Interreg
Baltic Sea Region

Co-funded by
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BLUE ECONOMY
BalMarGrav

BalMarGrav
MODERNIZED GRAVITY MAPS OF THE BALTIC SEA

Homogenized marine gravity maps of the southern and eastern Baltic Sea - results and pilot activity of the BalMarGrav project

Webinar | 09.09.2024

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https://interreg-baltic.eu/project/balmargrav

Homogenized marine gravity maps of southern and eastern Baltic Sea for modern 3D applications in marine geodesy, geology and navigation (BalMarGrav)

Small project of the Interreg Baltic Sea Region Programme 2021/27

Programme priority: 2. Water-smart societies

Programme objective: 2.2 Blue economy

Period of realization:

June 2022 - December 2024

Project value: 500 k€

EU funding: 400 k€

BalMarGrav Partners:

IGiK

Federal Agency for Cartography and Geodesy

NLS FINNISH GEOSPATIAL RESEARCH INSTITUTE FGI

TAL TECH

VILNIUS TECH
Vilnius Gediminas Technical University

LANTMÄTERIET

GDAŃSK UNIVERSITY OF TECHNOLOGY

PAŃSTWOWY INSTYTUT GEOLOGICZNY
MENTE ET MALLEO
1919
PAŃSTWOWY INSTYTUT BADAWCZY

1862
RIGA TECHNICAL UNIVERSITY

MARITIME UNIVERSITY OF SZCZECIN
MUS
POLAND

DTU

BalMarGrav Associated organisation:

REPUBLIC OF ESTONIA
LAND BOARD

Kartverket

Agency for Data Supply and Infrastructure

NLS
NATIONAL LAND SERVICE

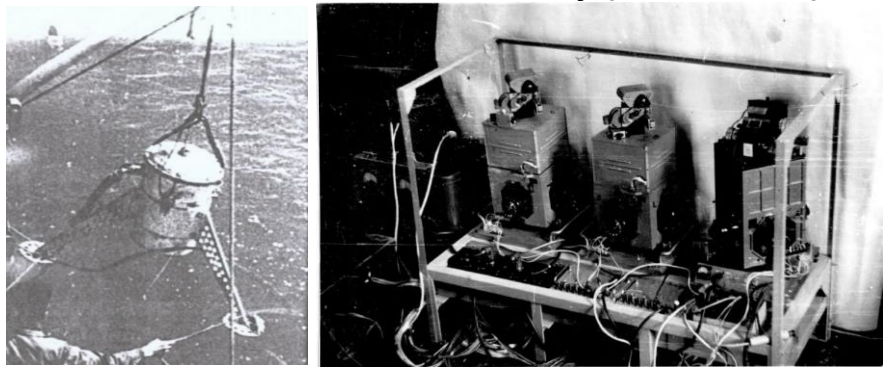
LATVIJAS ĢEOTELPISKĀS INFORMĀCIJAS AĢENTŪRA

LATVIJAS JŪRAS ADMINISTRĀCIJA
MARITIME ADMINISTRATION OF LATVIA

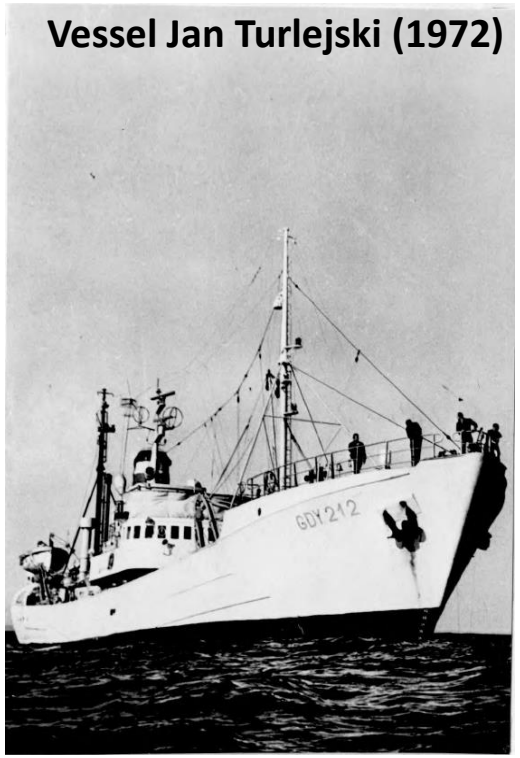
BalMarGrav CHALLENGES

Improving the problem of insufficient mapping of the marine gravity field in the east and south Baltic Sea by revitalization of the historical marine gravity data

Gravimeters for marine survey (1967, 1972)



Gravimeters for marine and terrestrial survey (2023)



BalMarGrav OBJECTIVES

Increasing the potential of sectoral agencies, Baltic Sea Hydrographic Commission and scientific community

