

Mean Dynamic Ocean Topography from GOCE

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Within the Priority Research programme "Mass Transport and Mass Distribution in the Earth System" of the German Research Foundation, the objective of the project **GEOTOP-3** is the study of the Sea Surface Topography and Mass Transport of the Antarctic Circumpolar Current in a cooperation of Institut für Astronomische und Physikalische Geodäsie Technische Universität München (**TUM-IAPG**), the Deutsches Geodätisches Forschungsinstitut München (**DGFI**), the Alfred-Wegener-Institut für Polar und Meeresforschung Bremerhaven (**AWI**) and the Technische Universität Dresden, Institut für Planetare Geodäsie (**TUD-IPG**).

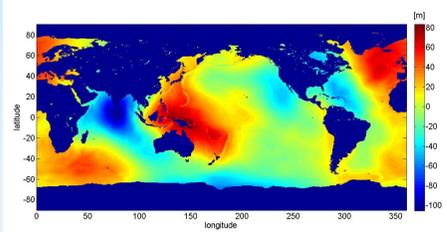
The absolute mean dynamic ocean topography (MDT) is determined from accurate geoid models from GOCE combined with a mean sea surface (MSS) model derived from a long time series of sea surface heights from multi-mission satellite altimetry. This implies the combination of data with fundamentally different characteristics and spatial resolution. The geoid models are global but their spatial resolution is limited to about 80km to 100km half-wavelength, while the altimetric sea surface is confined to ocean areas but has much higher spatial resolution.

These short scales features are removed by filtering in order to provide a dynamic topography field that is consistent with the geoid field.

In this study we use new MSS and GOCE gravity models and we investigate different ways to carry out the filtering of the altimetric surface.

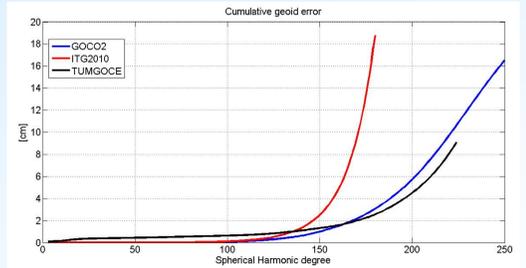
MEAN SEA SURFACE (h)

The MSS used for the computation of MDT was calculated by averaging the measurements of altimeter data from exact repeat cycles of the missions ERS-1/2, ENVISAT, TOPEX/Poseidon, Jason-1 and Jason-2, acquired within the period from October 1992 to April 2010. The comparison of this MSS with different MSSs (CLS01, CLS10, DTU10) shows good agreement with RMS differences below 5cm.



GEOID (N)

The high resolution geoid model TUMGOCE is used, [Yi, W.: *An alternative computation of a gravity field model from GOCE; Adv Sp Res, 50, 371-384, 2012*]. It is based on 18 months of GOCE data. TUMGOCE is available as spherical harmonic series up degree and order 224. The commission error at degree 180 is 2.5cm for TUMGOCE, while it is 16cm for the GRACE-only model ITG2010 and 3cm for the combined GRACE/GOCE-model GOCO2s.

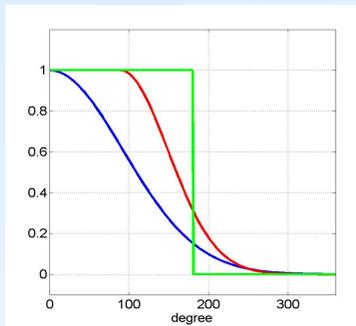


MDT = h - N

The mean dynamic topography is computed subtracting the geoid heights, N, from the mean sea surface heights, h. The h and N are made geometrically consistent (same reference and tide system) and spectrally consistent by filtering. For this purpose, the MSS is extended to the land areas and then the transition from land to sea is smoothed by iteratively estimating the spherical harmonic coefficients of the MSS from the combined land-ocean data set.

The selected filter is a **2D Butterworth low pass filter**.

It is applied to the spherical harmonic series up to a selected maximum degree. The chosen filter reduces the ringing effect (produced by the cutoff filter) while largely preserving the information of the highest degrees and orders of the series (which are damped by the Gauss filter).

