Combination of Marine and Altimetric Gravity Data for Geoid Determination

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1 Introduction

For the effective determination of high resolution geoid models, off-shore gravity data of the surrounding marine areas are required besides the land data in order to reduce truncation and edge effects. In view of European geoid computations, crossover adjusted ship gravity data are combined with altimeter derived anomalies from the KMS2002 model for the area 10°N - 82°N and 60°W - 70°E.

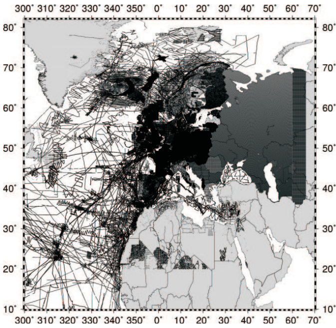

Fig. 1. Terrestrial gravity data.

Several problems exist with the combination of ship and altimetric data that result from the data collection and processing. While the altimetric anomalies (KMS2002) are roughly reduced to the geoid through the processing scheme with an arc-wise fitting of the sea surface heights to a global geopotential model, the ship data are referring to the sea surface at the time of observation, thus including the effect of the dynamic topography. Moreover, additional data inconsistencies may exist (e.g., systematic errors remaining after the crossover adjustment of the ship data, etc.). Regarding the data quality, recent satellite-positioned ship gravity data have a high point-wise accuracy, but are available only along the ship tracks. On the other hand, the altimeter data are usually less accurate, but are available ocean-wide with homogeneous accuracy.

2 Data combination

In this study, the problem of the dynamic topography and other data inconsistencies is handled in the following ways:

A) ignore problem, use ship and altimetric data as is
B) determine conversion surface by least-squares prediction from the differences $g_{conv} = g_{ship} - g_{alt}$ (correlation length 225 km, noise from input data file)
C) as B, but additional low-pass filtering based on 2°x2° geographical bins.

The conversion surface is then used to convert all data to the same target system:

a) ship system (correct altimetric data by $g_{alt,cor} = g_{alt} + g_{conv}$; implicitly assumes that the ship data have higher quality)
b) altimetric system (correct ship data by $g_{ship,cor} = g_{ship} - g_{conv}$; implicitly assumes that the altimetric data have higher quality).

The merging of the ship and altimetric data is done by two methods:

1) weighted mean of both data sets using the actual standard deviations
2) least-squares prediction (correlation length 20 km, noise from input data file).

The above described handling of the data inconsistencies leads to the following merged gravity anomaly data sets:

Data Set	Conversion Surface	Target System	Merging
A-1 / A-2	-	-	1 / 2
Ba1 / Ba2	B	a	1 / 2
Bb1 / Bb2	B	b	1 / 2
Ca1 / Ca2	C	a	1 / 2
Cb1 / Cb2	C	b	1 / 2

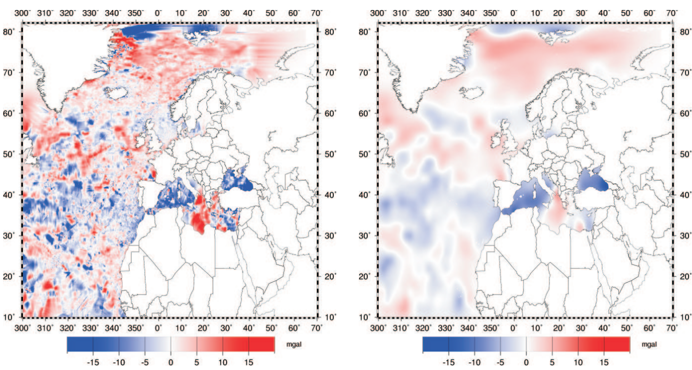

Fig. 2. Conversion surface B (left) and C (right).

3 Results

The combined gravity data sets are converted to height anomalies by the spectral combination technique using EGM96 as the reference model. The spectral weights are below 1.0 for degrees less than 50, i.e. the long wavelength gravity field components are not recovered from the gravity data. In all computations the zero degree terms are neglected. The results are evaluated by altimetric data and GPS/levelling data.

Table 1. Statistics of the differences CLS-geoid (CLS01-MSS + CLS-RIO03-DOT) minus gravimetric geoid.

		A_1	Ba1	Bb1	Ca1	Cb1
mean	[m]	-0.491	-0.544	-0.474	-0.544	-0.477
std.dev.	[m]	0.240	0.530	0.228	0.351	0.230
min.	[m]	-2.835	-2.827	-2.963	-2.263	-2.895
max.	[m]	2.346	4.060	1.827	2.331	2.298
		A_2	Ba2	Bb2	Ca2	Cb2
mean	[m]	-0.465	-0.531	-0.463	-0.531	-0.463
std.dev.	[m]	0.217	0.327	0.218	0.327	0.217
min.	[m]	-2.860	-2.252	-2.869	-2.252	-2.865
max.	[m]	2.238	2.225	1.909	2.225	2.197

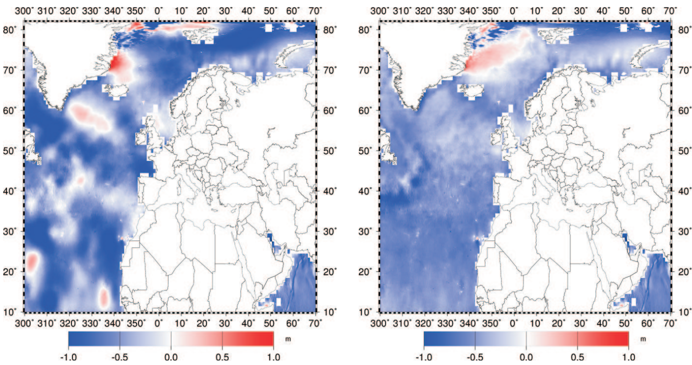

Fig. 3. Differences CLS-geoid minus gravimetric geoid Ca2 (left) and Cb2 (right).

Table 2. Statistics of the differences EUVN GPS/levelling data minus gravimetric geoid (after bias fit).

		A_1	Ba1	Bb1	Ca1	Cb1
std.dev.	[m]	0.264	0.326	0.250	0.302	0.243
min.	[m]	-0.911	-0.865	-1.006	-0.877	-0.941
max.	[m]	1.409	2.280	1.222	2.096	1.245
bias	[m]	-0.584	-0.557	-0.590	-0.582	-0.593
NS-tilt	[ppm]	0.087	0.105	0.095	0.083	0.093
EW-tilt	[ppm]	-0.088	-0.150	-0.101	-0.117	-0.101
		A_2	Ba2	Bb2	Ca2	Cb2
std.dev.	[m]	0.245	0.298	0.240	0.298	0.236
min.	[m]	-0.971	-0.913	-1.000	-0.913	-0.973
max.	[m]	0.757	1.713	0.699	1.713	0.709
bias	[m]	-0.591	-0.582	-0.592	-0.582	-0.595
NS-tilt	[ppm]	0.096	0.089	0.090	0.089	0.089
EW-tilt	[ppm]	-0.080	-0.116	-0.088	-0.116	-0.089

4 Conclusions

- the merging by least squares prediction (method 2) shows better results than the weighted mean (method 1)
- the conversion to the altimetric system (target system b) shows smaller standard deviations in all comparisons (independent of conversion surfaces B or C)
- conversion surface C in connection with target system b gives the best results

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