Analyzed historical marine gravity data recalculated to current reference systems (data source # refer to numbering in the NKG/FAMOS/BalMarGrav gravity DB)

1. Marine gravimetric measurements in Danish waters, 1970 (SDFI, Denmark, #42)

2. Gravimetric campaign - bottom measurements, 1966-1968 (BKG, Germany, #383)

3. Gravimetry in shallow waters, 1969-1973 (BKG, Germany, #381)

4. Gravimetric campaign vessel Zaria in 1970-1972 (IGiK, Poland, #319)

5. Gravimetric campaign vessel Jan Turlejski in 1972 (**IGiK, Poland, #995**)

6. Petrobaltic campaign - bottom measurements, 1978-1979 (**PGI-NRI, Poland, #996**)

7. Campaign along the coast Ustka-Rozewie - bottom measurements, 1976-1981 (**PGI-NRI, Poland, #997**)

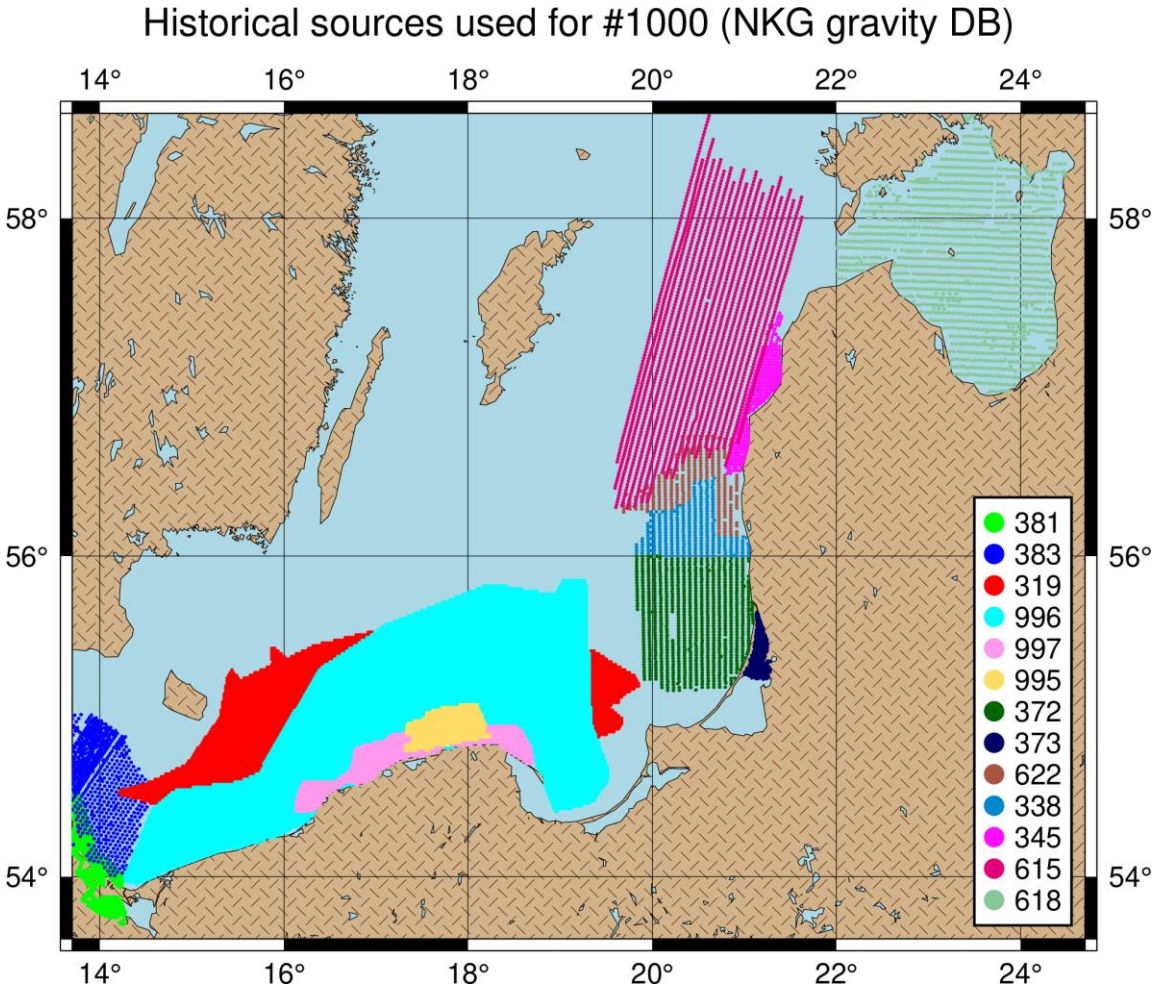
8. Gravimetric measurements in Lithuanian waters, 1968-1970 (NLS, Lithuania, #372)

