LANTMÄTERIET

EXPERIENCES AND RESULTS FROM FIVE YEARS OF MEASUREMENTS WITH LANTMÄTERIET'S ZLS DYNAMIC GRAVIMETER (ZLS D13)

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Abstract

2017 Lantmäteriet (the Swedish mapping, cadastral and land registration authority) purchased a dynamic gravimeter from ZLS Corporation. It was partly financed by EU via the FAMOS project. The main purpose with the gravimeter was to perform marine gravity measurements in order to check and complement older gravity data in the Baltic Sea - one of the sub activites in the FAMOS project. During 2017-2020 comprehensive campaigning was accomplished for production of data for the FAMOS database.

Here we show that the standard uncertainty of one measurement is estimated, based on internal cross over analysis, to less than 0.7 mGal for the marine measurements and even better in lake Vättern. We also compare with old datasets from the NKG gravity database and in general find good agreement. It is clear, though, that the old data were too sparse and that the new data significantly will improve indata grid for new geoid models. The airborne campaign also revealed an unmodeled scale factor that caused an offset of 1.4 mGal in the results. We also present some experiences gained during these years concerning e.g. drift, waves, installations, harbour ties etc.

The campaigns

Since 2017, 3 so called "piggy-back" campaigns and 10 dedicated 8 x 24 hours campaigns have been conducted, covering more or less the whole Swedish marine economic zone to a density of approximately 10 km between the lines. Apart from that also one airborne campaign over Kattegat, one dedicated campaign in the Gulf of Finland and one dedicated campaign in Sweden's second largest lake, Vätten, have been completed.

