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A new combined mean dynamic topography model – DTUUH22MDT

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Abstract.
Initially, a new geodetic mean dynamic topography model DTU22MDT is derived using the new DTU21MSS mean sea surface. The DTU21MSS model has been derived by including re-tracked CRYOSAT-2 altimetry also, hence, increasing its resolution. Some issues in the Polar regions have been solved too. The geoid model was XGM2019e complete to d/o 2160.
The processing scheme used for deriving the new geodetic MDT is similar to the one used for the previous geodetic DTU MDT models. However, the filtering was re-evaluated by adjusting the quasi-gaussian filter width to optimize the fit to drifter velocities. Also, optimal filtering was introduced in the coastal areas.
Subsequently, the drifter velocities are integrated to enhance the resolution of the MDT model. Weights and constraints are introduced in the inversion and tuned to obtain a smooth model with enhanced details. A special concern is devoted to the coastal areas to optimize the extrapolation towards the coast line. The presentation will focus on the coastal zone when assessing the methodology, the data and the final model DTUUH22MDT.

The Geodetic MDT

Since the previous geodetic model, the DTU19MDT, was derived newer models for both the Mean Sea Surface and geoid have become available. That is:

- New Mean Sea Surface DTU21MSS (mainly Cryosat-2 retracking in coastal and polar regions)
- New XGM2019e geoid complete to d/o 2160 based on the GOCO06S and terrestrial data including marine gravity anomalies derived from satellite altimetry.

Developments in the DTU MDT modelling:

	Mean Sea Surface	Geoid
DTU13MDT	DTU13MSS	EIGEN-6C3stat
DTU15MDT	DTU15MSS	GOCO05S-EIGEN-6C4 hybrid
DTU16MDT	DTU15MSS	GOCO05C-EIGEN-6C4 hybrid
DTU17MDT	DTU15MSS	OGMOC hybrid
DTU19MDT	DTU18MSS	OGMOC hybrid
DTU22MDT	DTU21MSS	XGM2019e

The computation of the geodetic MDT is based on the combined XGM2019e geoid model in which the marine gravity derived from satellite altimetry (Andersen et al., 2017) had been included to reduce the unresolved parts of the geoid up to harmonic degree and order 2160. Hence, less filtering is needed to reduce the effects of the shorter scale geoid signals that are not recovered by GRACE and GOCE. Although, the gravity derived from satellite altimetry is based on mean sea surface heights and not purely the gravimetric geoid, the less filtering is believed to improve the recovery of the ocean signal. As mean sea surface model, the DTU21MSS mean sea surface. It has been computed using multi-mission altimeter data and represents a 20-years mean (1993-2012).
The filtering, as previously, was done using a Gaussian filter with varying width and anisotropy. For the new model the filtering process was combined with optimal filtering in the coastal areas where issues with the standard filtering due to land had been identified.
The resulting geodetic mean dynamic topography model DTU22MDT is shown in Figure 1. The associated geostrophic surface currents are shown in Figure 2.

Comparison with drifters:
During the process of optimizing the filtering the derived geostrophic surface currents were compared with drifter velocities.
The drifter velocities had been corrected for Ekman flows empirically and for geostrophic current anomalies obtained from AVISO. Only bins (1/4x1/4 deg) where the mean flow may be computed from at least 20 observations were used. The data set is displayed in Figure 3 below.
The results of the comparison of the models are shown in the table below:

[cm/s]	lat 10-30 u	lat 10-30 v	lat 30-50 u	lat 30-50 v
DTU15MDT	5	5.9	5	4.9
DTU16MDT	4.9	5.6	4.7	4.7
DTU17MDT	4.9	5.5	4.7	4.7
DTU19MDT	4.8	5.5	4.7	4.6
DTU22MDT	4.7	5.3	4.7	4.5

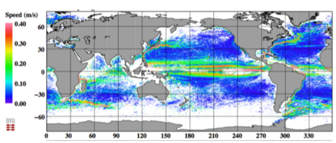

Figure 3. Mean drifter velocities used for the assessment of the geodetic models.

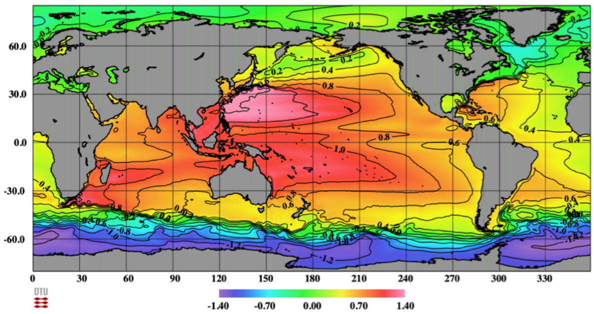

Figure 1. Mean dynamic topography from the geodetic DTU22MDT.

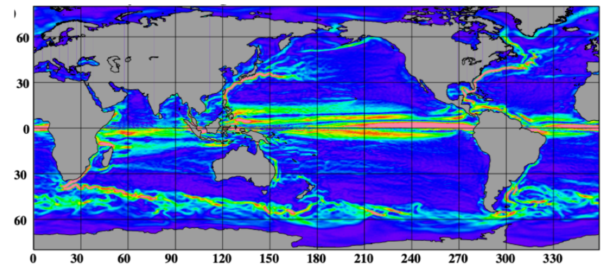

Figure 2. Geostrophic surface current speed associated with the geodetic mean dynamic topography model DTU22MDT (colors as in Figure 4).

The Gulf Stream area

Zooming in in western North Atlantic area the differences between the models may be displayed more clearly. The MDTs are shown in Figure 6 and the geostrophic currents in Figure 7.

