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Use of GOCE L2 Gravity Gradients for full resolution Geoid

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Abstract

The objective of this study is to develop methodology to use GOCE gravity gradients for enhanced geoid modelling and ocean circulation modelling.
In specific regions with a rough gravity field, the resolution of the geoid may be enhanced substantially if GOCE gradiometer data are used in addition of the GOCE spherical harmonic coefficient model (EGMs) since in such areas the GOCE gradients contain more information than the EGM itself. Hence, the use of gradients may lead to improve the resolution of e.g. the marine geoid which in turn will improve the estimation of the ocean circulation. This is tested using GOCE gravity gradient data, the GEOCOL program (GRAVSOFT) and Reduced Point Mass (RPM) program. Tests are carried out in the GOCINA region and in the Mediterranean basin. Furthermore, the effect of the decreasing height of the GOCE satellite on gravity gradients and associated MDT is investigated.

Methodology

To investigate if a higher accuracy could be obtained by the direct use of GOCE satellite gradients, prediction of geoid height data was done in two different areas: GOCINA (North Atlantic) [1] and Mediterranean region. In both regions, local geoid height prediction was done using two methods, one of them being Least-Squares Collocation (LSC, [2]) and the other the Reduced Point Mass (RPM, [3]).
The results presented in this study are based on all available GOCE gradient data (from November 2009 to September 2013), but computed for three different data timeseries (**Fig. 1**):

- from November 2009 to July 2012 (nominal GOCE orbit)
- from August 2012 to September 2013 (lowered GOCE orbit)
- from November 2009 to September 2013

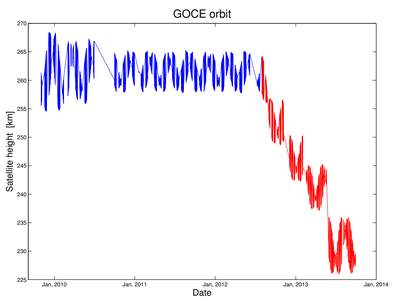

Figure 1: GOCE satellite orbit height

To ensure that the contribution of the masses outside the test areas can be neglected, truncation of the long wavelength part of the gravity field (up to degree and order 100) is performed (see **Fig 2**).

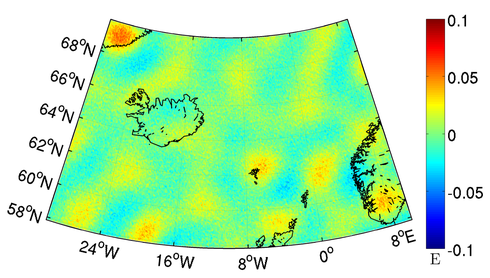

Figure 2a: Truncated Tzz (contribution up to sph d/o 100 is subtracted) in GOCINA region.

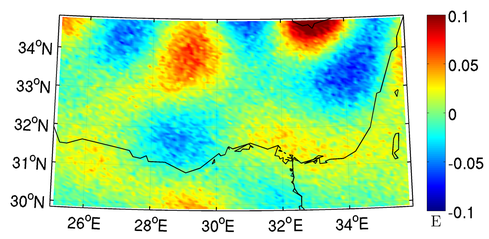

Figure 2b: Truncated Tzz (contribution up to sph d/o 100 is subtracted) in Mediterranean region.

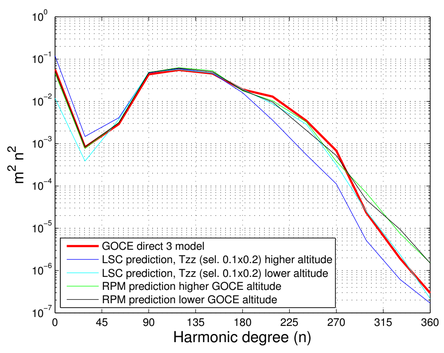

Figure 3a: Gocina power spectrum of predicted geoid height by separate datasets for lower/higher GOCE altitude