9. Gravimetric measurements in the Curonian Lagoon, 1973-1974 (NLS, Lithuania, #373)

10-13. Gravimetric campaign in Latvian waters, 1976, 1977-1979, 1980, 1990 (LGIA, Latvia, #338, #345, #615; **RTU, Latvia, #622**)

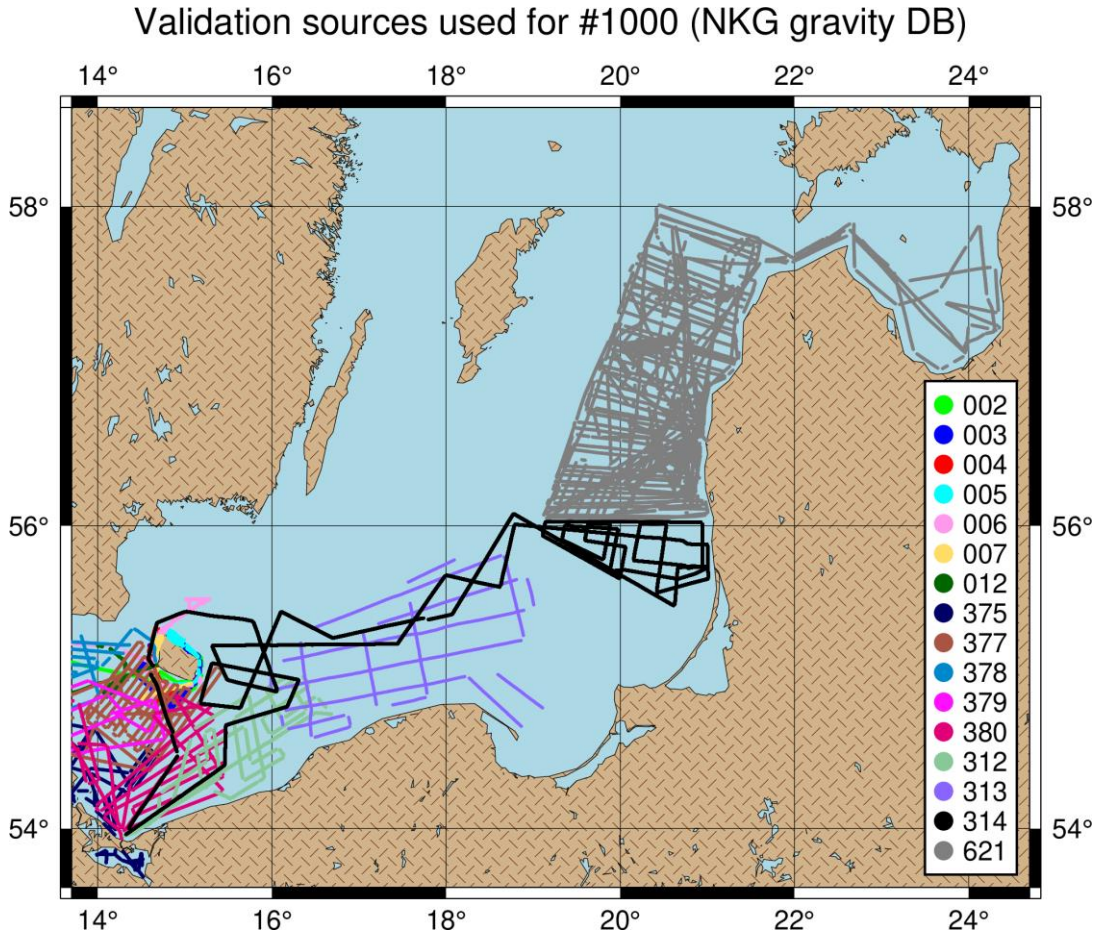
14. Gravimetric measurements in the Gulf of Riga, 1966-1967 (ELB, Estonia, #618)

15. Bottom gravity measurements, 1956 (NLS/FGI, Finland, #998)



Modern marine gravity data used for validation of historical data

- **DTU, Denmark:** #002 (2015), #003 (2015), #004 (2015), #005 (2015), #006 (2015), #007 (2016) and #012 (2017)
- **BKG and GFZ, Germany**: #375 (2013), #377 (2015), #378 (2016), #379 (2017) and #380 (2018)
- **GUT, HOPN and MUS, Poland:** #312 (2019), #313 (2021) and **#314 (2023 - BalMarGrav)**
- **LGIA, Latvia and LM, Sweden: #621 (2023 - BalMarGrav)**



Harbour ties - reference land gravity measurements in 2023

Absolute:

- **IGiK, Poland:** Szczecin, Klaiped, Liepaja/Grobina, Riga

Relative:

- **DTU, Denmark:** Rønne (Borholm)
- **IGiK and PGI-NRI, Poland:** Świnoujście, Darłówko, Ustka, Łeba, Władysławowo, Hel, Gdańsk
- **LGIA, Latvia:** Riga, Liepaja
- **VGTU, Lithuania:** Klaipeda

