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Fjords, lakes and marine gravity measurements

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NKG2014, Göteborg, Sweden

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Motivation

- GOAL! → Obtain normal height at 1 cm!
  - Using GNSS + Geoid (HREF) → height (NN2000)
  - Surveying, agriculture, roadbuilding
  - Starting point → Geoid – GNSS – leveling ~ 6 cm

Topics

- Fjords/lakes
- Marine gravity

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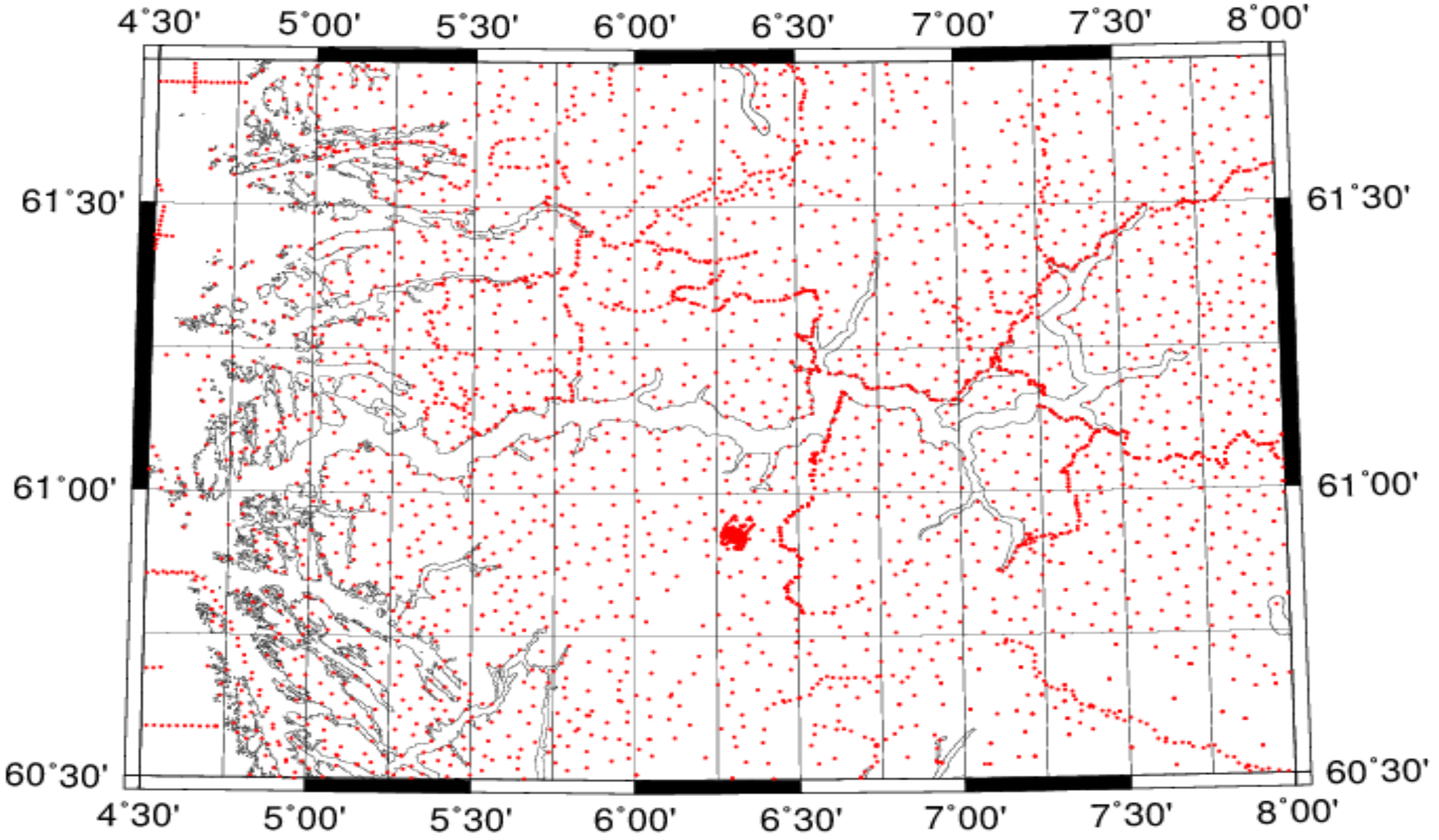
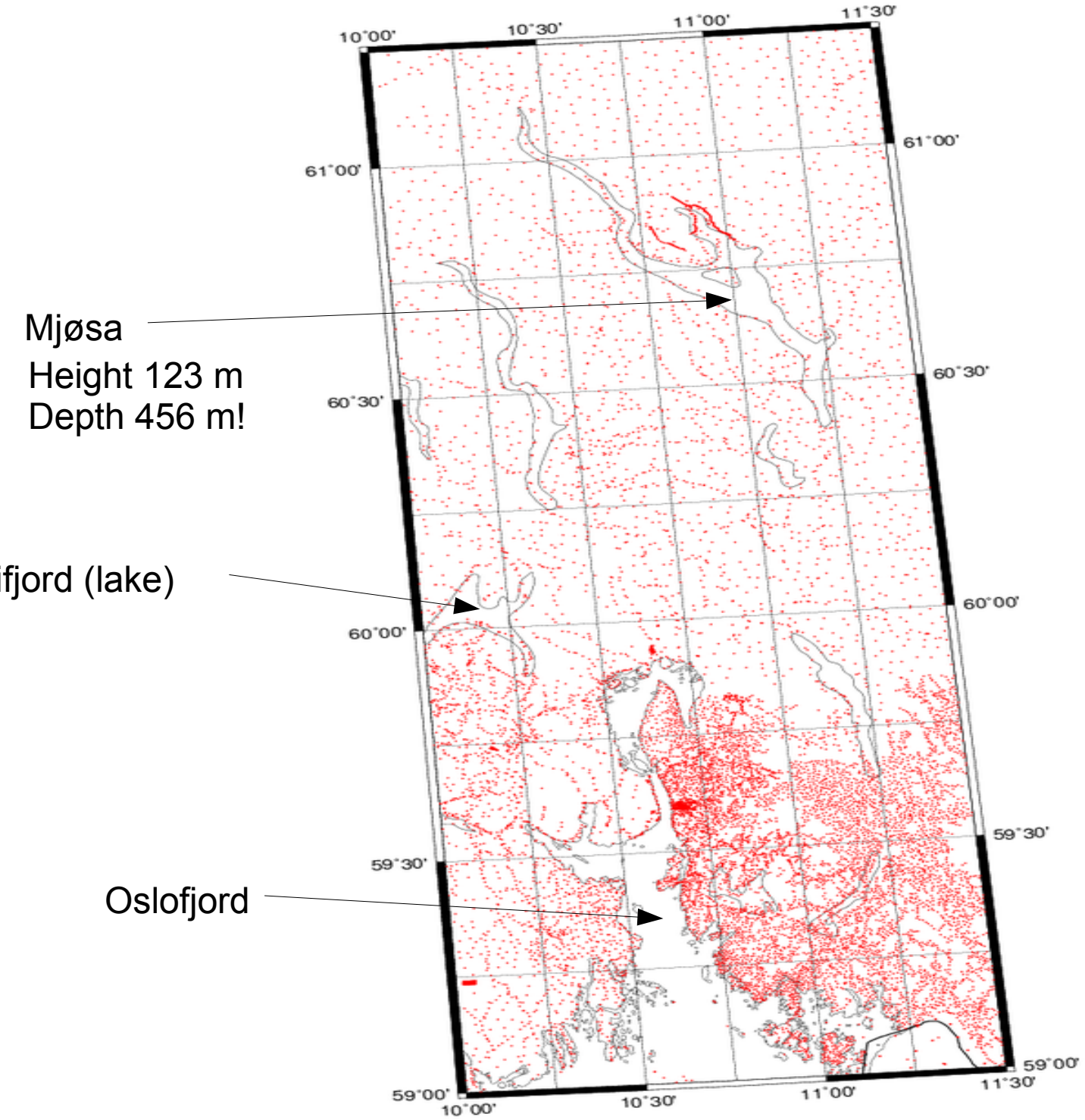
Gravity measurement with spacing 3-5 km, but NONE in the fjords



… or lakes



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Use ships to fill fjords and lakes with gravity measurements

H.U. Sverdrup on Sognefjord and Oslofjord

Skiblander on Mjøsa

Telemarkskanalen

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Where have we measured with BGM-3