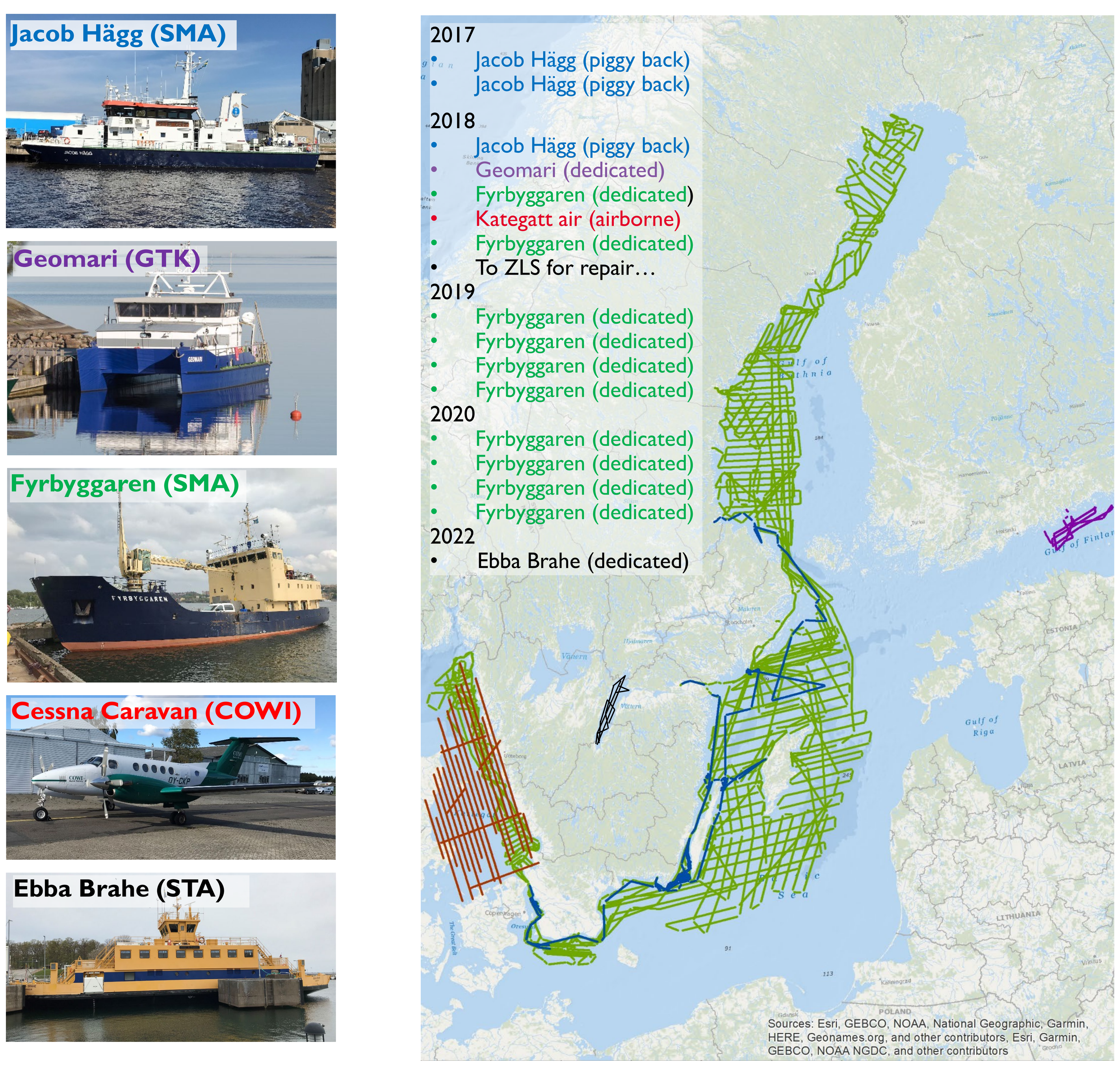

Figure 1. Vessels used and the tracks measured with Lantmäteriet's dynamic gravimter, ZLS D13, during 2017-2022

Results

Internal cross-over analyses indicate a measurement uncertainty (1σ) of less than 0.7 mGal for marin gravity measurements (Figure 2 and Table 1). Comparison with old data from the NKG databasae (NKG2015) (Table 2) and new marin gravity data from the FAMOS_ver2 database (Table 3) normally agree in the mean within 1 mGal with a standard deviation less than 2 mGal. A comparison of ZLS D13 data and the NKG 2015 grid shows good agreement in areas with observation but significant differences (±10 mGal) in areas with sparse (e.g. the proper Baltic Sea south of Åland islands) or no data (e.g. along the Swedish west coast) (Figure 3 and 4).

Table 1. Internal cross over statistics for all measurements with ZLS D13 and for only those with Fyrbyggaren

	ZLS-D13	Fyrbyggaren
No xo	1720	1375
Mean	0.00	0.06
StdDev	0.92	0.85
Max	3.84	3.50
Min	-4.76	-2.83
$StdUnc_{D13}$	0.68	0.65