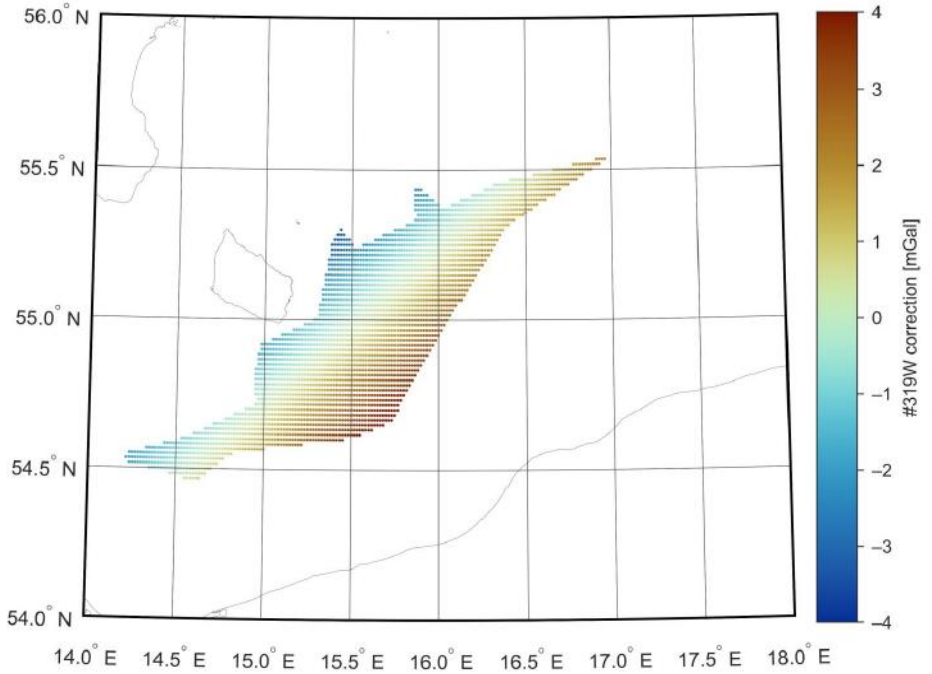
Preparation of historical marine gravity data for gridding

- Calculation of total topographic correction (Joachim Schwabe, BKG, 2024):
  - 2'' DEM/bathymetry BalMarGrav model (EuroDEM with MERIT ver. 11/2023 and EMODnet Digital Bathymetry 2022)
  - density for bedrock/land - 2670 kg/m^3 and for water/ocean - 1007 kg/m^3
  - integration radius 166.7 km, rectangular prism formulas up to ~300 m and tesseroids formulas beyond, DEM geometry is assumed on the ellipsoid

- Recalculation of Bouguer anomalies for all historical sources (Monika Wilde-Piórko, IGiK, 2024):
  - estimation of uncertainties of the input data based on reported and validated values - from 1.0 to 2.4 mGal
  - modification of historical data based on validation sources

    - #319 divided into two parts outside the #996, +1.7 mGal offset added to the eastern part; the western part was corrected by linear correction surface
    - #995 added offset +3.6 mGal
    - #996 added offset -0.7 mGal
    - other sources used as is (except #042 and #998)