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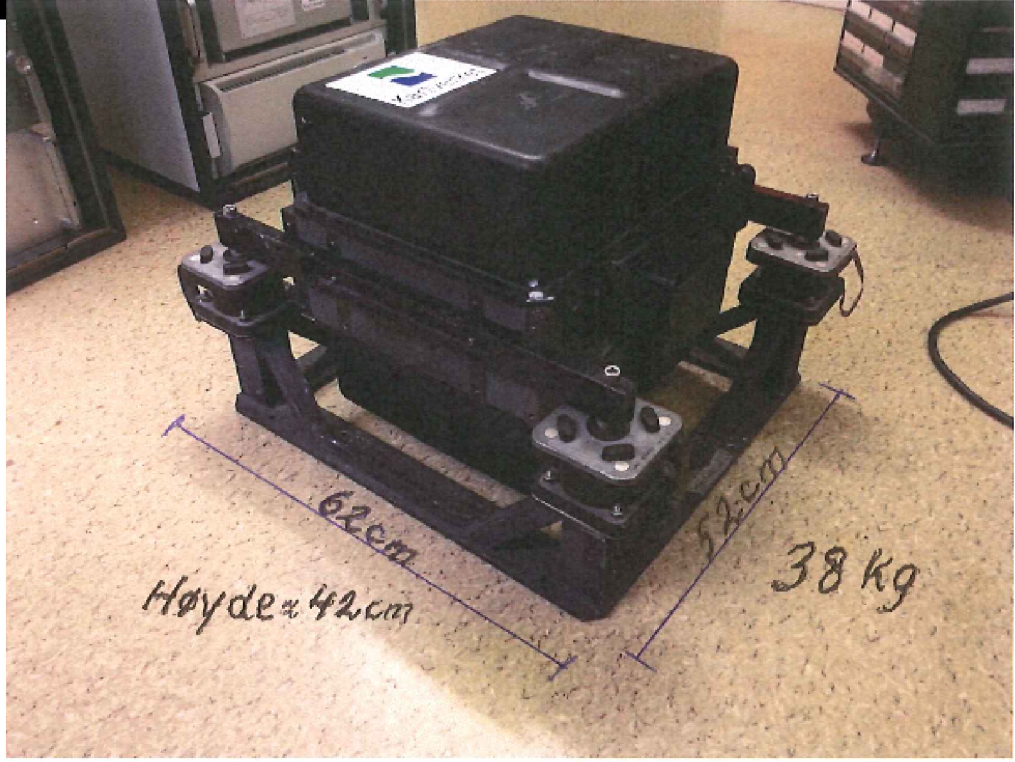
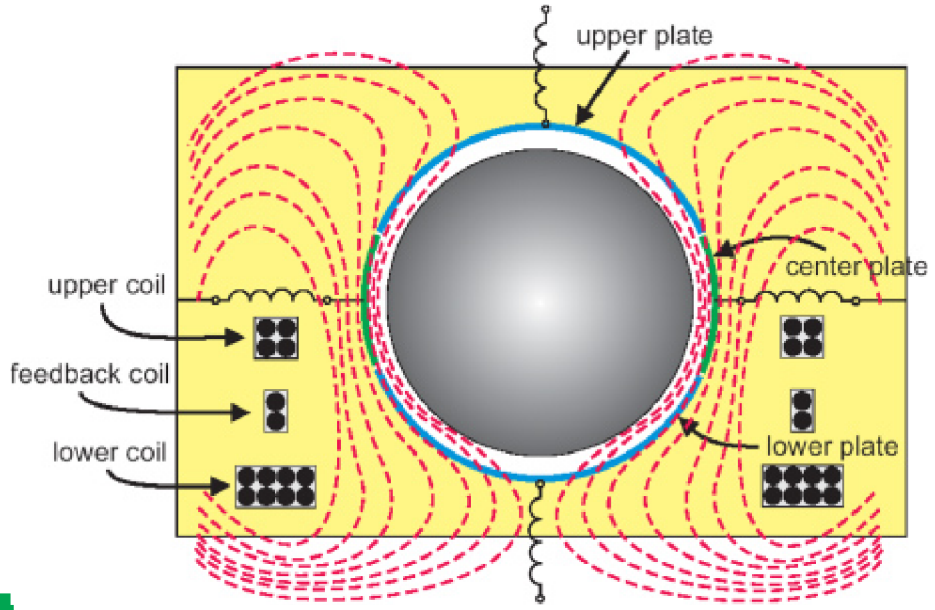
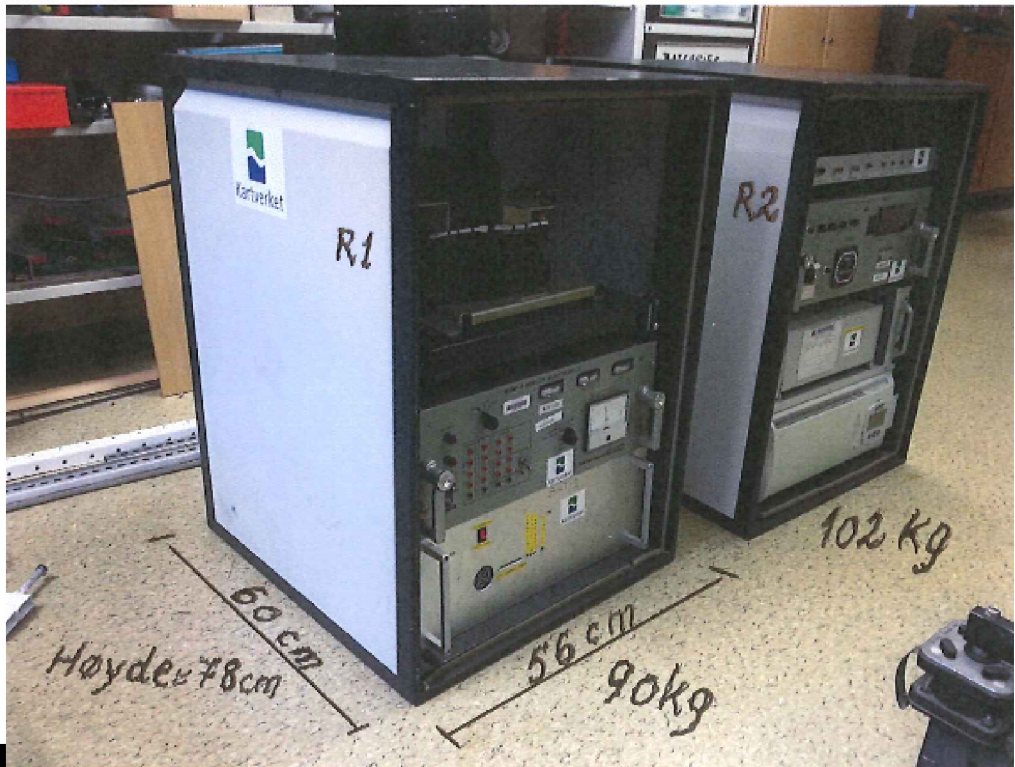
Bell marine gravimeter – BGM-3 – similar principle as a superconducting gravimeter, but without superconducting!







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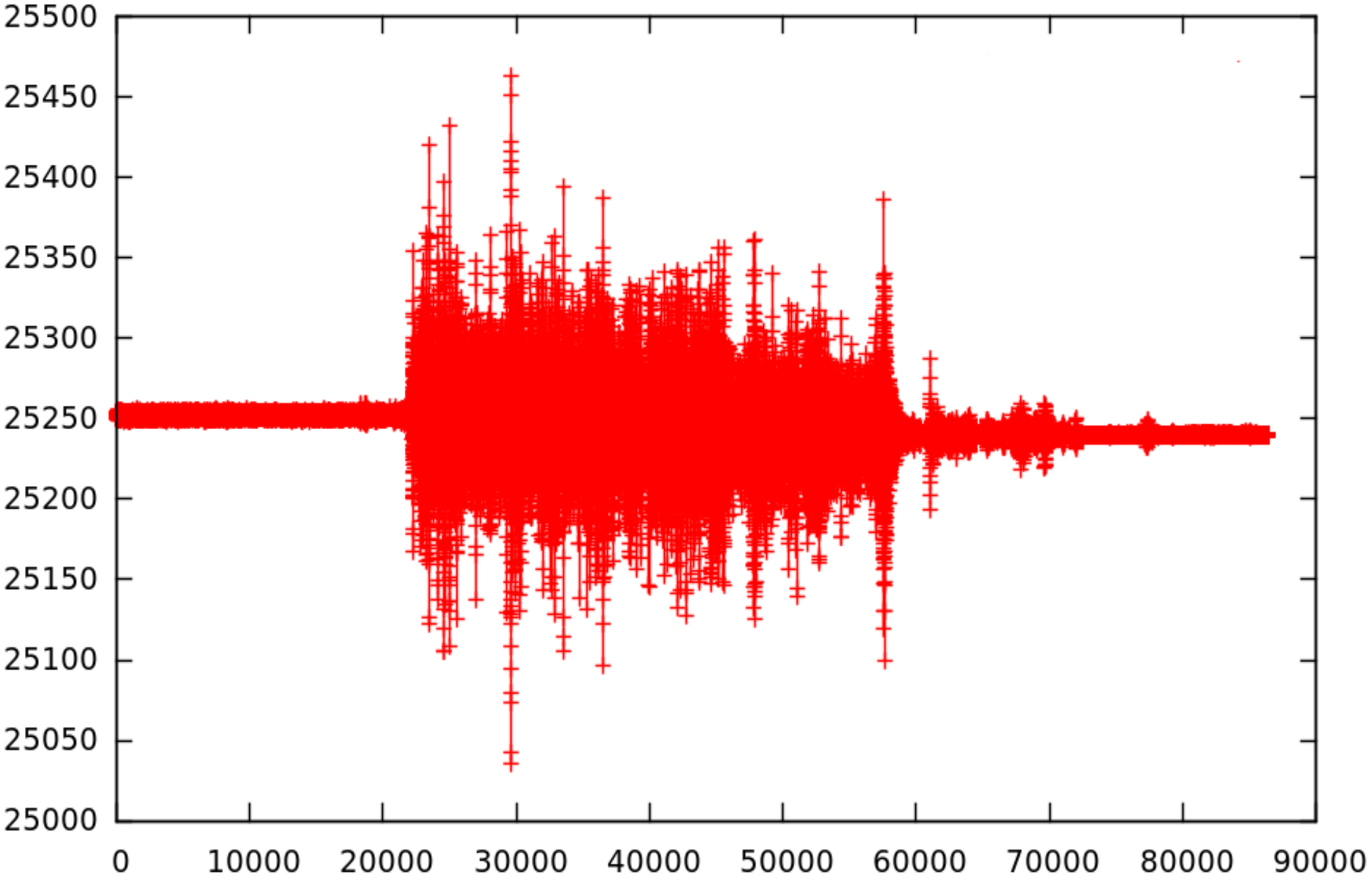
Raw marine gravity mesurements looks noisy!



