# A Global Mean Ocean Circulation Estimation using GOCE – DTU12MDT

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**Summary**
The Gravity and Ocean Circulation Experiment - GOCE satellite mission measure the Earth gravity field with unprecedented accuracy leading to substantial improvements in the modelling of the ocean circulation and transport. In this study of the performance of GOCE, a newer gravity model have been combined with the DTU10MSS mean sea surface model to construct a global mean dynamic topography model. The results of preliminary analyses using preliminary GOCE gravity models clearly demonstrated the potential of GOCE mission. Both the resolution and the estimation of the surface currents have been improved significantly compared to results obtained using pre-GOCE gravity field models. The results of this study show that geostrophic surface currents associated with the mean circulation have been further improved and that currents having speeds down to 5 cm/s have been recovered.

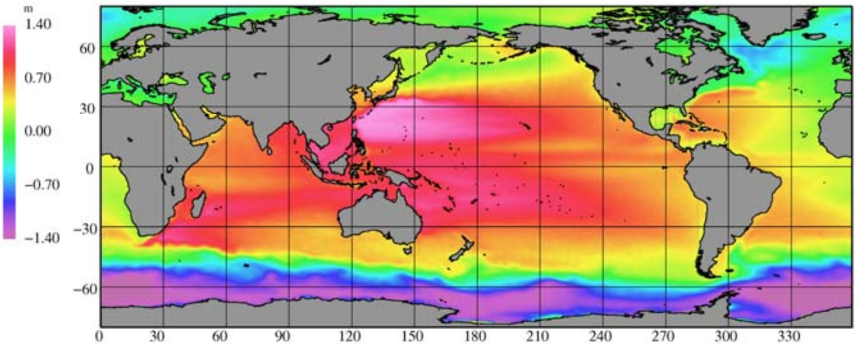

Figure 1. MDT based on GOCE gravity field model DIR rel.1.

**Computation of the Mean Dynamic Topography**
The MDT is obtained by MDT = MSS – *N.* As mean sea surface the DTU10MSS is used. The geoid is computed using EIGEN-6C gravity model (Förste et al, 2011). Subsequently, a proper filtering of the differences is required to eliminate the short scale geoid signals that are not recovered by the gravity model, to obtain a useful estimate of the MDT. Usually, the filtering is carried out using the isotropic truncated Gaussian filter with a half-width at half-maximum around 1.0 spherical degree. An example is shown in Figure 1.
In this study where the EIGEN-6C model is used, the unmodelled parts of the geoid is much smaller because EIGEN-6C is a combination model where, e.g., GOCE, GRACE and surface gravity based on satellite altimetry have been used. In addition, the shorter wavelength part of the geoid were removed using the EGM2008 geopotential model (Pavlis et al, 2008). Naturally, the use of altimetric gravity over the oceans will not improve the estimation of the MDT but less filtering is required. In this computation an isotropic truncated Gaussian filter with a half-width at half-maximum of 0.75 spherical degrees was used. Approaching the Equator an an-isotropic filter was used to overcome problems with stripes. Furthermore, the computation of geostrophic current components, especially the North-south velocity, was regularised at the Equator. The resullting geostrophic surface flows are shown in Figure 2.