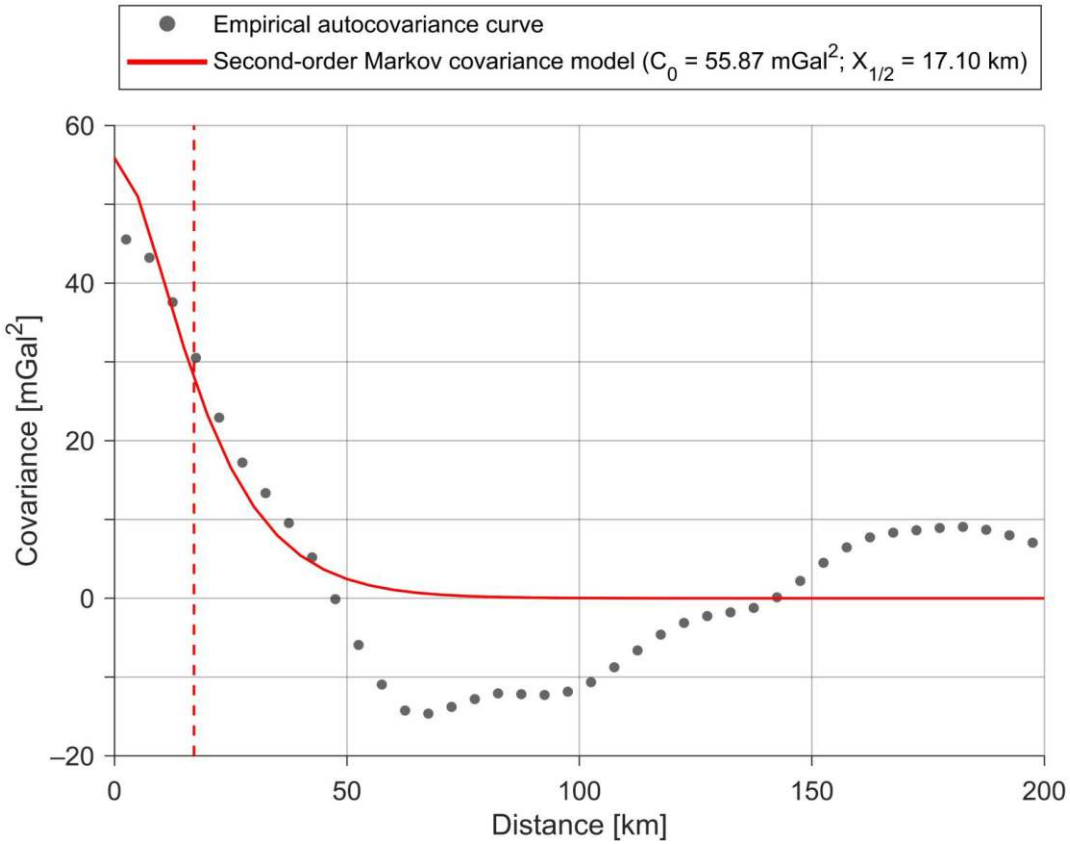
Western part of #319



Sander Varbla, TalTech (2024)

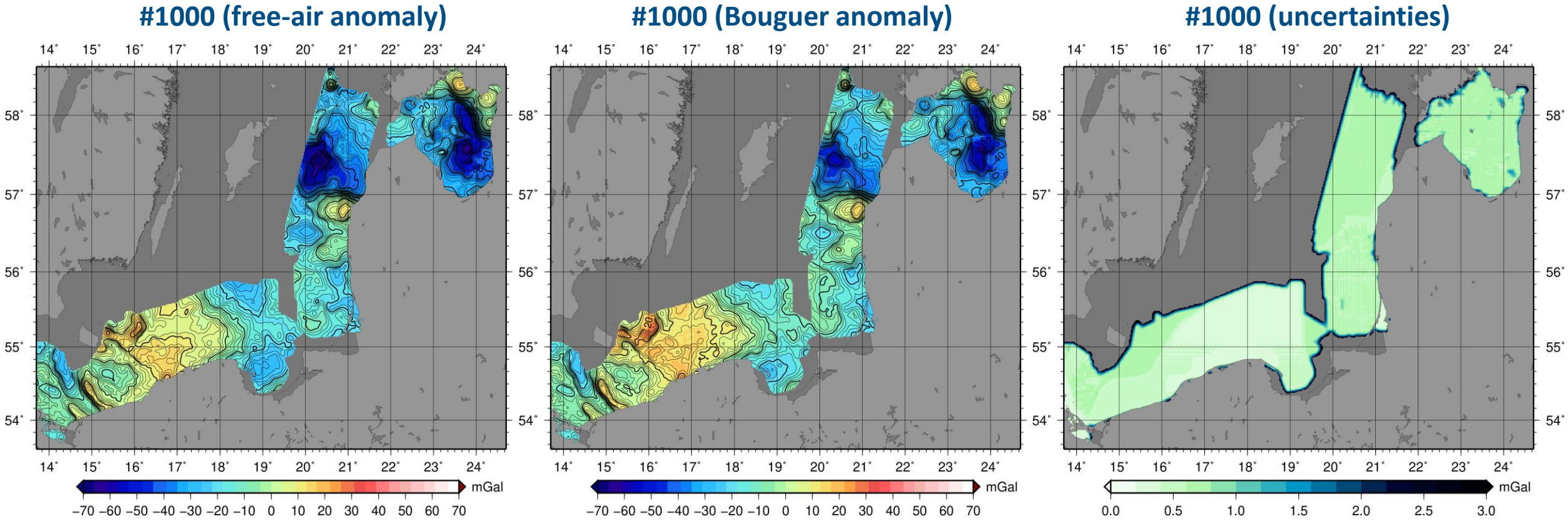
Gridding of historical marine gravity data (13.7-24.7° E 53.6-58.6° N, 1.2′ by 0.6′)

- Gridding of Bouguer anomalies data by Least-squares Collocation method (Sander Varbla, TalTech, 2024):
  - GO_CONS_GCF_2_DIR_R6 global geopotential model (d/o 300) used to remove and later restore the long-wavelength gravity signal
  - covariances of residual gravity were determined using the second-order Markov covariance model (signal variance 55.97 $mGal^2$ and correlation length of 17.10 km) fitted to the empirical autocovariance curve (5 km distance groups)
  - grid node value prediction done by using 100 closest points to a grid node in each quadrant
  - extrapolation was allowed up to 6 km from the nearest available data point
- Gridded free-air anomalies were obtained by restoring the topographic effects with uncertainties assumed equivalent to the Bouguer anomalies