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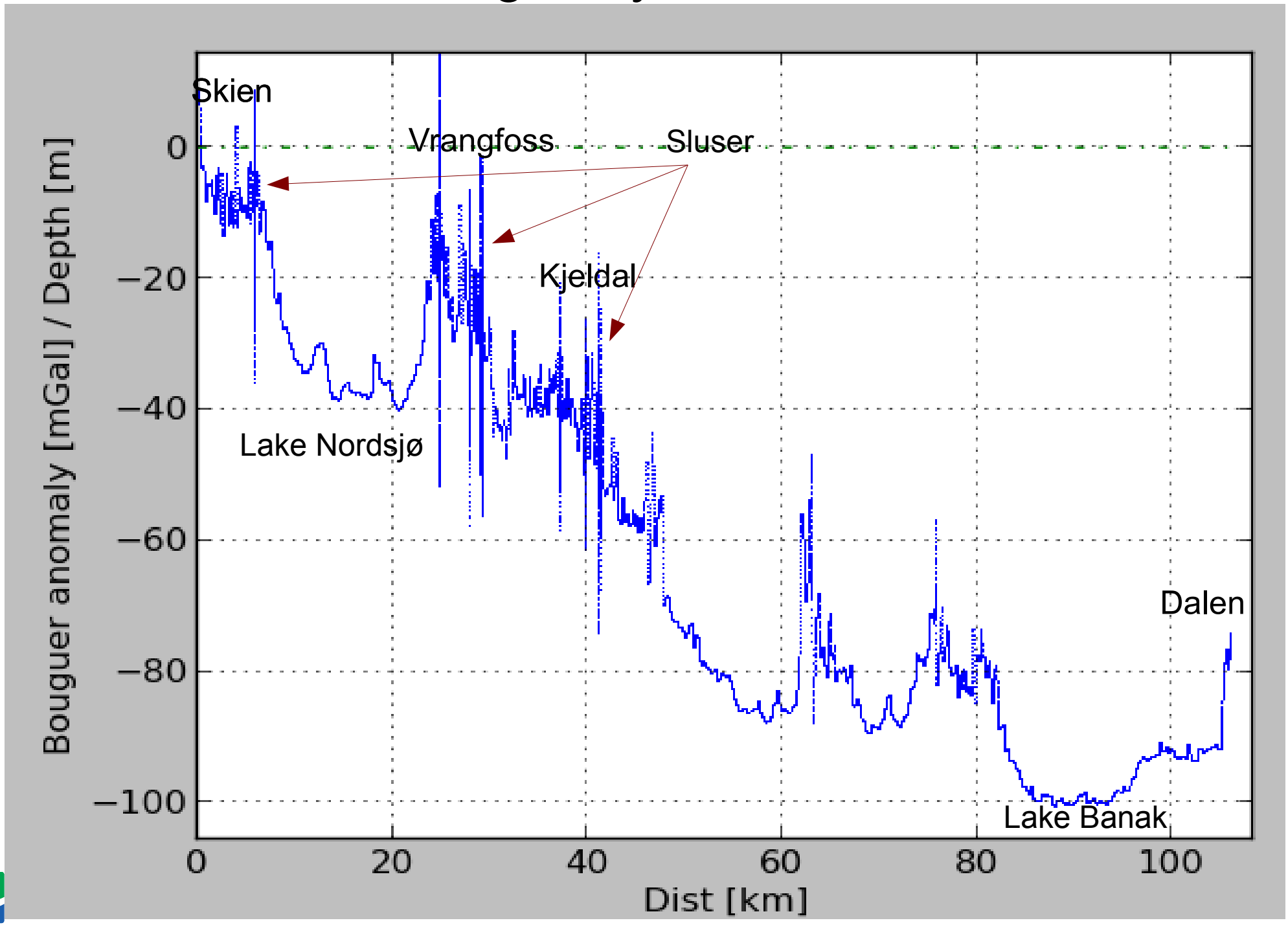
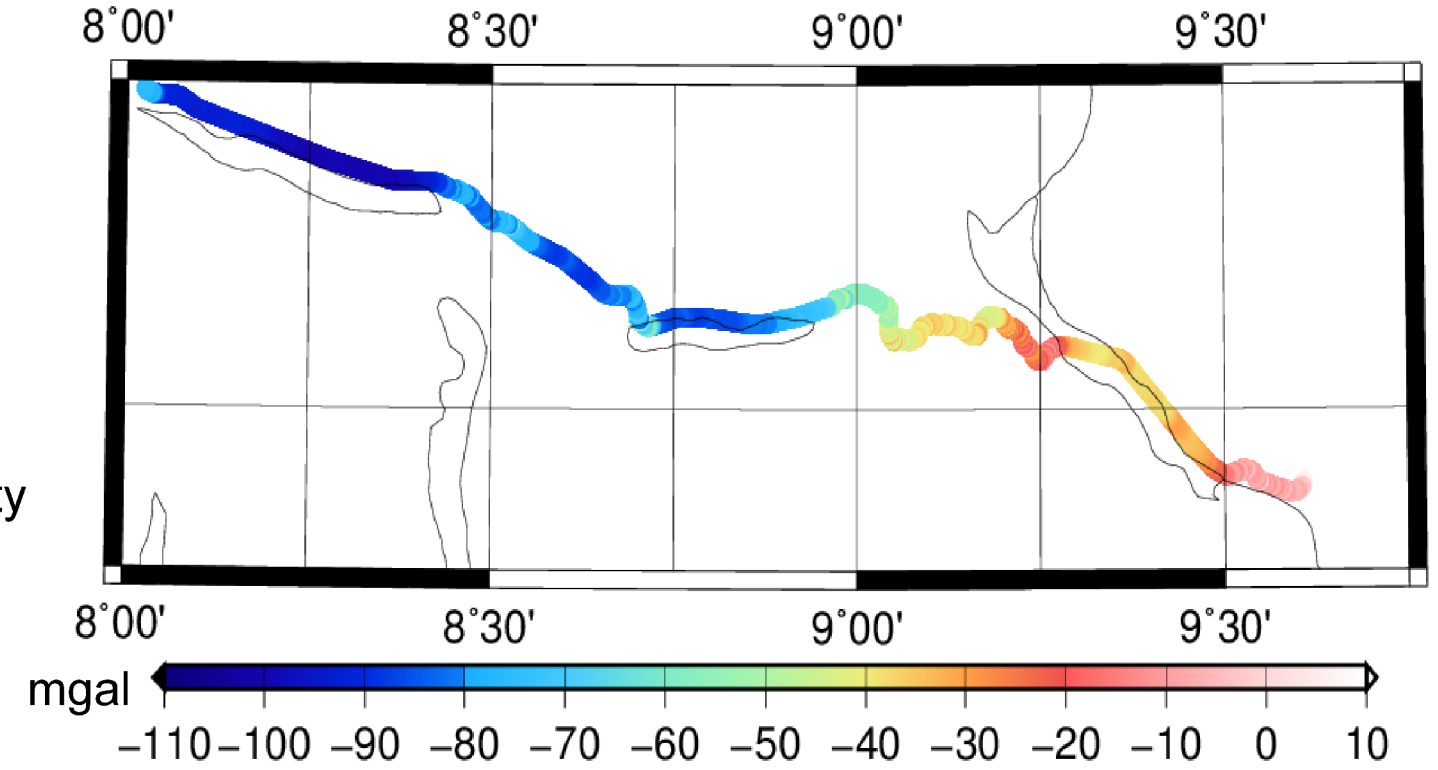
Filtered marine gravity measurements