The improvements related to the filtering when deriving the geodetic model DTU22MDT can be observed. Also, the effects of integrating the drifter information and, subsequently, to use the error fields in an adaptive integration are clearly demonstrated.

Though the models mostly display the same features, there are visible differences in important details. The spacing between the contour lines off the Florida coast is larger in the maps of the geodetic MDTs than for the combination models. Some improvements are found in the DTU22MDT compared to DTU19MDT. For the combination MDT the contour lines off the Florida coast are much tighter, hereby improving the reproduction of the MDT changes towards the Florida coast further.

The Combination MDT

With the DTUUH22MDT we aim at integrating mean drifter velocities into the modeling. The integration should be carried out in an optimal way in which the error characteristics are taken into account.

The MDT was derived using a finite difference model into which both the MDT heights and the mean currents may be integrated. To represent covariances and reduce the effects of noise both minimum variance and minimum slope constraints were included. Furthermore, specific constraints at the coastlines was included in the inversion to avoid currents crossing the coastlines. The geostrophic surface currents associated with the new combination model DTUUH22MDT are shown in Figure 4.

For comparisons the geostrophic currents of the CNES-CLS18 model are shown in Figure 5.

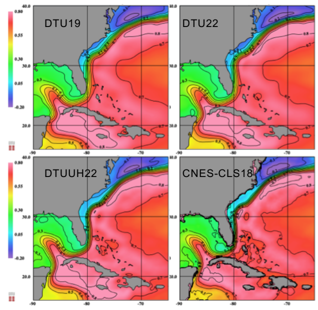

Figure 6. The two geodetic and the two combination MDTs

The differences are even better displayed when geostrophic surface current speed in the Gulf Stream area is compared. Again, the two models generally display the same features. However, the geodetic MDT does not reproduce the geostrophic speed off of the coast very well. The combination MDT performs much better; off of the Florida coast the current speed increases from about 0.5 m/s to more than 1.0 m/s.

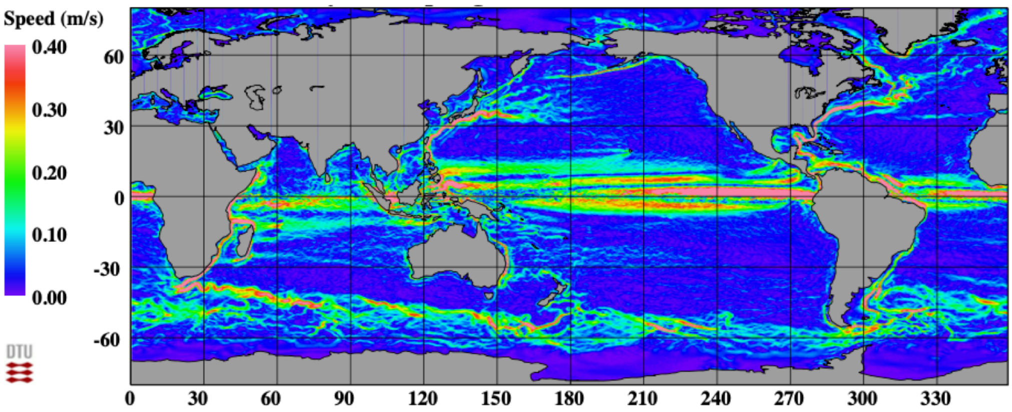

Figure 4. Geostrophic surface current speed associated with the combination model DTUUH22MDT.

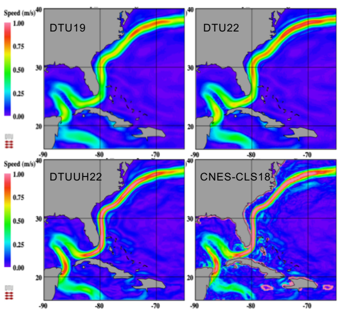

Figure 7. Geostrophic surface current speed associated with the two geodetic and the two combination MDTs

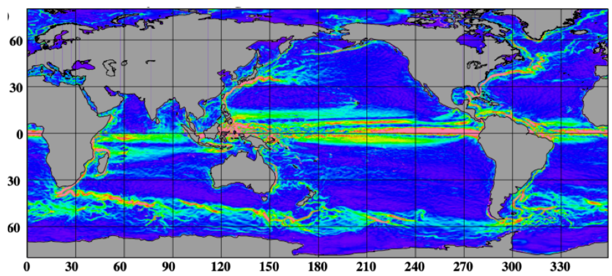

Figure 5. Geostrophic surface currents associated with the combination model CNES-CLS-18.

The Gulf Stream area continued..

In Figure 8 the differences of the combination models relative to the geodetic model DTU22MDT are shown. For the DTUUH22MDT the differences to the geodetic model are within 10 cm. Hence, the effects of integrating the drifter velocities on the MDT are of that order of magnitude. Also, the scales appear to be shorter than a few hundreds of kilometers agreeing well with the resolution of the geodetic model. For comparison the CNES-CLS18 show larger differences and longer scales.

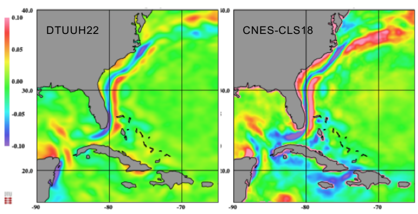

Figure 8. Differences of the two combination MDTs relative to the geodetic model DTU22MDT

Summary

A two step computation of the MDT is presented:

- An update of the geodetic MDT resulting in the model DTU22MDT and
- An integration of the geodetic MDT with drifter velocities resulting in the combination model DTUUH22MDT.

Both models are available at:
https://ftp.spacecenter.dk/pub/DTU22/MDT/

#LPS22

DTU