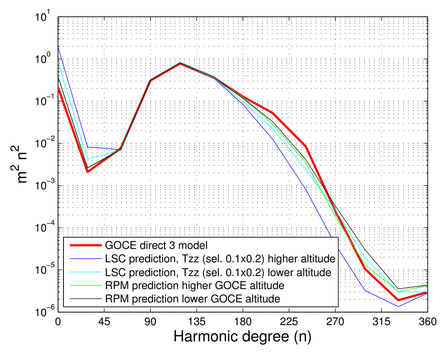

Figure 3a: Mediterranean power spectrum of predicted geoid height by separate datasets for lower/higher GOCE altitude

Comparison of geoid predicted by using two datasets: when GOCE satellite was in 255km orbit (Nov/2009 to Jul/2012) and when orbit was reduced (Aug/2012 to Sep/2013) showed no additional information in lowering of the satellite. (see **Fig 3a** and **3b**).

The model for the ocean Mean Dynamic Topography (MDT) is computed by removing the computed geoid based on the GOCE Time-wise global geopotential model (release 5, Tim5), enhanced by GOCE Tzz gradients, from the DTU10 Mean Sea Surface (MSS) [4].

GOCINA

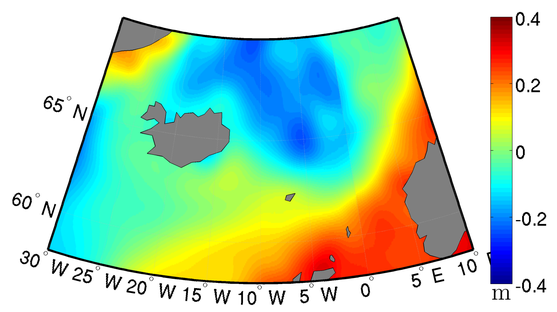

Figure 5a: Gocina DTU10 MDT

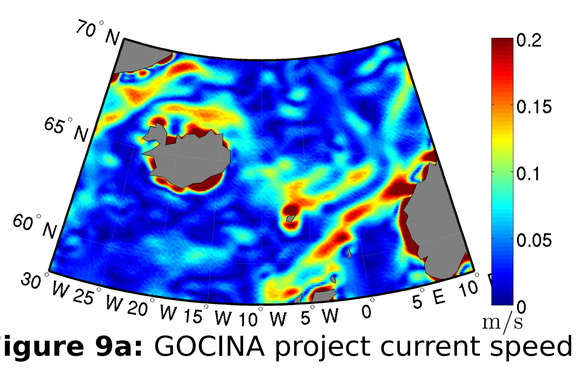

Figure 9a: GOCINA project current speed

Mediterranean

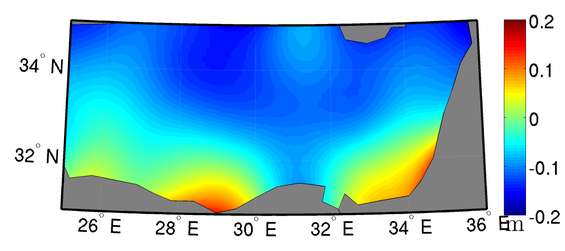

Figure 5b: Mediterranean DTU10 MDT

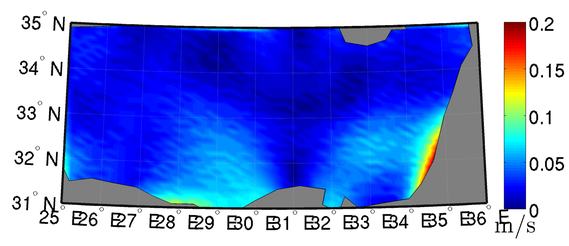

Figure 9b: Mediterranean DTU10 current speed

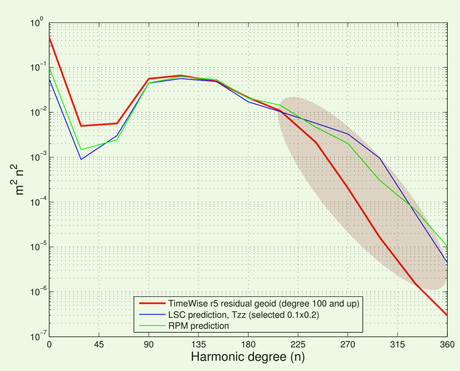

Figure 6a: Gocina Tim5 enhanced geoid power spectrum

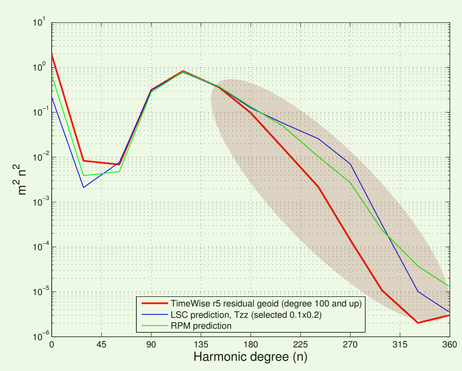

Figure 6b: Mediterranean Tim5 enhanced geoid power spectrum