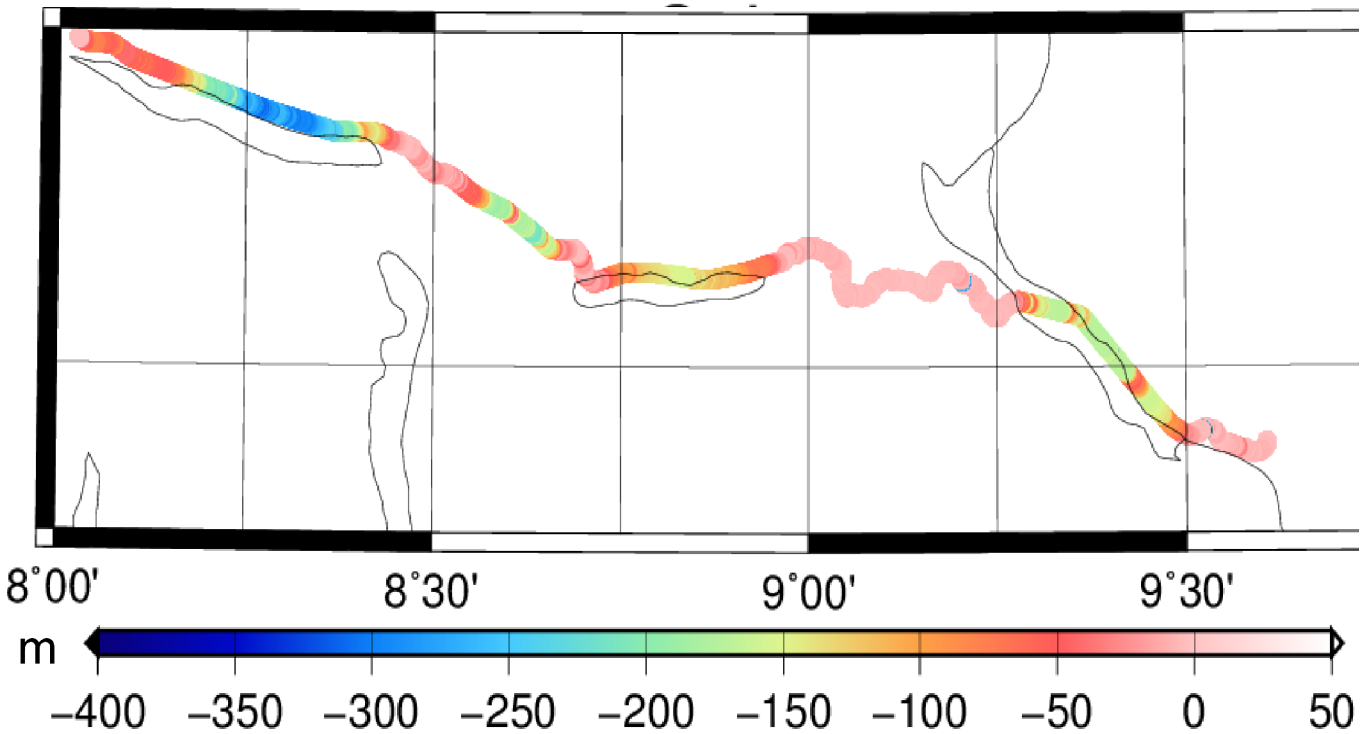


Telemarkskanalen

Gravity



Depth



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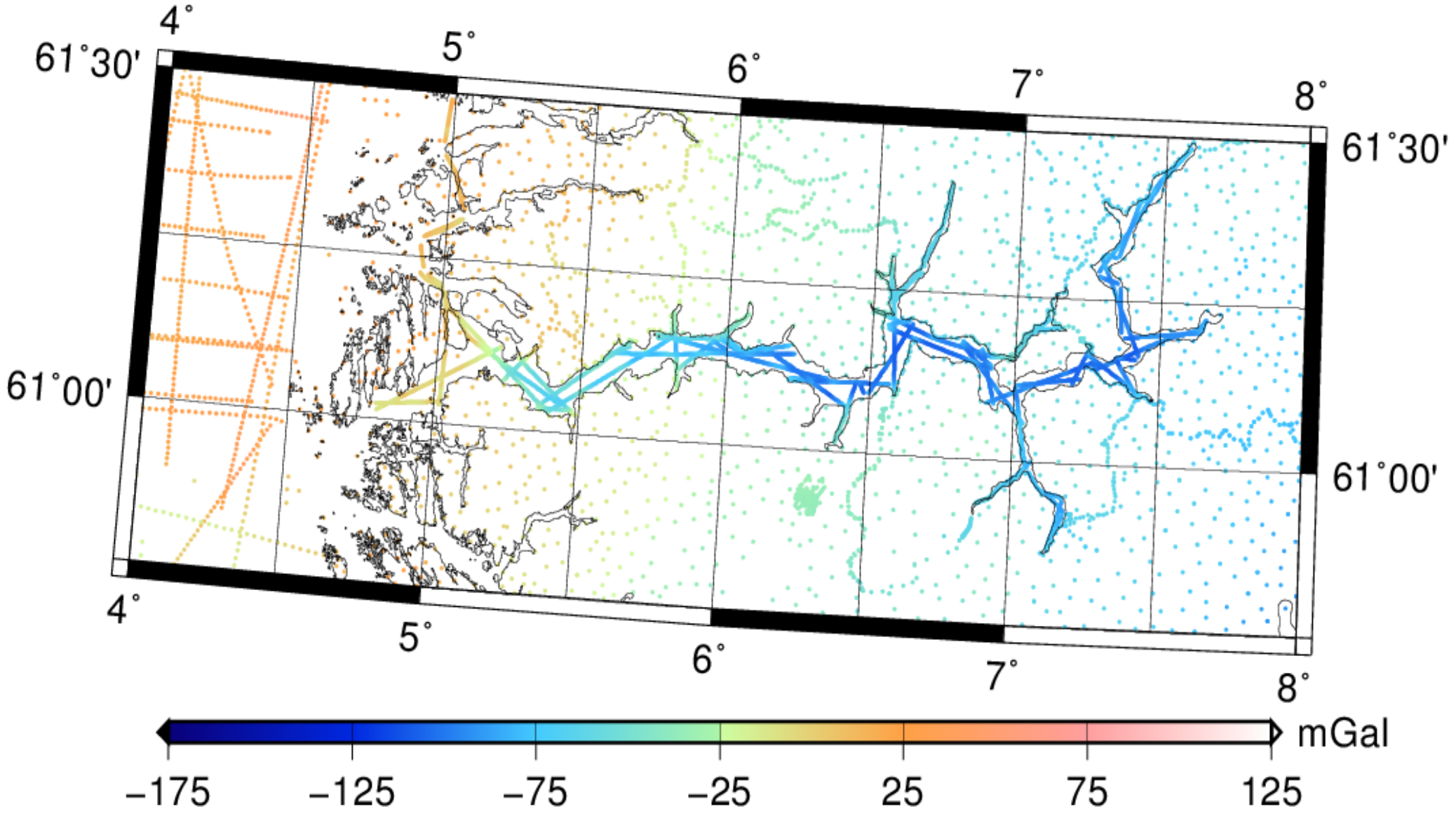
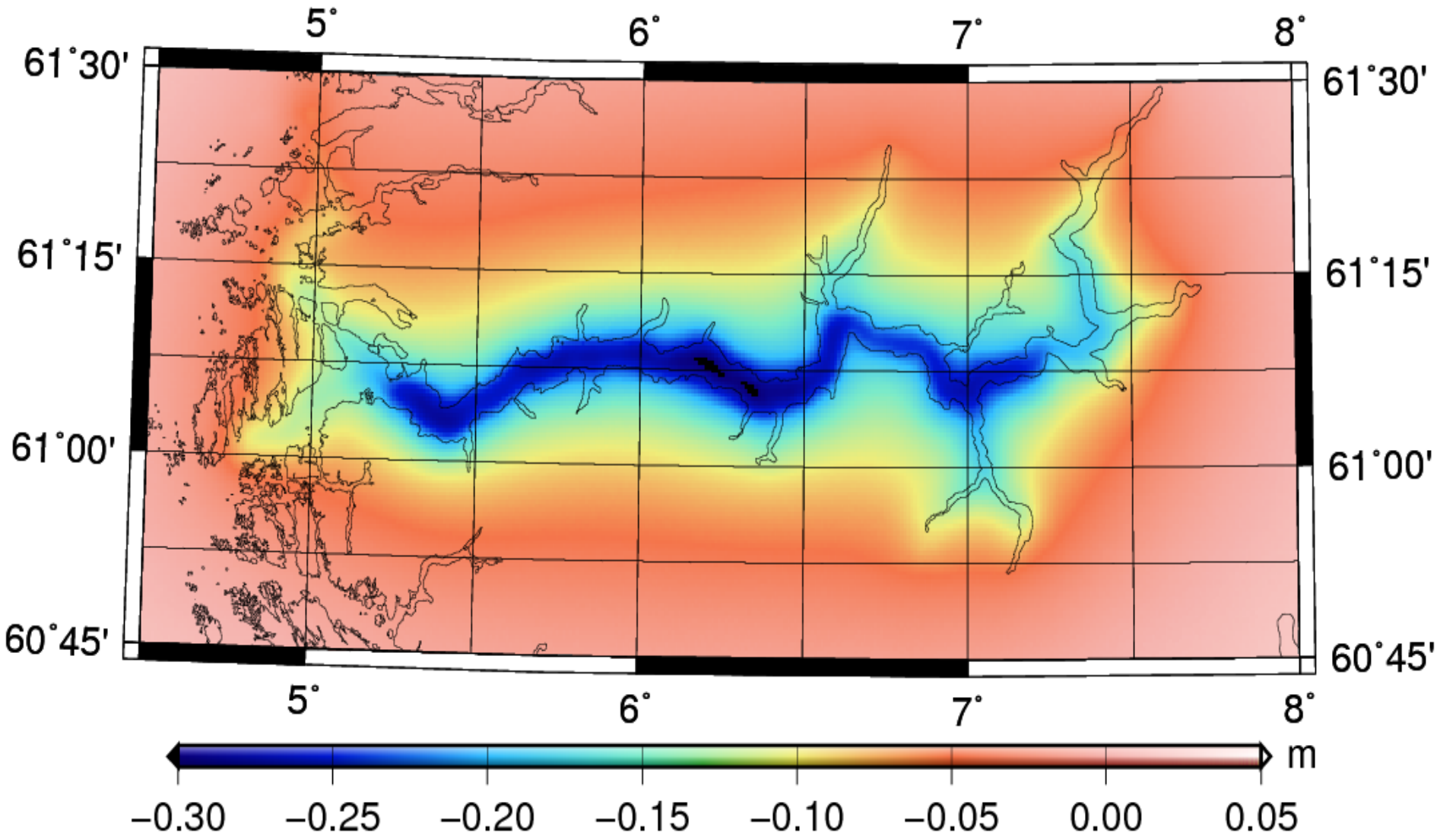
Sognefjord with gravity data