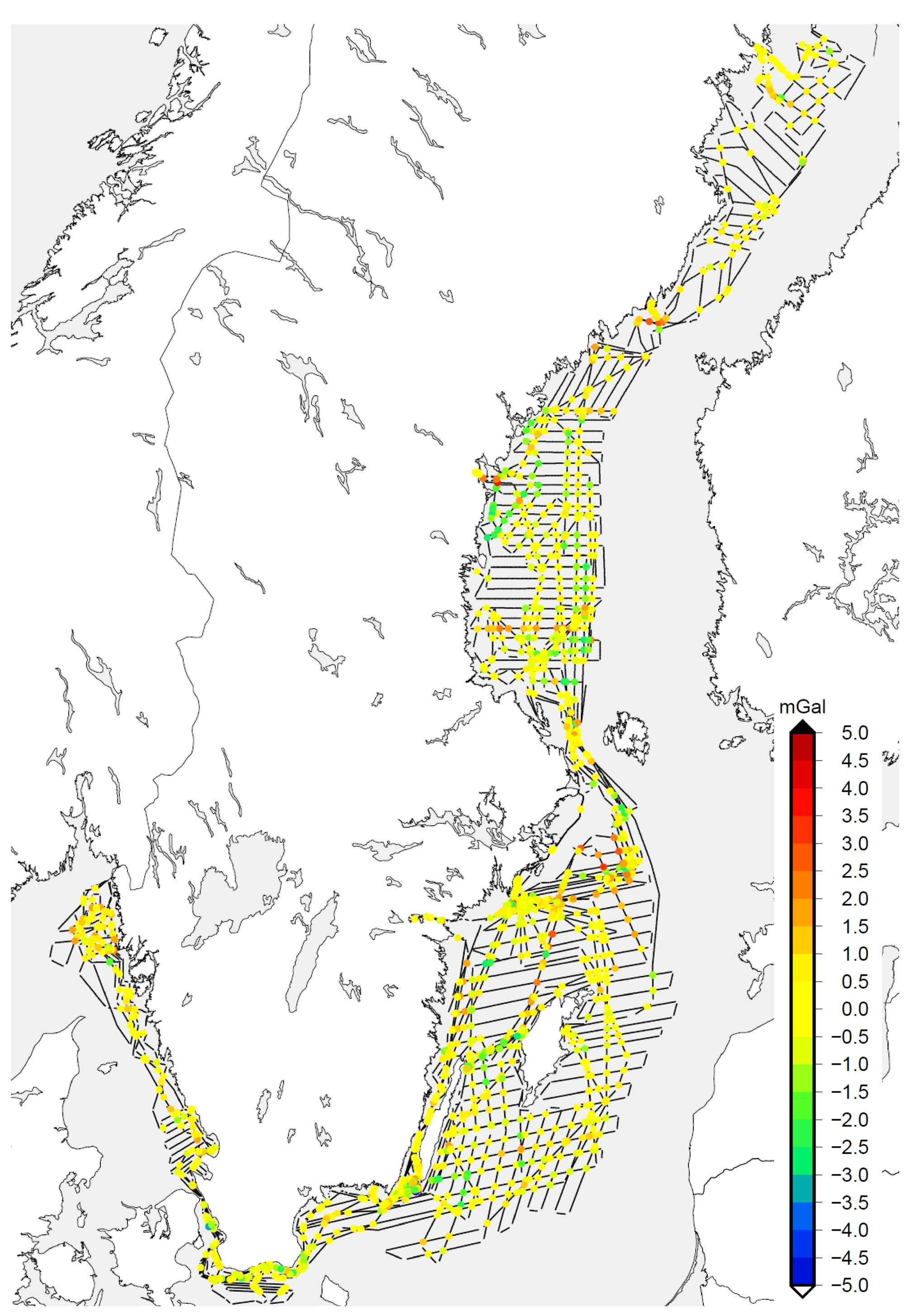

Figure 2. Internal cross over differences for marine gravity measurements with ZLS D13, during 2017-2022

Table 2. Comparison of old data from the NKG2015 dataset and the new ZLS D13 data.

Publication no	Remarks	Mean	StdDev	Min	Max	Count	Search rad
42	Marine: Danish 1970	5,18	4,04	-1,38	15,82	20	2 km
322	Ice data + Finnish land data + sea bottom data, Kiviniemi, bottom always conv. to surface	0,09	0,99	-2,51	2,28	37	3 km
330	Ice gravity measurements, Gulf of Bothnia	0,72	1,51	-1,45	3,1	6	3 km
332	Ice gravity measurements, Gulf of Bothnia	0,64	0,98	-1,51	4,01	96	3 km
351	Marine Fehmarn 1973	2,47	1,56	-0,31	4,4	11	2 km
358	Ice gravity measurements, Gulf of Bothnia	0,67	1,50	-3,55	3,71	30	3 km
610	Marine Haakon Mossby 1996	-0,25	1,19	-6,71	4,49	352	2 km
616	NKG airborne 1999	-0,78	1,99	-11,4	5,56	632	2 km
NKG2015_grid		-0,43	2,54	-21,18	20,69	51338	2 km

Table 3. Comparison of marine gravity data from the FAMOS_ver2 dataset and the ZLS D13 data.

Publication no	Remarks	Mean	StdDev	Min	Max	Count	Search rad
367	Urd 2017, resampled to one observation every 60 seconds	0,55	0,85	-1,82	2,45	89	2 km
368	Airisto 2015	1,13	1,01	-1,17	7,32	218	2 km
369	Jacob Hägg 2016	-0,26	1,34	-4,19	3,47	209	2 km
377	Deneb 2015	-	-	-	-	-	
378	Deneb 2016	-0,63	0,59	-1,79	0,83	55	2 km
379	Deneb 2017	-		-	-	-	
397	Jacob Hägg 2015	0,34	1,36	-4,9	5,12	200	2 km
FAMOS_LM6a_ver2_grid		-0,29	2,32	-21,17	15,45	51338	2 km