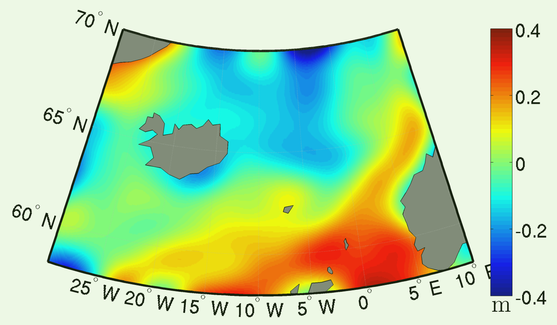

Figure 7a: Gocina Tim5 enhanced MDT (2° filter)

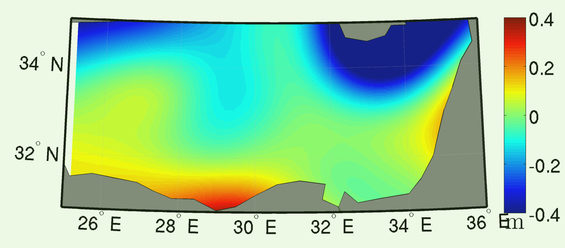

Figure 7b: Mediterranean Tim5 enhanced MDT (2° filter)

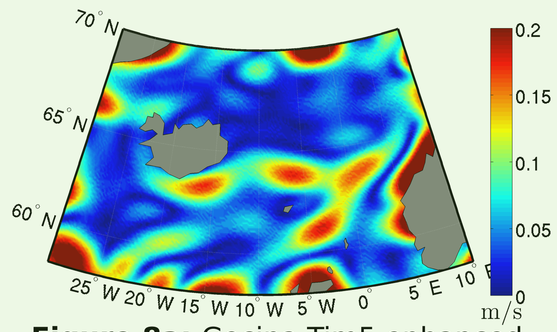

Figure 8a: Gocina Tim5 enhanced current speed (2° filter)

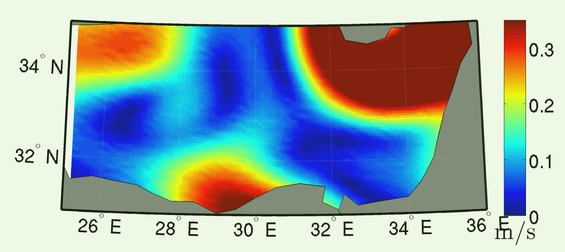

Figure 8b: Mediterranean Tim5 enhanced current speed (2° filter)

Discussion

Comparison of geoid predicted by using higher GOCE orbit (Nov/2009 to Jul/2012) and when orbit was reduced (Aug/2012 to Sep/2013) showed no additional information in lowering of the satellite. However, when both datasets are used (full GOCE Tzz dataset: Nov/2009 to Sep/2013), comparison shows improvement in the geoid determination using Tzz gradients in the spectral band from the sph. harm. degree 180 to 280.
The surface geostrophic currents calculated from the GOCE Direct MDT current speeds reveal that all of the gross features of the general circulation in the region are clear. However, the MDT calculated in the GOCINA project shows the smallest scale details, which makes it the best ocean circulation representation in this region.

References

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