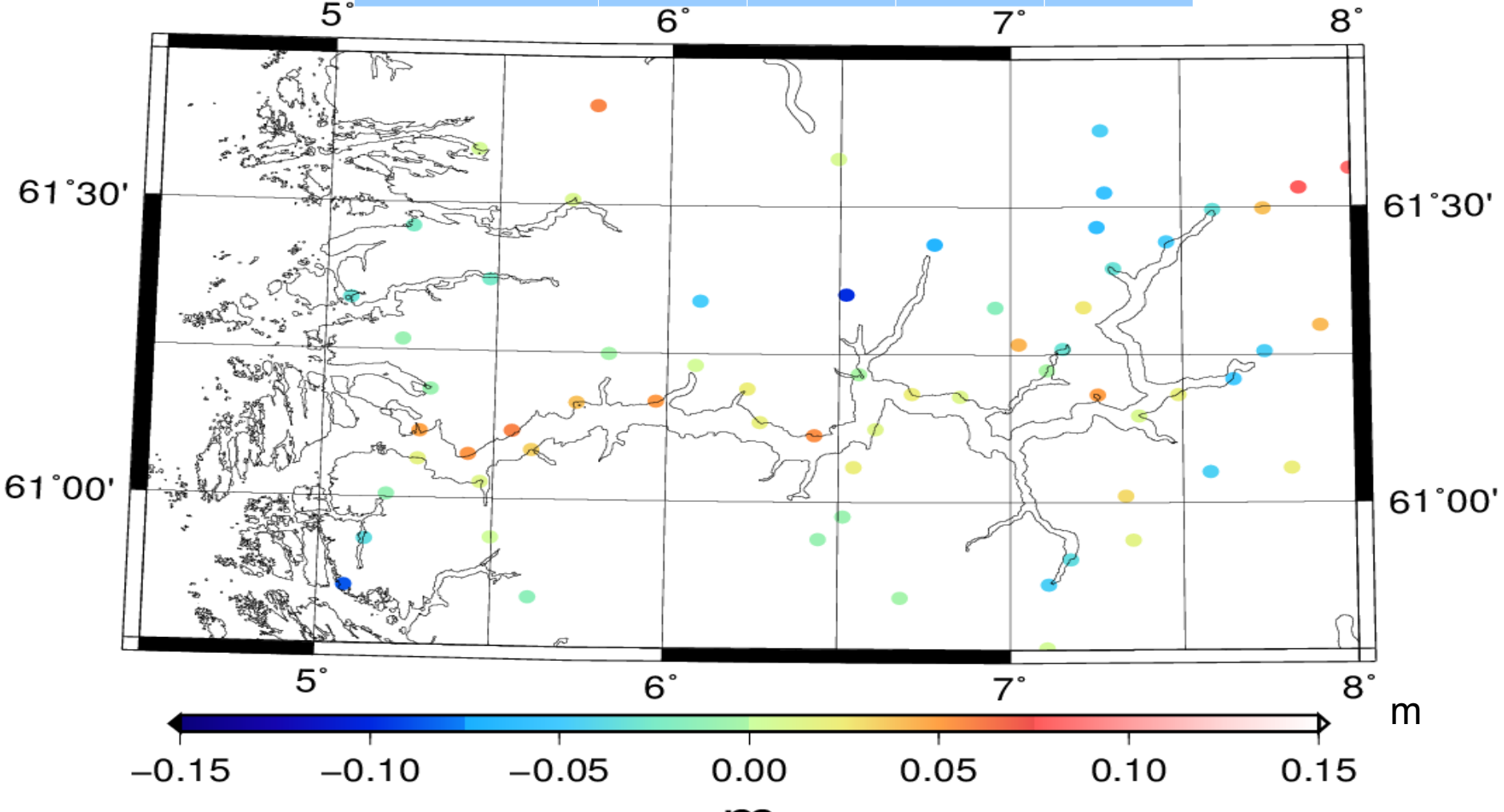


A change of >30 cm in geoid is observed when adding marine gravity measurements in the Sognefjord!



Compare to 65 GPS/leveling points show that adding gravity data in the fjord improves the geoid

Sognefjord	min	max	mean	sd
No	-0.115	0.119	0.000	0.056
Yes	-0.099	0.081	-0.000	0.039