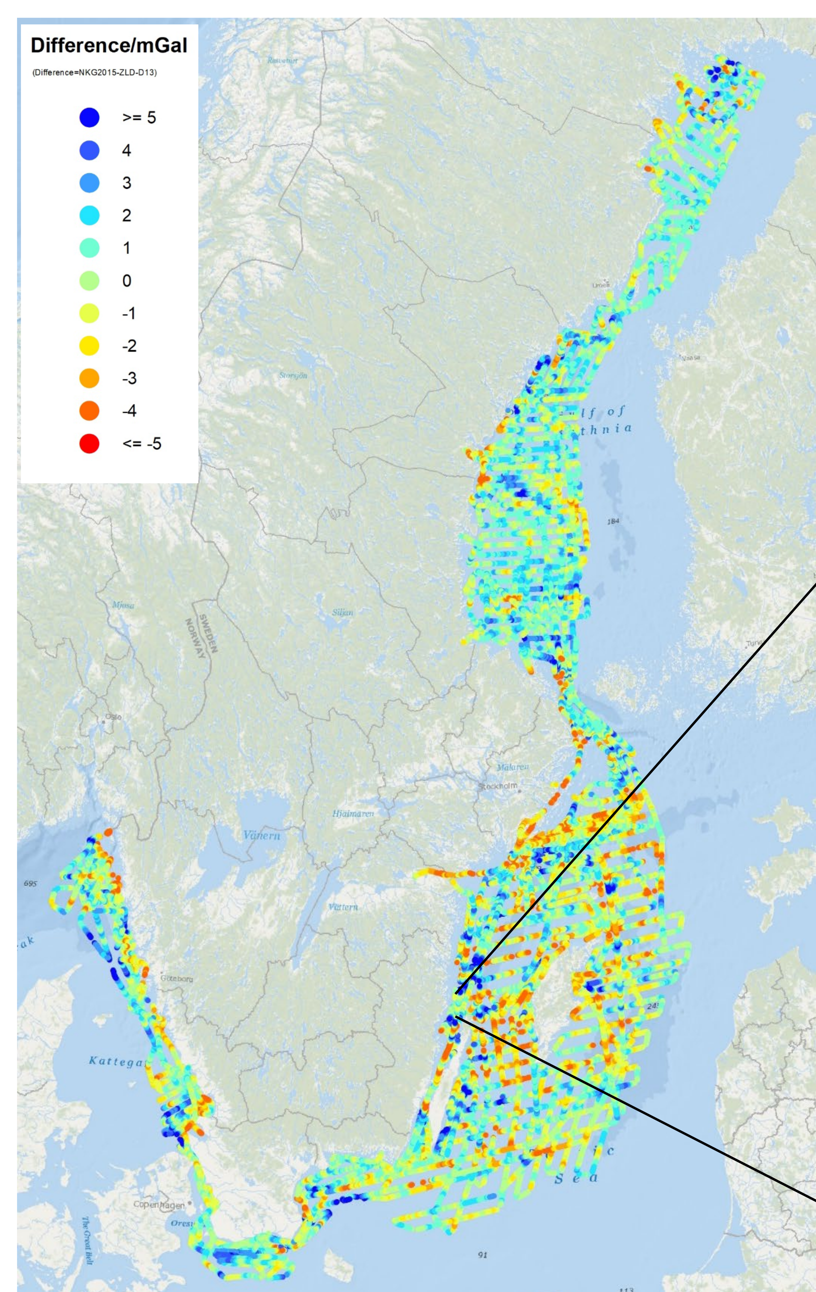

Figure 3. Differences between ZLS D13 data and the NKG2015 grid.

Table 4. Statistics for comparison between ZLS D13 data and the NKG2015 grid.