Sander Varbla, TalTech (2024)

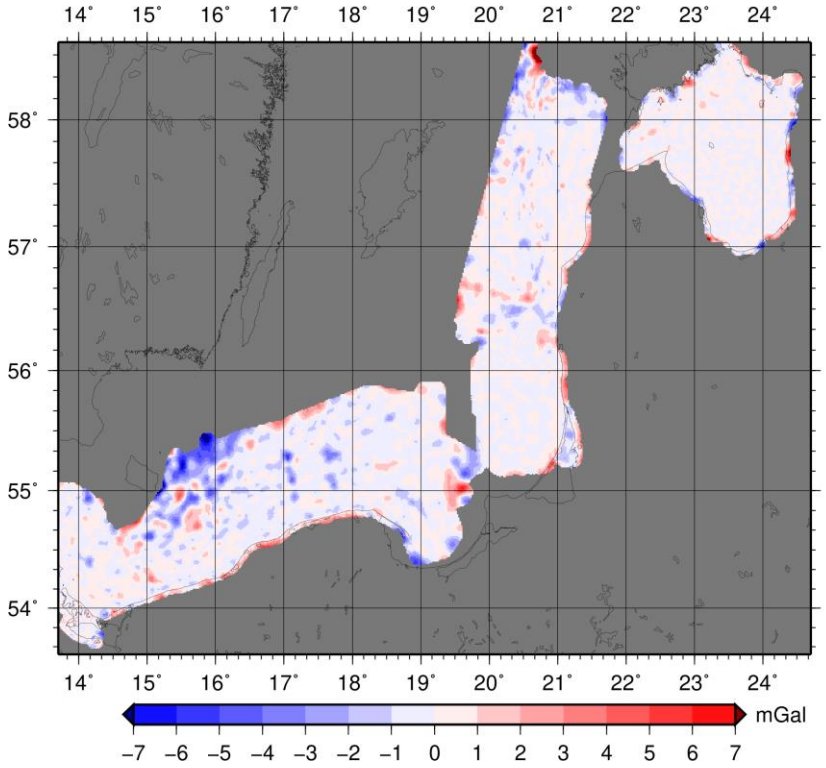
Homogenized marine historical gravity data of southern and eastern Baltic Sea



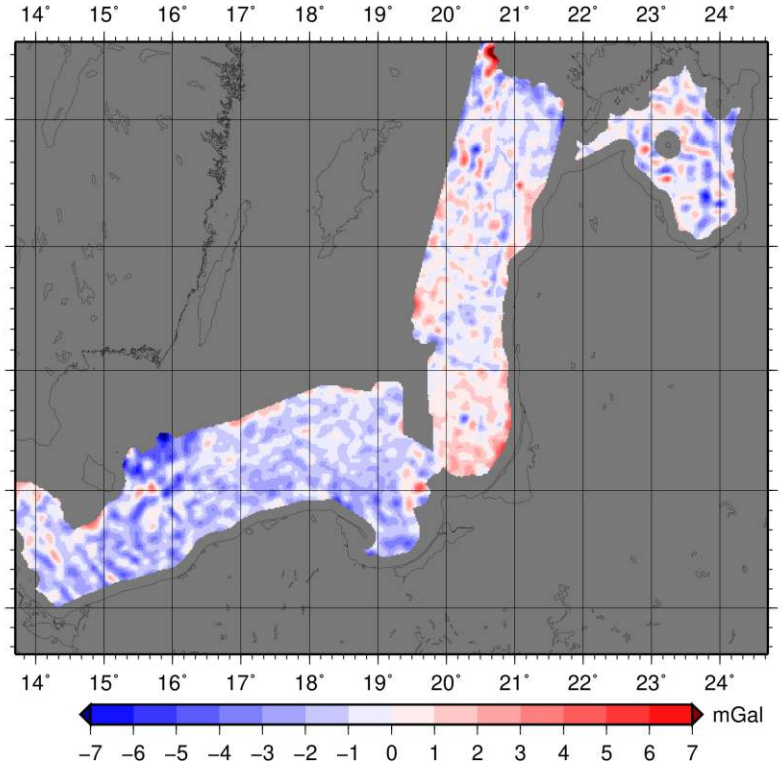
Homogenized historical gravity data has been added to the Nordic Geodetic Commission gravity data base under the extraction license „product_balmargrav” (**source #1000**) and is available to the public under the **CC BY 4.0** license