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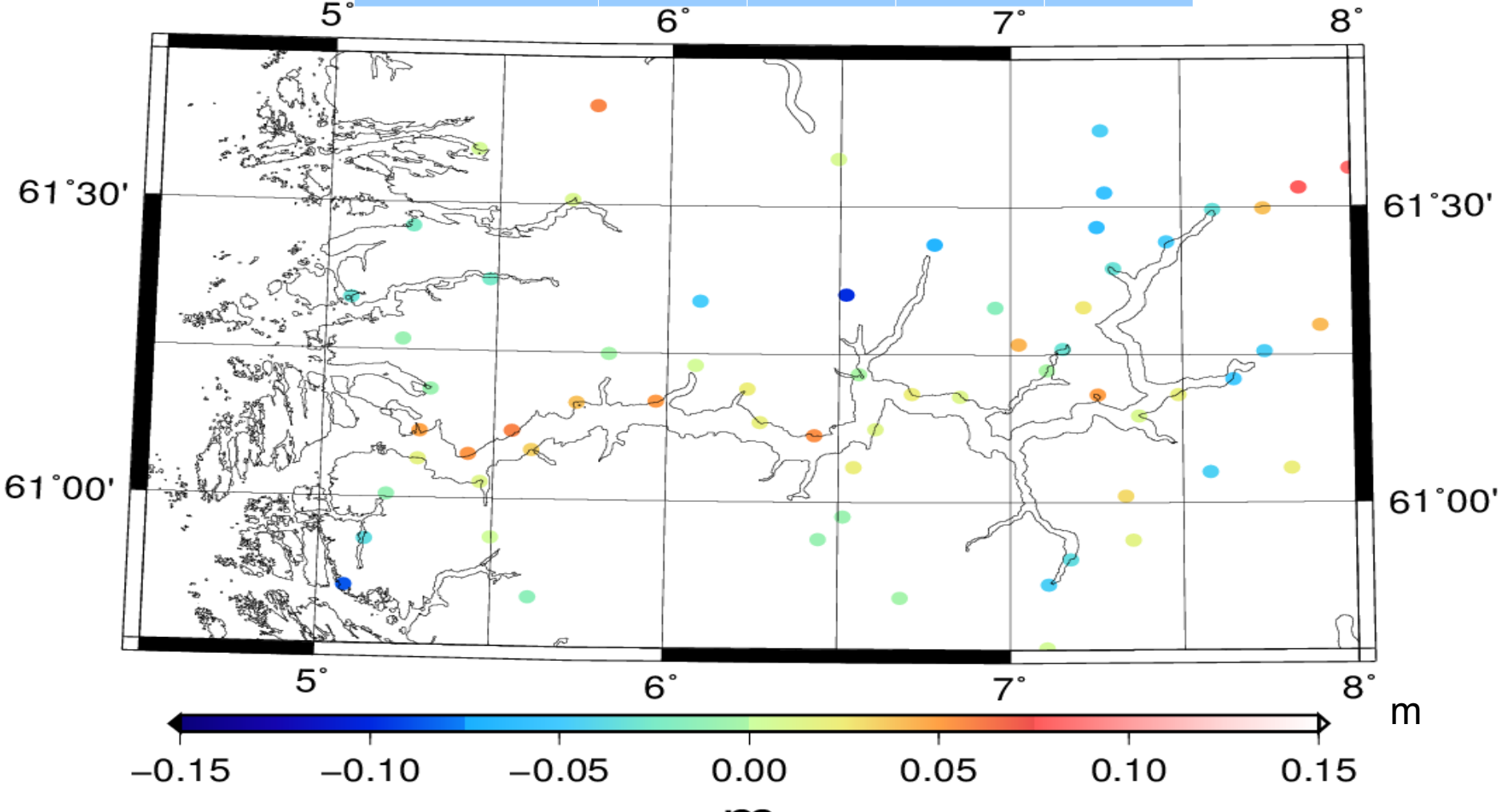
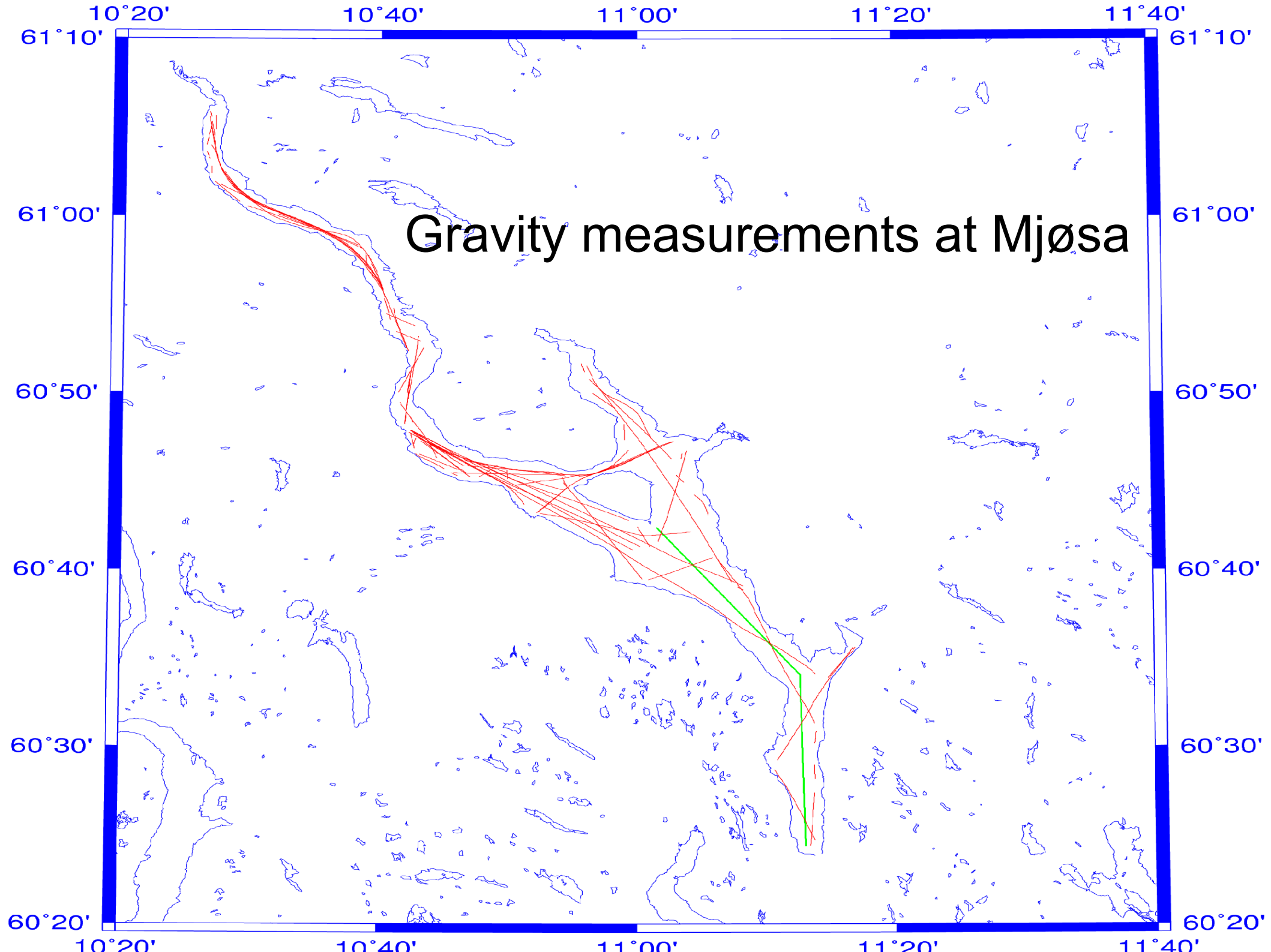
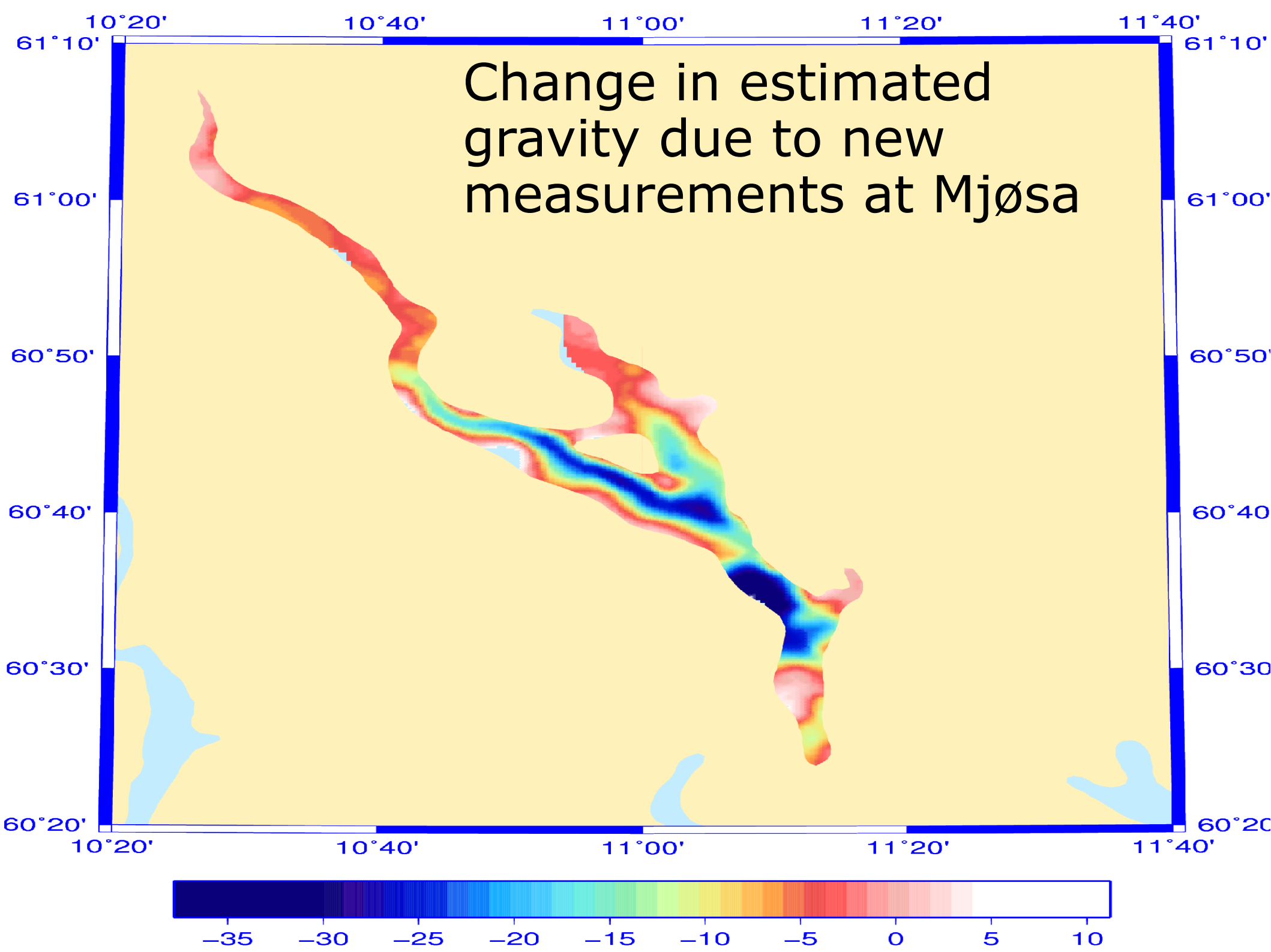
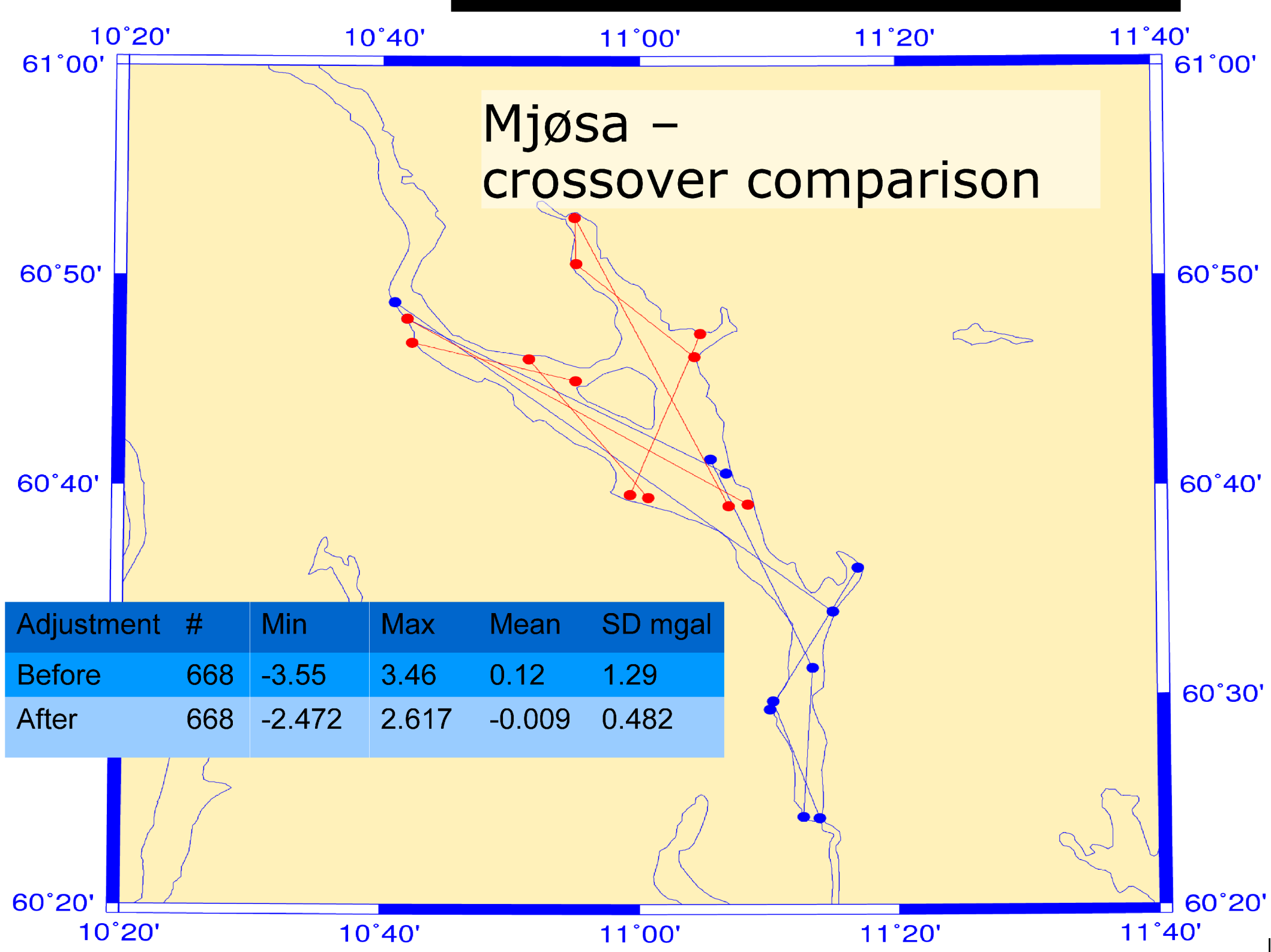