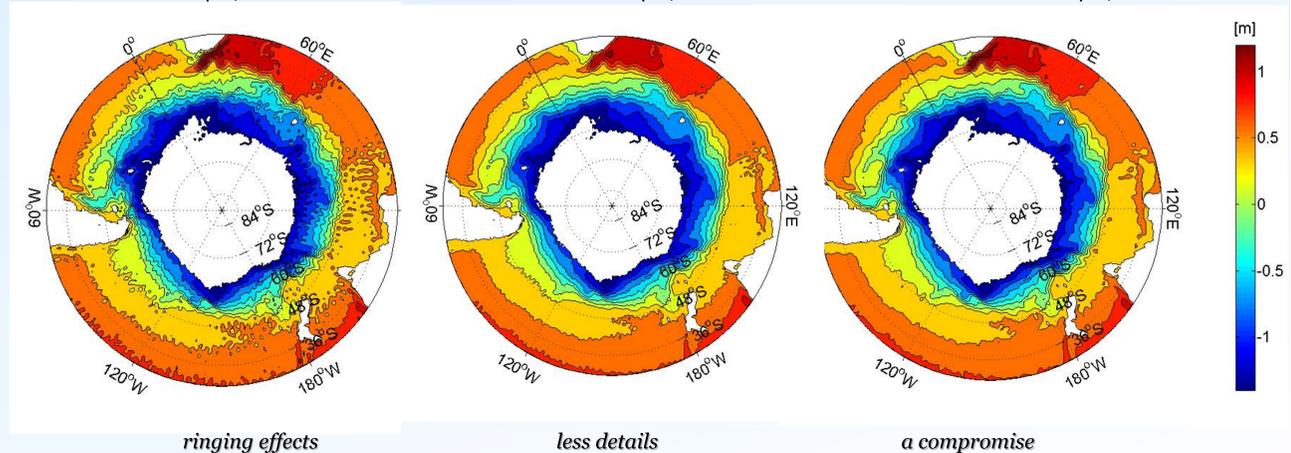


The **cutoff filter** up d/o 180 compared with the **Gauss filter** and the **Butterworth filter** referring to the same threshold.

Cutoff filter up d/o 180

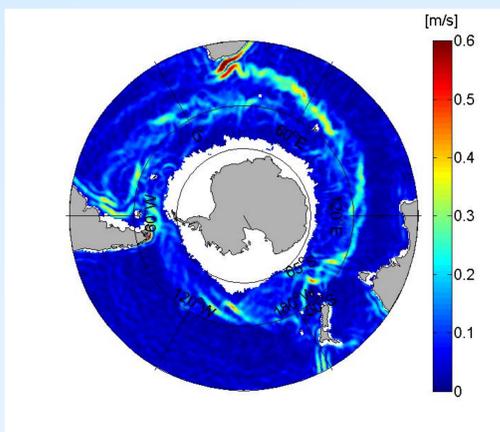
Gauss filter up d/o 180

Butterworth filter up d/o 180



SURFACE VELOCITIES

Magnitude of the geostrophic velocities from geodetic data (up d/o 180)

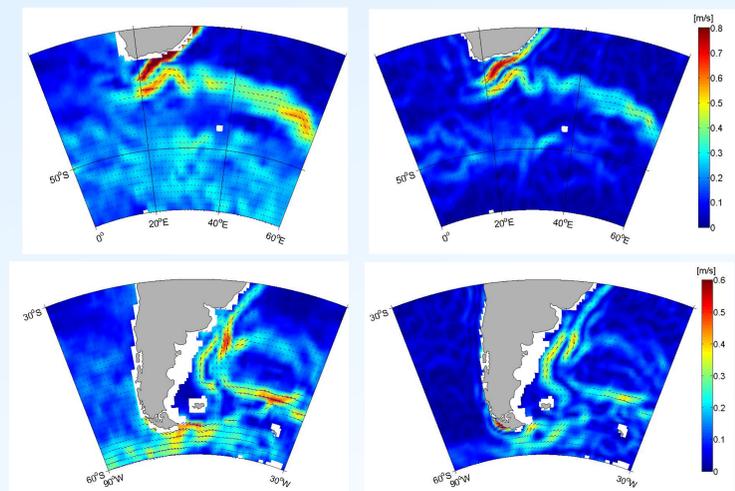


The mean geostrophic velocities are derived from the surface gradients of the MDT.

$$\mathbf{u}_H = -\frac{g}{f} \mathbf{k} \times \nabla_H (\text{MDT})$$

These velocities (derived from satellite data only) can be compared with the in-situ drifter measurements. The Global Drifter Program of NOAA and AOML collects satellite-tracked drifting buoys ("drifter") measurements of upper ocean currents. Geodetic velocities were compared to the surface geostrophic component of drifter currents, [Albertella et al.: *High resolution dynamic ocean topography in the Southern Ocean from GOCE; Geophys J Int, 190, 2012*].

Magnitude of the geostrophic velocities from drifter observations and geodetic data



RMS vector difference ≈ 7 cm/s

RMS vector difference ≈ 6 cm/s

CONCLUSIONS

From 18 months of GOCE data, oceanographic fields like mean dynamic topography and geostrophic velocities were computed with a spatial resolution that was not possible before GOCE. This is in particular of great benefit in areas with strong currents such as Agulhas or the Antarctic Circumpolar Current. Geostrophic velocities deduced from satellite data only show good agreement with geostrophic velocities derived from drifter measurements.