Validation of homogenized marine historical gravity data

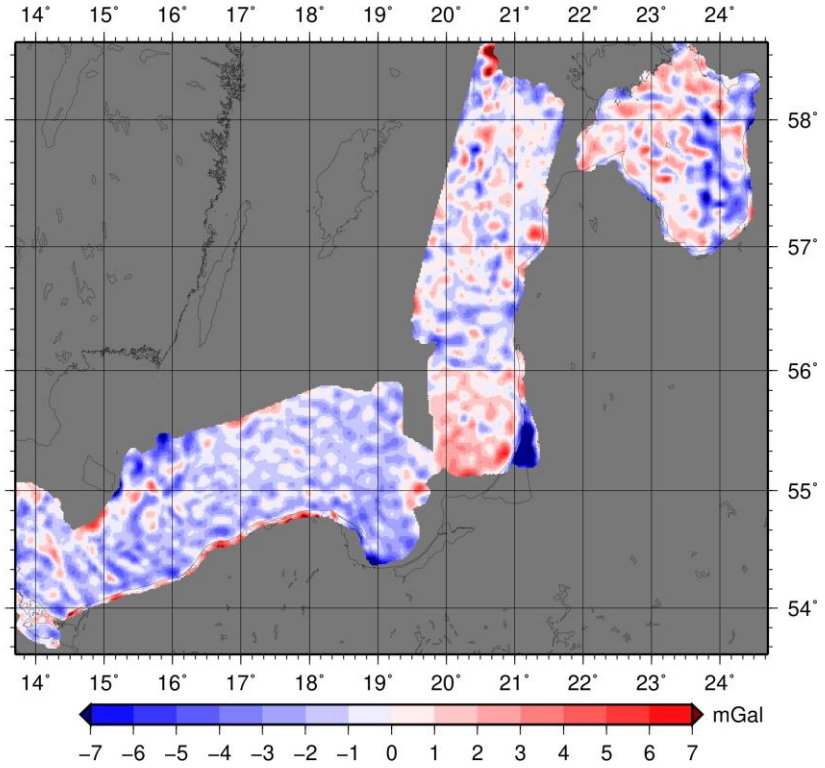
#1000 – BKG5D_FA



#1000 – DTU23_FA



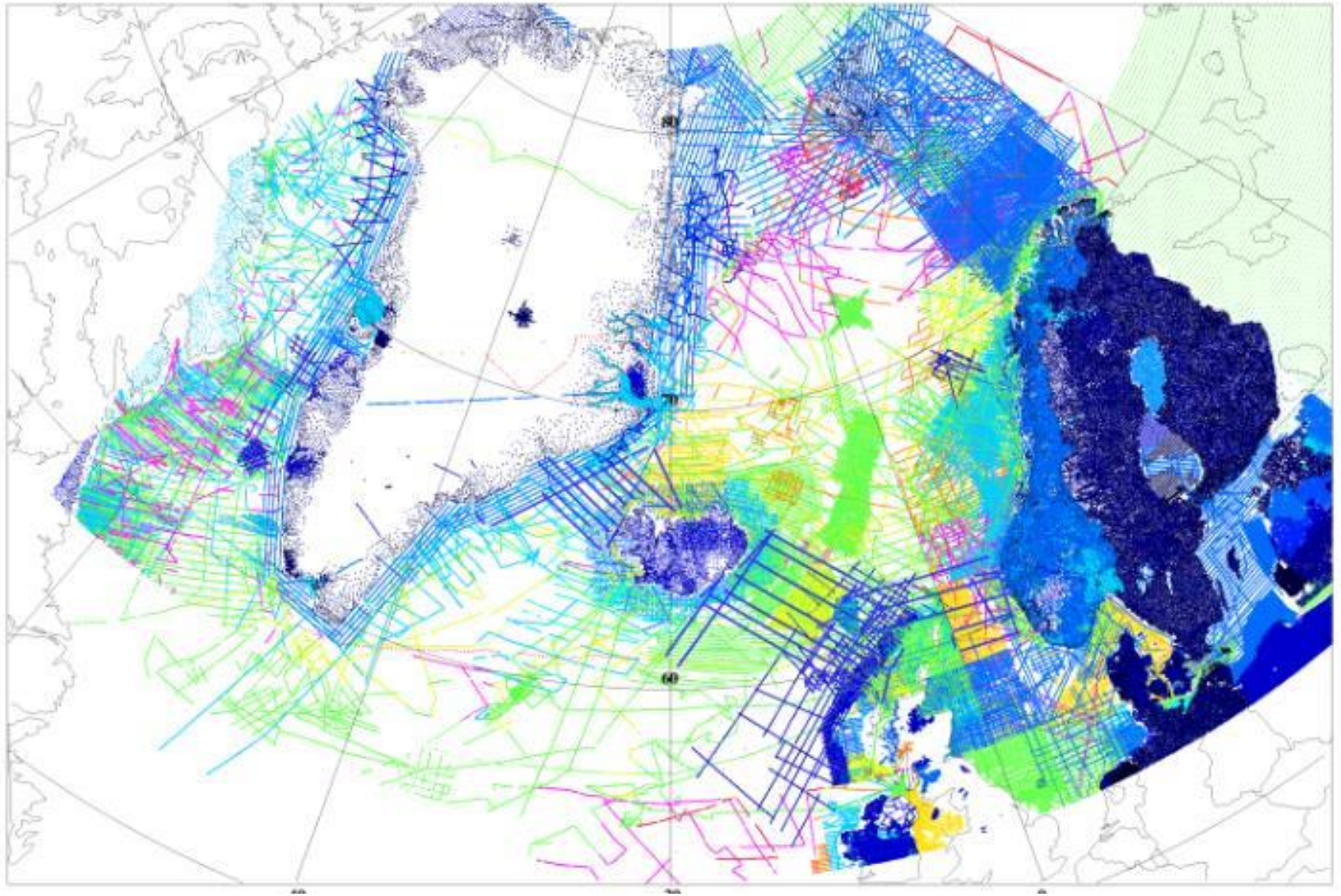
#1000 – EIGEN-6CN



Model	Mean [mGal]	Std [mGal]	Min [mGal]	Max [mGal]	Comments
BKG5D_FA	-0.1	1.1	-8.5	+12.0	Gravity model (FAMOS project)
DTU23_FA	-0.8	1.5	-7.7	+9.8	Altimetric model (> 10 km from coast)
EIGEN-6CN	-0.8	2.0	-13.8	+10.8	Combined global gravity model

NKG/FAMOS/BalMarGrav gravity DB

- NKG gravity DB: part of regional geodetic infrastructure
- Brief historical overview
- Broader regional cooperation: FAMOS, GM, BalMarGrav
- BalMarGrav: gravity DB modernization (DB migration, CSV input format, secure licensing)
- BalMarGrav-project: the final product (product_balmargrav)



Nordic Geodetic Commission - Gravity Data Base (ver. 2008)

BalMarGrav: gravity DB modernization

- Gravity DB today: a suite of SQL databases
- DB migration at DTU:

  Moved from a virtual computer ”somewhere on DTU campus”

  to DTU Space, backup-on-demand

BalMarGrav: gravity DB modernization

- **80char input format vs. CSV input format**

Simple (o):
60001 56.520670 8.450670 366.09 4.21 9999.00

80char (i/o):
A 5631.24B 827.04BE 366.09B 0.0X5526.97B 4.21B 44 60001 0.0X 2.09999.00

CSV (i/o):
A,56.520670,B,8.450670,B,E,366.09,B,0.00,X,981526.970,B,4.21,B,44,60001,0.00,X, … 2.0,9999.00

Advantages of CSV input format as compared to (historical) 80char input format

- **Gravity information can be inserted into DB in a more flexible way**