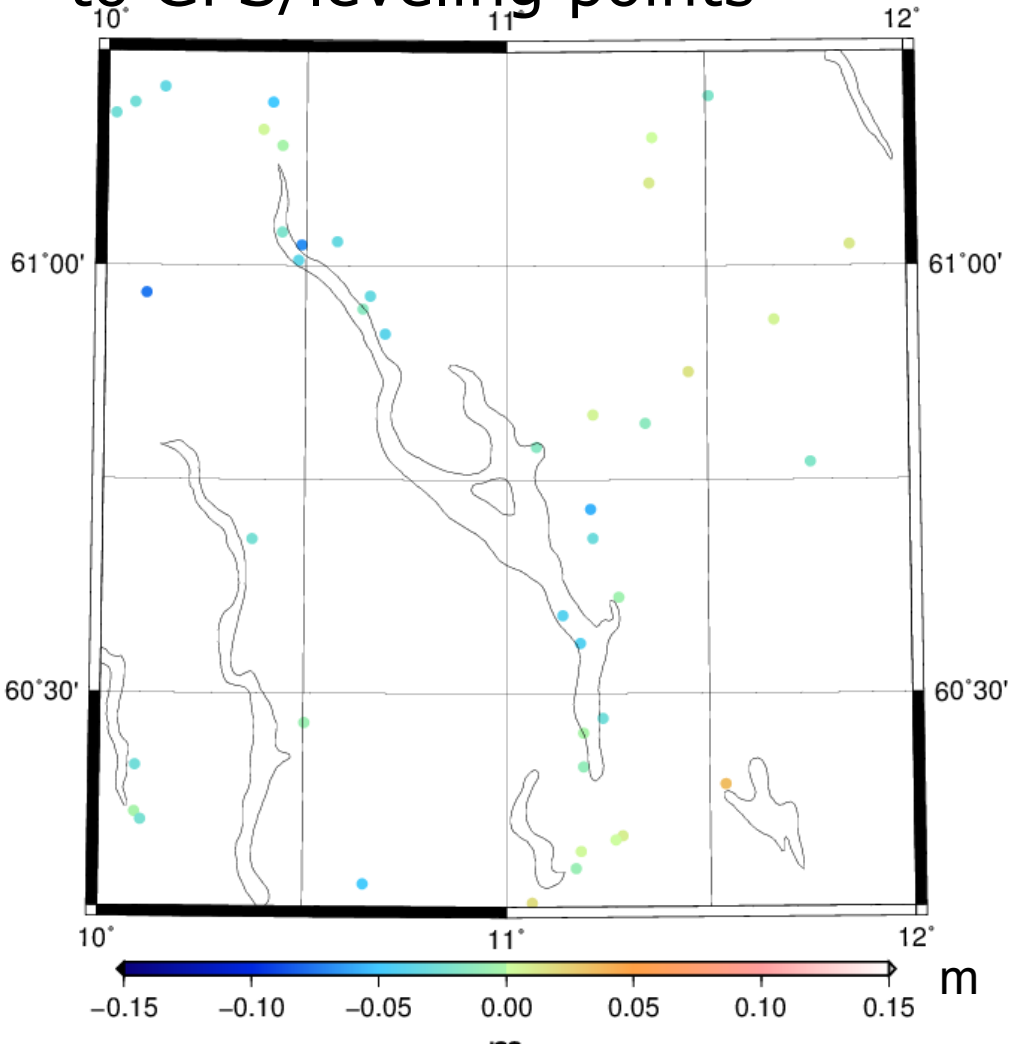

Gravity measurements at Mjøsa
10°20'
10°40'
11°00'
11°20'
11°40'
61°10'
61°00'
60°50'
60°40'
60°30'
60°20'

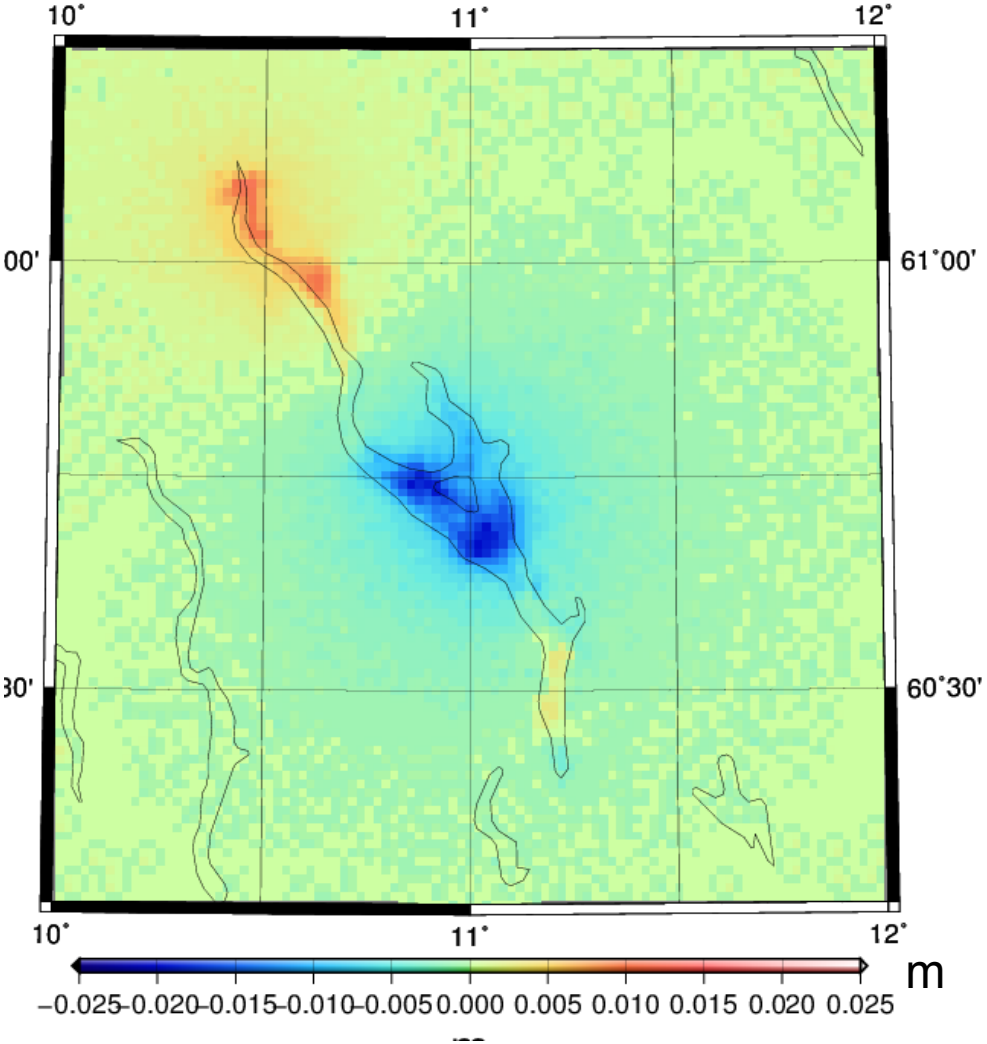

Change in estimated gravity due to new measurements at Mjøsa
10°20'
10°40'
11°00'
11°20'
11°40'
61°10'
61°00'
60°50'
60°40'
60°30'
60°20'
−35
−30
−25
−20
−15
−10
−5
0
5
10



Adjustment	#	Min	Max	Mean	SD mgal
Before	668	-3.55	3.46	0.12	1.29
After	668	-2.472	2.617	-0.009	0.482

Change in geoid of 2 cm, but no improvement compared to GPS/leveling points





Gravity at Mjøsa	# GPS	Min	Max	Mean	SD/detrended [mgal]
NO	44	0.2	0.327	0.268	0.026/0.019
YES	44	0.199	0.327	0.267	0.027/0.019

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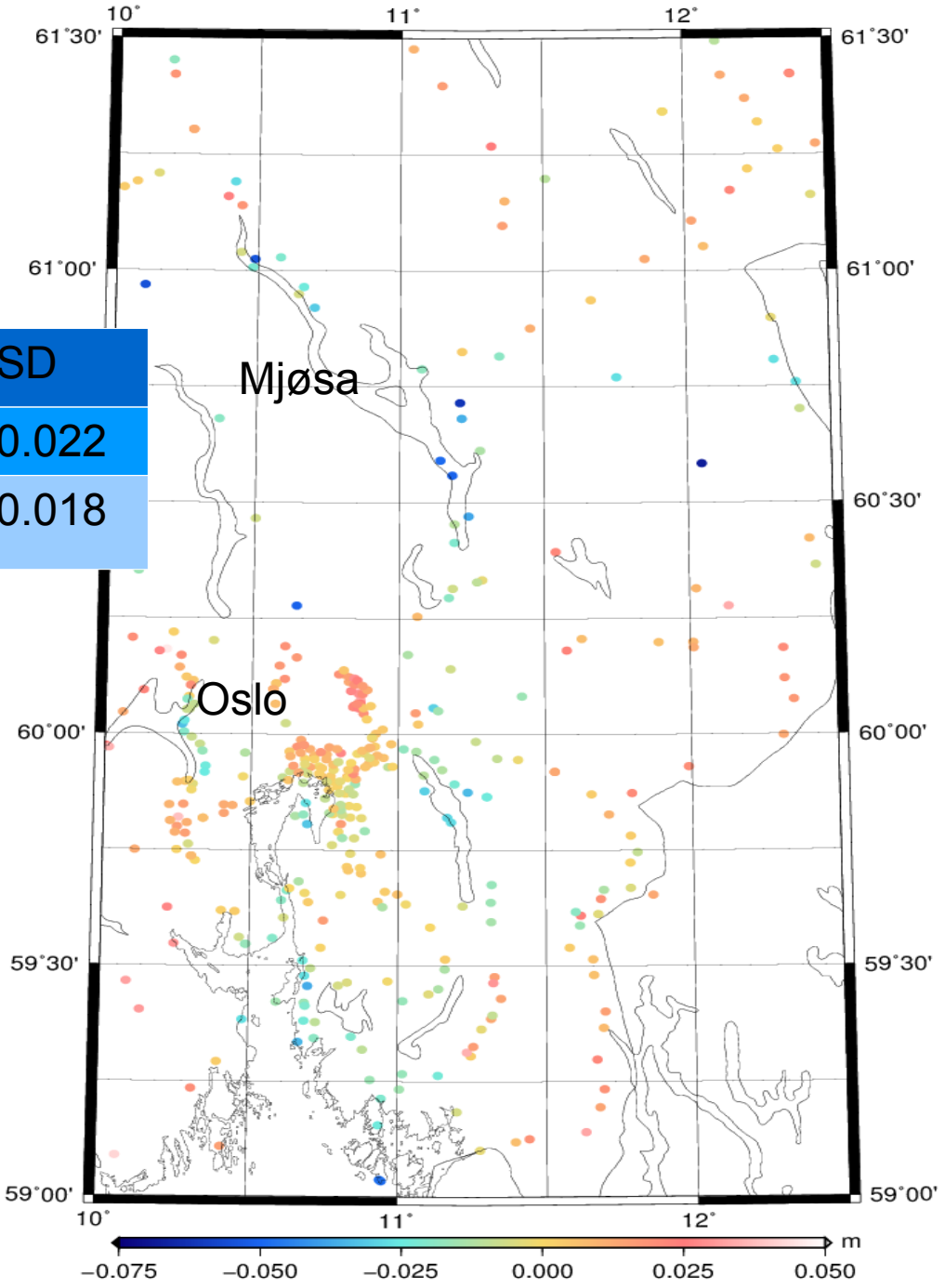
“Flat” areas of Norway (around Oslo and Mjøsa): fit to GPS/leveling of 1.8 cm after detrending

