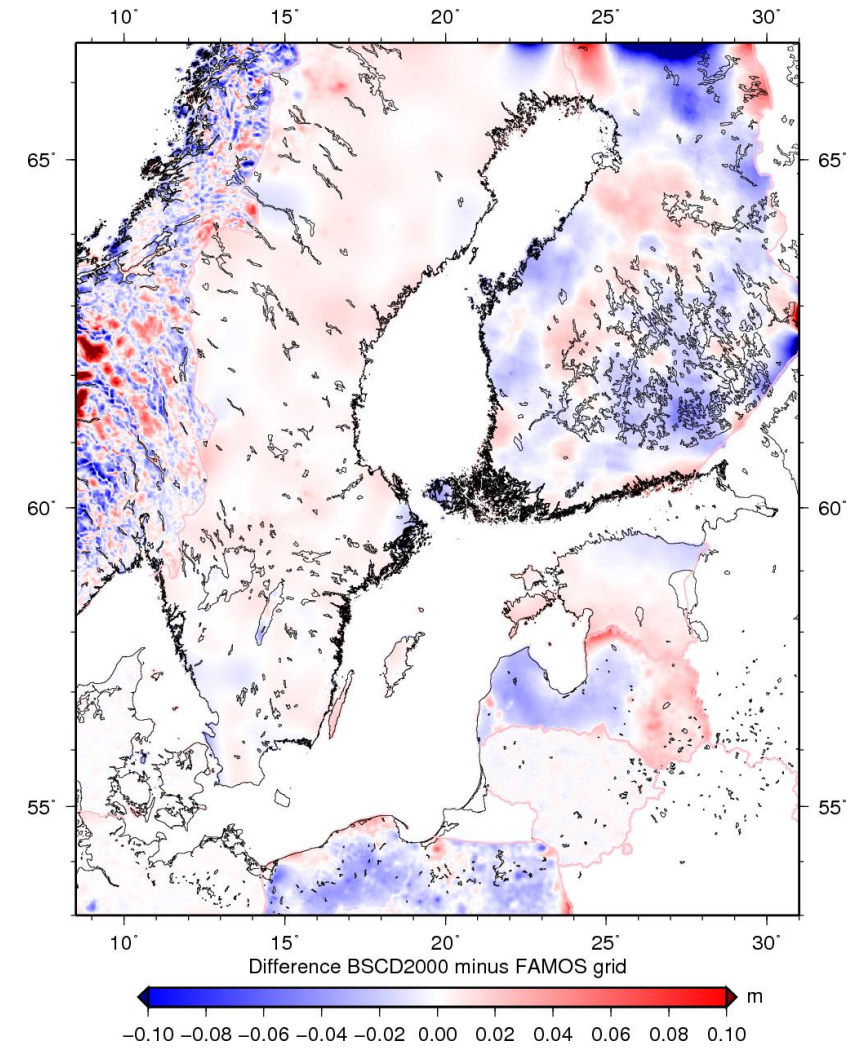


Blending experiments based on 1st-gen geoid solutions (= GravDB v2)

- Difference blend minus average



- Impact of additional blend of national models



Blending experiments based on 1st-gen geoid solutions (= GravDB v2)

- Differences of BSCD2000 minus national quasigeoid models in transition zones on land
(Note that Bornholm was excluded from the Danish model due to the local height datum)

Country		Model	Type	Difference BSCD2000–national			
				mean	SD	Min.	Max.
DK	Denmark	dvr90g2013.01	Geoid	0.002	0.0026	−0.007	0.009
DE	Germany	GCG2016	Quasigeoid	−0.002	0.0027	−0.011	0.007
PL	Poland	geoid2011-PL-EVRF2007-NH	Quasigeoid	0.002	0.0031	−0.008	0.017
NO	Norway	NN2000-HREF2018b	Quasigeoid	0.002	0.0074	−0.047	0.053
SW	Sweden	SWEN17_RH2000	Quasigeoid	−0.002	0.0067	−0.047	0.042
FI	Finland	FIN2005N00	Quasigeoid	0.002	0.0020	−0.001	0.009
EE	Estonia	EST-GEOID2017	Quasigeoid	0.009	0.0131	−0.008	0.053
LV	Latvia	LV'14	Quasigeoid	−0.001	0.0087	−0.051	0.023
LT	Lithuania	LIT20G	Quasigeoid	−0.001	0.0043	−0.020	0.018

According gravity anomaly grids (with GravDB v3)