- **More than 1000 source# possible**

BalMarGrav: gravity DB modernization

- **secure licensing**

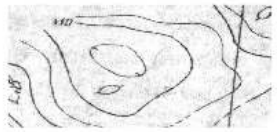
main idea: Source **#1000** are the only data in DB **publication_1000**.
No other DB contains data from source **#1000**.

”product_balmargrav license”:
read rights for user **product_balmargrav** in SQL DB
publication_1000 (and no read rights to other DBs)

other ”licenses”: all_balmargrav, germany_bkg_owner, …

Pilot activity in the BalMarGrav project (9-16 September 2024)

- Downloading the homogenized historical marine gravity data from the Nordic Geodetic Commission gravity data base by **sending the e-mail** to gs@space.dtu.dk (Gabriel Strykowski) with request to access the **source #1000** under the „product_balmargrav” licence
- **Verification** of downloaded data
- Filling out the **on-line survey:** https://forms.office.com/e/gdXatkECvg



BalMarGrav

MODERNIZED GRAVITY MAPS OF THE BALTIC SEA

Interreg Baltic Sea Region

Co-funded by the European Union

BLUE ECONOMY BalMarGrav

The BalMarGrav Working Group: Tobias Bauer, Mirjam Bilker-Koivula, Przemysław Dykowski, Artu Ellmann, Orjan Josefsson, Jānis Kaminskis, Jan Kryński, Tobias Nilsson, Romuald Obuchovski, Per-Anders Olsson, Tomasz Olszak, Eimuntas Kazimieras Paršeliūnas, Jerzy Pyrchla, Krzysztof Pyrchla, Olga Rosowiecka, Joachim Schwabe, Gabriel Strykowski, Małgorzata Szelachowska, Jakub Szulwic, Arkadiusz Tomczak, Sander Varbla, Monika Wilde-Piórko, Vents Zuševics.

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