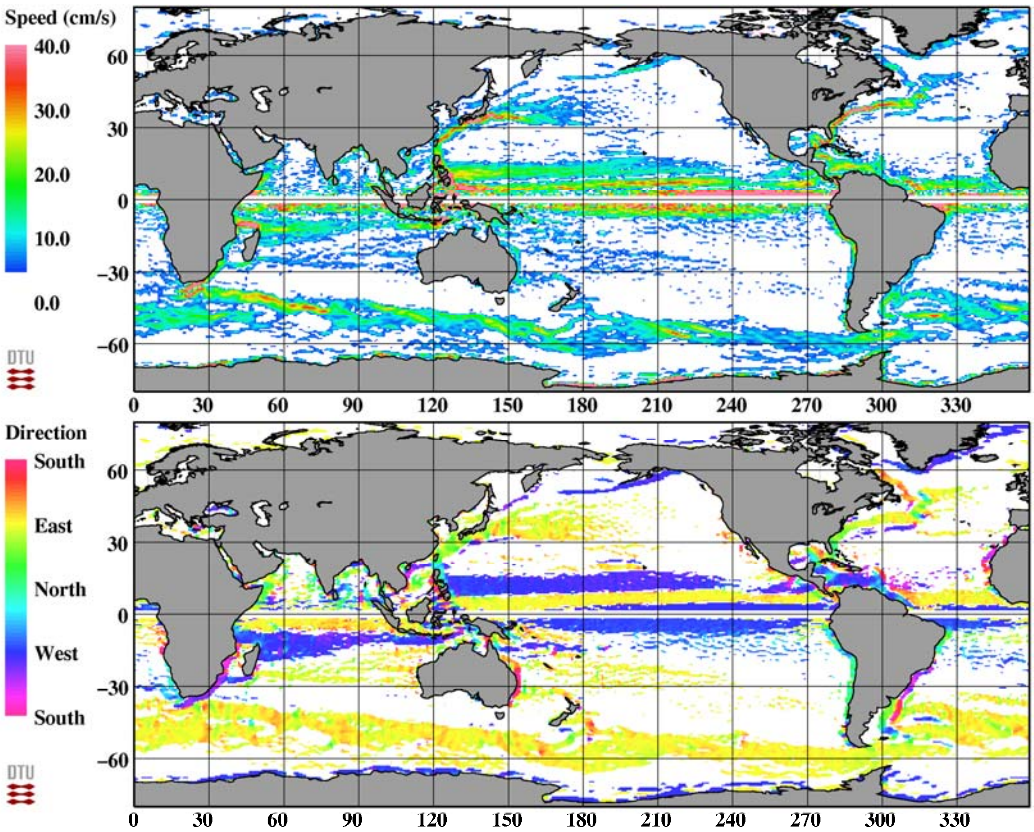

Figure 2. Geostrophic surface current speed and direction from MDT based on the EIGEN-6C model for speeds > 5cm/s

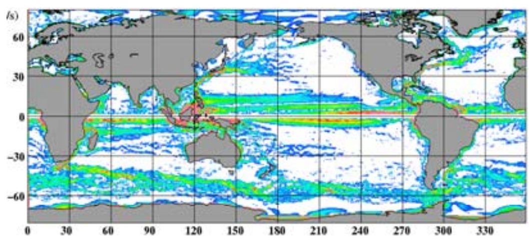
Figure 3. Geostrophic surface current speed from Maximenko's MDT. (Same colour scale as in Figure 2.)


The Gravity field and steady-state Ocean Circulation Explorer (GOCE)

**Evaluation**
The evaluation of the GOCE preliminary MDT is carried out through comparisons with an MDT based on oceanographic in-situ data constructed by Maximenko et al. (2009). The comparisons are carried out using the associated geostrophic surface current components, mainly, since the MDTs appear very similar.

*Global comparisons*
Both the GOCE based geostrophic surface currents (Figure 2) and the currents based on Maximenko's MDT (Figure 3) display the flows of the major current systems very clearly and consistently.

Going into a more detailed comparison of the recovered sub-current systems and their different flow paths, the GOCE flows agree very well with the Maximenko flows; e.g. in the Equatorial Pacific where the Westward flow of the Equatorial current and the Eastern flow of the North Equatorial Pacific current displayed by the GOCE flows are found in the Maximenko flows as well. Hence, the enhanced details in the GOCE MDT are consistent with the oceanographic in-situ data that was used in the derivation of the Maximenko MDT.

Ref.: Knudsen, P., R. Bingham, O. Andersen, M.-H. Rio, Enhanced Mean Dynamic Topography and Ocean Circulation Estimation using GOCE Preliminary Models, J. of Geodesy, 2011, DOI 10.1007/s00190-011-0485-8.

**Discussion**
The GOCE MDT display the well known features related to the major ocean current systems. In addition, the GOCE gravity model has enhanced the resolution and sharpened the geometry of those features. A computation of the geotrophic surface current speeds clearly display the improvements in the description of the current systems. Sub-current systems and their different branches and flow paths are revealed. The results of this analysis using a newer GOCE gravity model clearly demonstrate the success of GOCE mission. Future GOCE models are expected to further enhance studies of the ocean circulation.
The computation of the MDTs followed the recommendations from the GOCE User Toolbox (GUT) tutorials applying the so-called space domain method. With no doubt the filtering may be improved by incorporating elements of the spectral method especially for eliminating the influence of the short scale geoid. Also the use of optimal filtering methods where the actual error covariances are taken into account may lead to improvements and, in turn, provide error estimates of the filtered MDT.

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GOCE