Synthetic Mean Dynamic Topography Models In The North Atlantic

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SUMMARY

One of the goals of the EU project GOCINA (Geoid and Ocean Circulation in the North Atlantic) is to compute a synthetic mean dynamic topography (MDT), which is the difference between the mean sea surface and the geoid. The mean dynamic topography provides the absolute reference surface for the ocean circulation.
The improved determination of the mean circulation will advance the understanding of the role of the ocean mass and heat transport in climate change.

New synthetic mean dynamic topography models have been computed from the best available geoid models (EGM96, GRACE, GOCINA03P) and the new mean sea surface model KMS03. These models will be compared with state of the art mean dynamic topography models in the North Atlantic GOCINA area.

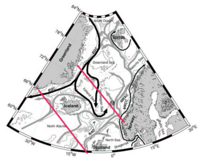
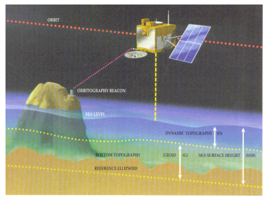


Fig. 1: The GOCINA area

GEOID, MEAN SEA SURFACE, AND MEAN DYNAMIC TOPOGRAPHY



Differences in the ocean water density, winds, and variations in atmospheric pressure cause the mean sea surface to depart from the geoid resulting in the mean dynamic topography.

Fig. 2: Sketch showing the relationship between the geoid , the mean dynamic topography, and the mean sea surface.

EXISTING MEAN DYNAMIC TOPOGRAPHIES

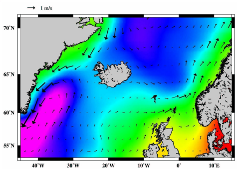


Fig. 3a: MDT model computed from the OCCAM OGCM (Ocean General Circulation Model), assimilating both altimetric data and in-situ measurements.

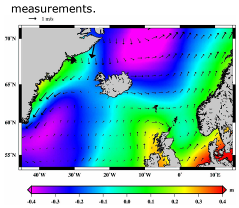


Fig. 3b: CLS MDT model computed using the "geoid synthetic" technique.

Traditionally MDT computations were based on climatology (e.g. the Levitus model), but other methods are now in use. Among these is the "geoid synthetic" method where absolute dynamic topography deduced from in-situ measurements is compared to altimetric SLA. Another method is to derive the MDT from ocean general circulation models (OGCMs).

Several mean dynamic topography models in the GOCINA area have been investigated. The best of these show good overall coincidence in the mean circulation pattern although made from different methods.

Fig. 3:
Except in the costal area northeast of Greenland the OCCAM and the CLS MDT models are very similar. Along the northwestern European coast and the eastern coast of Greenland, the water level is roughly 50 cm higher than in the area southeast of Greenland. This results in a circulation pattern very similar to figure 1. Both the Irminger Current southeast of Greenland, the East Greenland Current (EGC), the Northwest Atlantic Current (NWAC) along the coast of Norway, and the East Iceland Current northeast of Iceland are very clear.

THE GOCINA03P GEOID

To compute a good synthetic MDT requires both a good mean sea surface and an accurate geoid. In most marine areas the gravimetric geoid is not known with sufficient accuracy to allow full use of the mean sea surface information. However, in a few regions sufficient in-situ information about the Earths gravity field exists to compute a more accurate geoid. The GOCINA area is one of those regions.

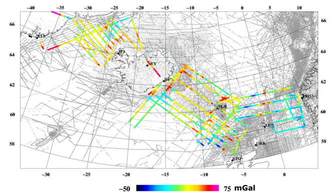


Fig. 4: The new airborne free air anomalies used for the calculation of GOCINA03P. Excisting gravity data are shown as gray dots.

GOCINA03P is a KMS geoid for the Nordic area and Greenland calculated by R. Forsberg. It has GGM01 as reference and is using both marine and airborne gravity data. Recent the geoid has been updated with new airborne data (survey performed summer 2003). This new data is connecting and verifying the excisting data. Satellite altimetry (KMS02 gravity field) is draped in gravity data voids.

THE KMS03 MEAN SEA SURFACE

The newest version of the KMS Mean Sea Surface is derived from a combination of T/P, T/P tandem mission, ERS1, ERS2, Geosat, and GFO data. The resolution of the mean sea surface is 2 minutes corresponding to 1/30 degree, which is equivalent to 4 km at the Equator.

Unlike for older surfaces a method has been included to account for the inter-annual ocean variability (like the major El-Niño event in 1997-98).

The model is based on 9 years of data, consistent with the period of the investigated MDT models.

OTHER GEOIDS

Besides the GOCINA03P geoid (see box) two global geoid models have been investigated in the GOCINA area. One is the well-known EGM96 that consists primary of altimetry data in the area and is relatively smooth.

A new geoid has also been produced. To degree and order 65 it is based on the GGM01 gravity field from the GRACE satellite. From degree 65 to degree 95 there is a smooth transition from GGM01 to EGM96. Above degree and order 95 the geoid is solely based on EGM96.

SYNTHETIC MEAN DYNAMIC TOPOGRAPHIES FROM MEAN SEA SURFACE AND GEOID

Three MDT models produced from the KMS03 mean sea surface and the selected geoids (EGM96, GGM01/EGM96, GOCINA03P) are shown here. They are all upward continued to 100 km to get a smoother model. The geostrophic ocean surface currents are obtained from the mean dynamic topography by differentiation.

MDT FROM EGM96

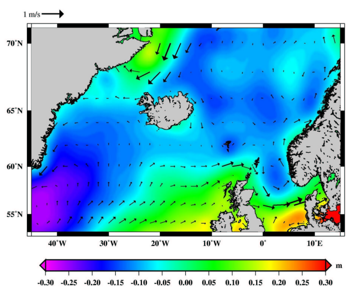


Fig. 5: The water level in the Denmark Strait is low in this model. This makes the EGC current less pronounced although it is still visible. Along the coast of Norway the pattern is the same, the Northwest Atlantic Current (NWAC) is visible although very weak.
Southeast of Greenland the Irminger Current is clear.

MDT FROM GGM01/EGM96

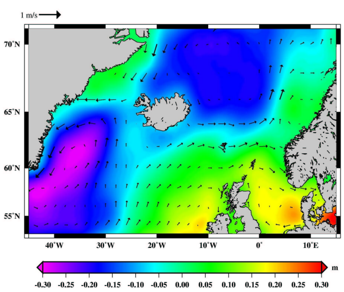


Fig. 6: The low MDT level northeast and southwest of Iceland makes both the Irminger Current and the East Iceland Current (EIC) very clear.
The East Greenland Current appears to end in the Denmark Strait as a result of a sharp transition in the MDT.
The NWAC along the coast of Norway is clear, although placed a bit too to the west if compared to the hydrodynamic MDTs.

MDT FROM GOCINA03P

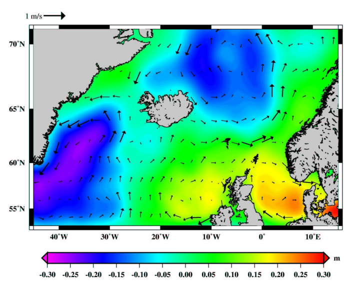


Fig. 7: This combination of mean sea surface and gravimetric geoid makes the East Greenland Current flow almost as expected from the hydrodynamic models.

The water level around Iceland is a little too high. This makes both the Irminger Current and the East Iceland Current (EIC) a bit narrow, although they are still clear. The Northwest Atlantic Current is visible although placed westwards due to the narrow EIC.

GOCINA

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