Detrend	#	Min	Max	Mean	SD
Before	397	0.203	0.346	0.286	0.022
After	397	-0.068	0.046	0.0	0.018



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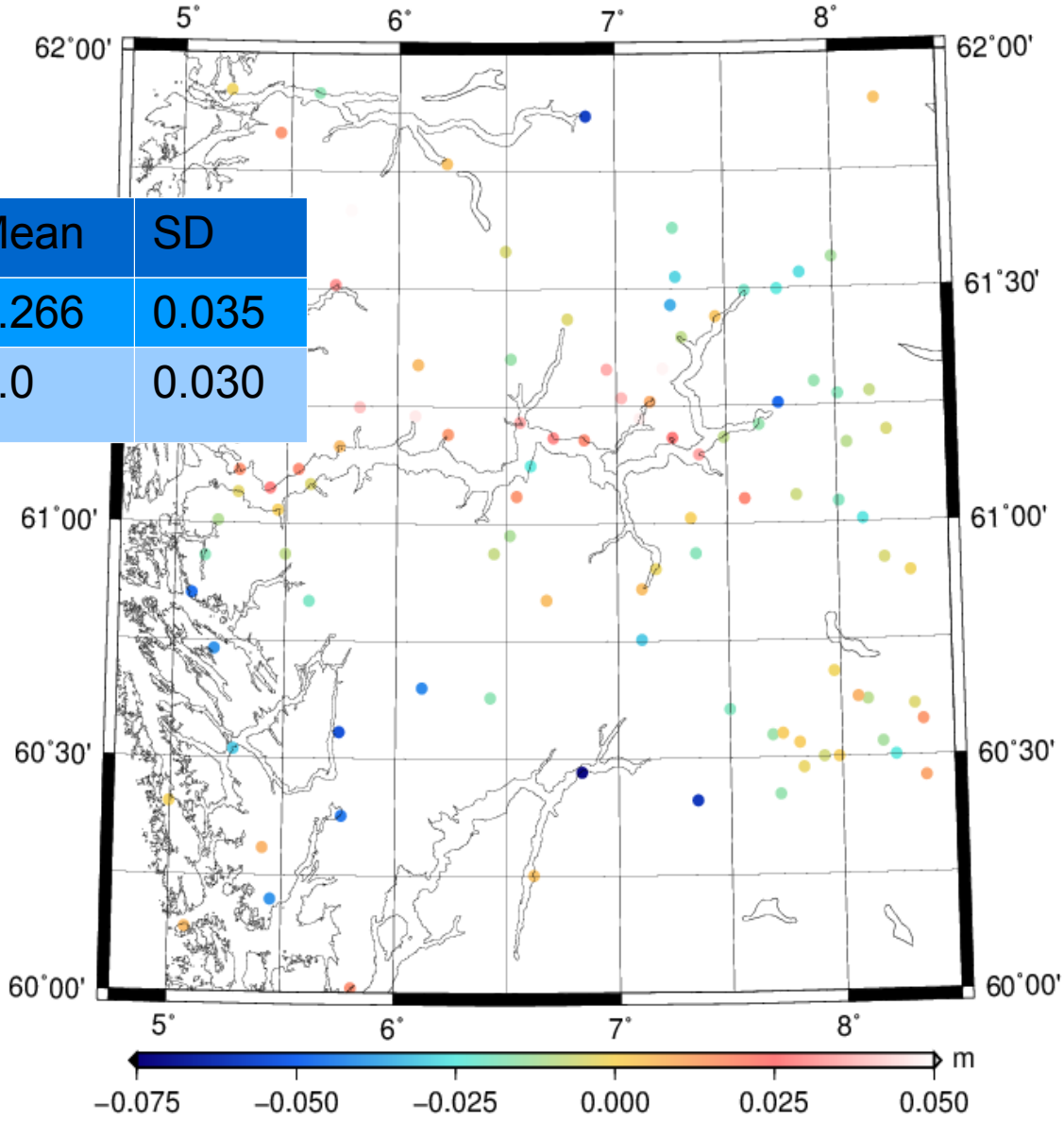
Norwegian west coast: geoid with marine gravity data fits the GPS/leveling at 3.0 – 3.5 cm

Detrend	#	Min	Max	Mean	SD
Before	113	0.173	0.397	0.266	0.035
After	113	-0.073	0.119	0.0	0.030



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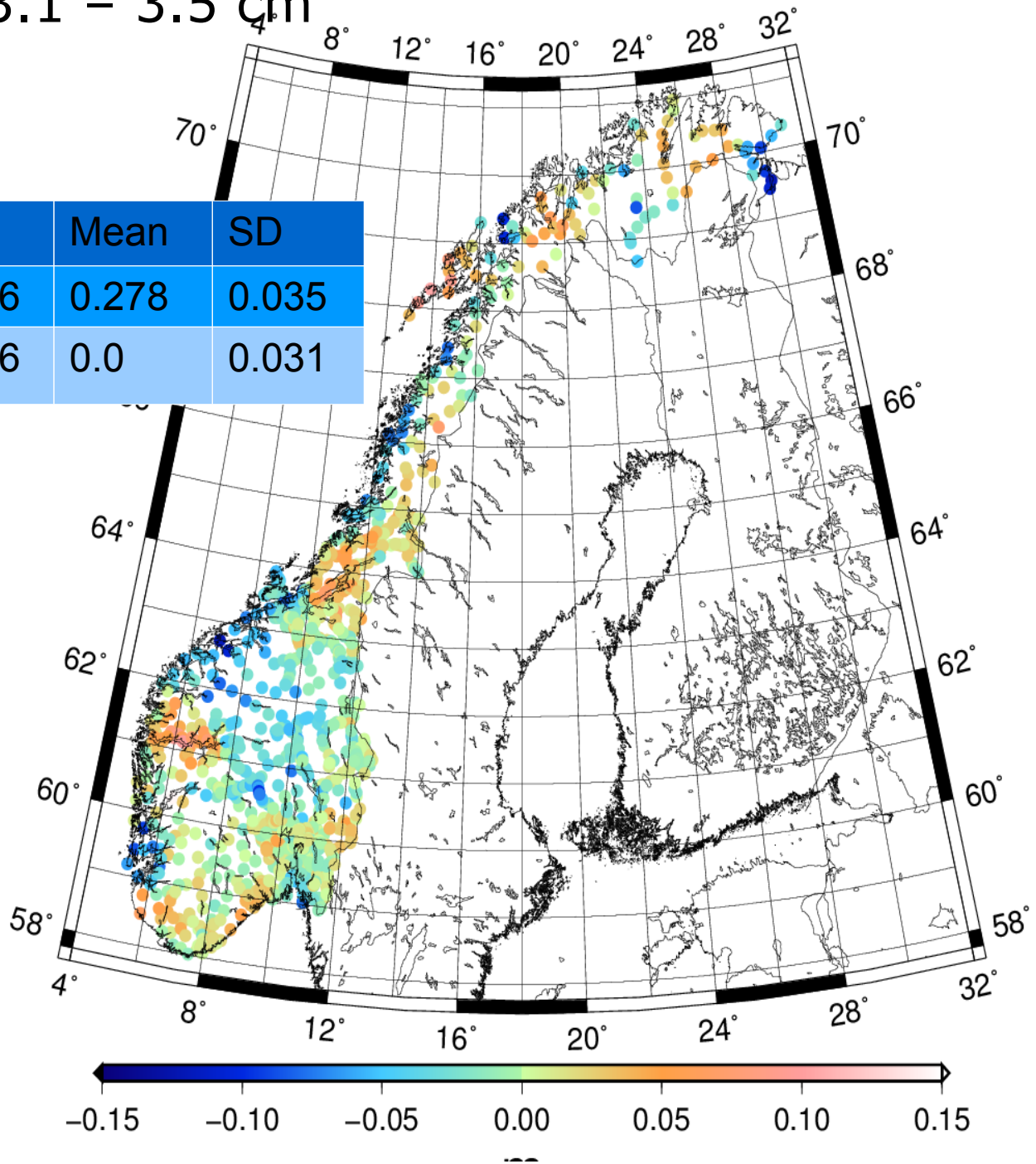
Geoid covering mainland of Norway fits the GPS/leveling at 3.1 – 3.5 cm

Detrend	#	Min	Max	Mean	SD
Before	1344	0.129	0.396	0.278	0.035
After	1344	-0.121	0.146	0.0	0.031



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… still hunting that 1 cm geoid

ζ – GPS - Leveling

~6 cm → 3.1 cm

Marine gravity:

- improves the geoid

- cheap and expensive