No xo	51338
Mean	-0.43
StdDev	2.54
Max	20.69
Min	-21.18

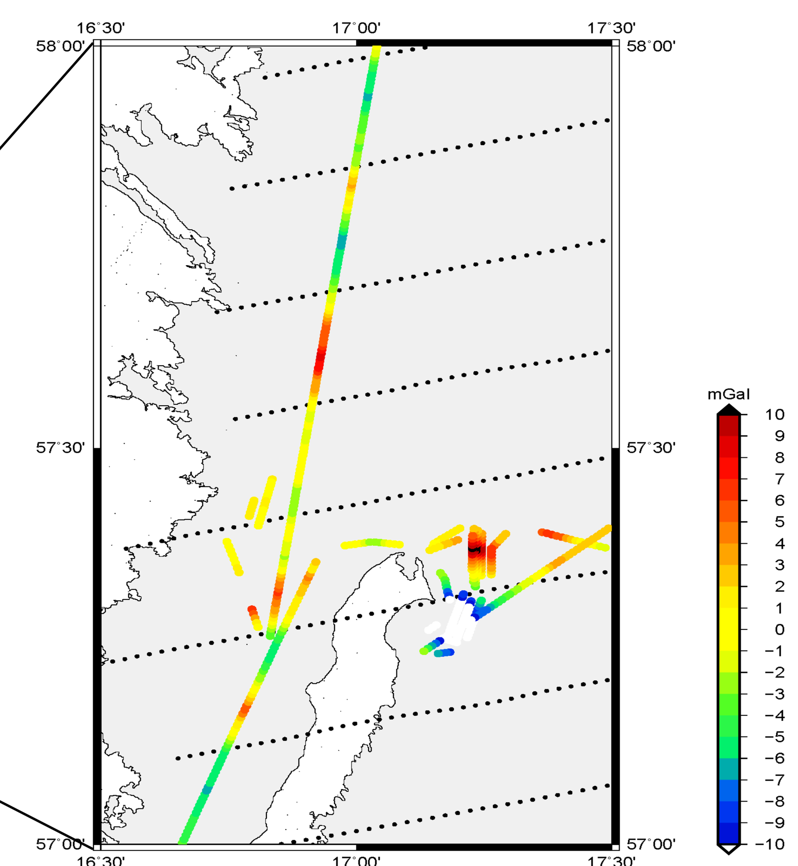

Figure 4. Differences between ZLS D13 data and the NKG2015 grid showing good agreement in areas close to observations (black dots represent data from NKG airborne campaign 1999) and larger differences in areas between observations (±10 mGal). Distance between airborne lines is approximately 15 km.

Experiences gained

Comparsions of data from the airborne Kattegatt campaign and marine gravity measurements, both with the same instrument, revealed an until then unknown scale error in the instrument (Fonseka, 2020) resulting in an offset between airborne and marine data of some 1.4 mGal. Investigations have shown that this scale error has no significant effect on the marine gravity measurements since all campaigns, if extended in north-south direction, have good harbour ties in both ends (where the gravity difference is largest). This shows the importance of regular harbour ties, especially if the gravity differences are large.

In 2018 the instrument was damaged by water leakage and had to be sent to ZLS for repair. Before that accident the drift in the instrument was around 1 mGal/day, mostly due to cycle slips between physical and digital spring tension values. After the repair this problem was solved and the drift was then more or less 0.

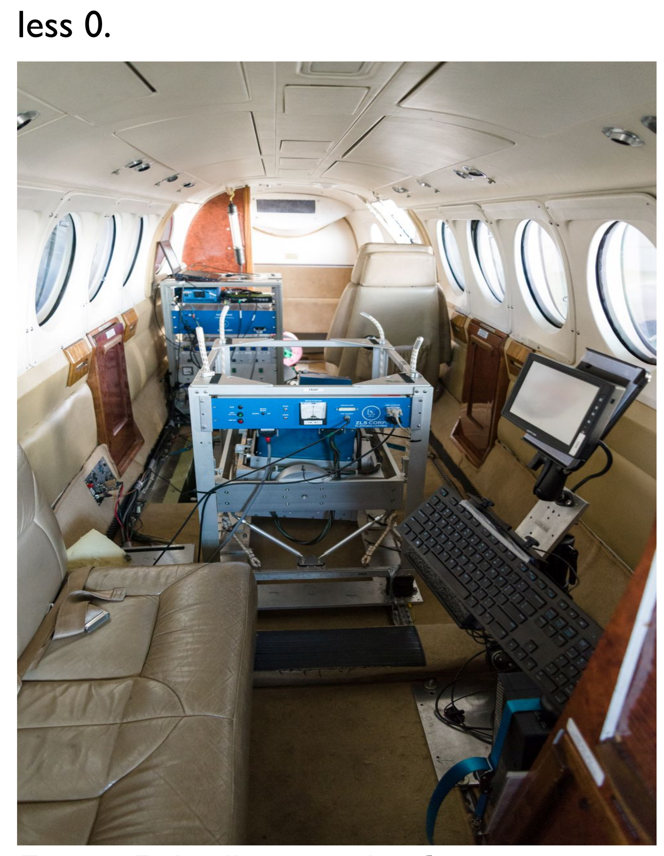

Figure 5. Istallation in the Cessna Caravan ariplane

Figure 6. Installation at the Geomari Research vessel

References

Fonseka P. G. C. C. (2022), *Evaluation of airborne and marine gravity data over Kattegat region.* Master Thesis, University of Gävle.