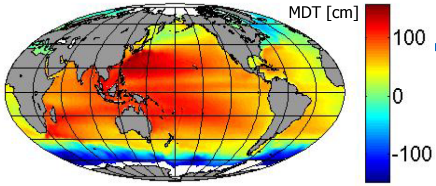


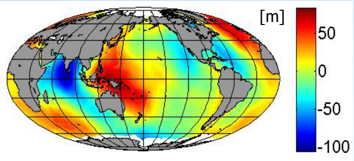
The impact of the new gravity field models on the Mean Dynamic Ocean Topography and the derived geostrophic velocities

Alberta Albertella[1], Tijana Janjic[2], Roman Savcenko[3], Martin Horwath[1]

[1]IAPG, Munich, Germany (albertella@bv.tum.de, martin.horwath@bv.tum.de),
[2]AWI, Bremerhaven, Germany, (Tijana.Janjic.Pfander@awi.de), [3]DGFI, Munich, Germany (savcenko@dgfi.badw.de)

The absolute Mean Dynamic ocean Topography (MDT) can be determined from an accurate geoid model and a Mean Sea Surface (MSS). The MSS is derived using long-term time series of sea surface heights from multi-mission satellite altimetry. Recently, data from the Gravity field and steady-state Ocean Circulation Explorer (GOCE) satellite has become available. Now, GOCE and GRACE satellite data can be combined to obtain a geoid with higher accuracy and spatial resolution than before. The improvement in the geoid accuracy and resolution implies improvements in the resolution of MDT. Here we investigate the impact of change in the MDT resolution.

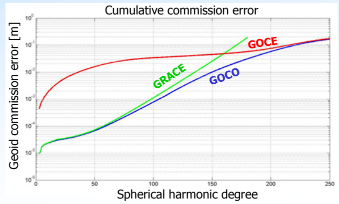
MEAN SEA SURFACE (h)



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 0.5°×0.5° resolution of this MSS is adequate for the computation of long term MDT. The comparison of this MSS with different MSSs (CLS01, CLS10, DTU10, after adaption of resolution) shows good agreement with RMS differences below 5 cm.

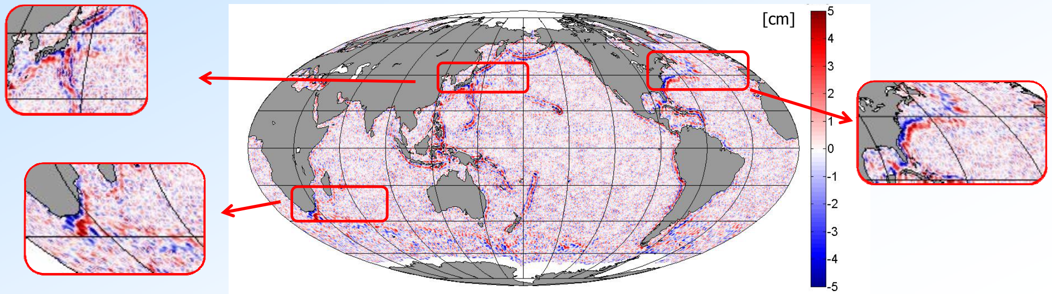
GEOID (N)

The high resolution geoid model GOCO02S (Pail et al. 2010) is used. It is based on GRACE data (for the low to middle frequencies) and on GOCE data (for higher frequencies). GOCO2S combines the two data sets in an optimal way and provides a geoid of high accuracy up to degree and order 250. The commission error at degree 180 for GOCO2S is around 3.5 cm, while for GRACE-only models, at degree 180 the error is 16 cm.



MDT = h – N

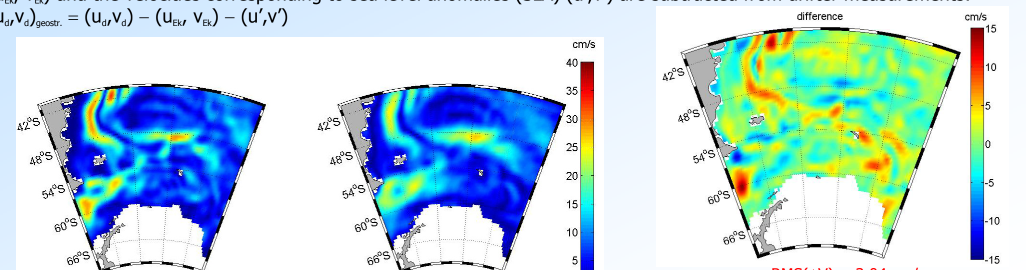
The mean dynamic topography is computed subtracting the geoid heights, N, from the mean sea surface heights, h (Albertella et al. 2008). h and N are made geometrically consistent (tide system and reference) and spectrally consistent by filtering. For this purpose, the MSS is extended in the land areas 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. Then a Gauss filter is applied acting on the harmonic component up to a selected maximum degree. The improvement from inclusion of GOCE data is visible when we consider (for example) the bandwidth from spherical harmonic degrees 150 to 180. Oceanographic signal is visible especially in the areas of the major oceanic currents (Gulf, Agulhas, Kuroshio).



Bandwidth between L=150 and L=180 for MDT with **GOCE and GRACE** data

Surface Velocities

The mean geostrophic velocities are derived from the gradient of the MDT. These velocities (u,v) (derived from satellite only data) can be compared with the in-situ drifter measurements. The Global Drifter Program of NOAA and AOML collects satellite-tracked drifting buoys ("drifter") measurements (u_d,v_d) of upper ocean currents. At www.aoml.noaa.gov/envids a large set of data from February 1979 to December 2010, covering almost all the sea surface, is available. We extract only their geostrophic component in order to compare with the geodetic velocities. That is, an estimate of the mean Ekman currents (u_{Ek}, v_{Ek}) and the velocities corresponding to sea level anomalies (SLA) (u′,v′) are subtracted from drifter measurements:
$(u_d,v_d)_{geostr.} = (u_d,v_d) - (u_{Ek}, v_{Ek}) - (u',v')$



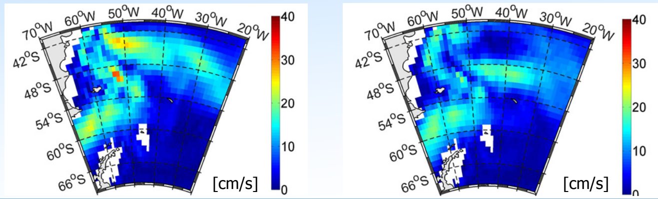
Modulus of the velocities from drifter minus Ekman currents and SLA velocities

Modulus of the velocities from geodetic MDT (filtered up L=180)

RMS(ΔV) = 3.04 cm/s
RMS(Δv) = 2.52 cm/s, RMS(Δu) = 3.32 cm/s
Differences between geostrophic velocities derived from drifter data and from geodetic MDT.

Ocean Model and Data Assimilation

Incorporating the MDT into a numerical ocean model through data assimilation is a difficult task because the ocean general circulation models commonly show systematic deviation from the measured MDT. The ocean model used in this study is the Finite-Element Ocean circulation Model (FEOM) . The model is configured on a global, almost regular triangular mesh with spatial resolution of 1.5°, and with 24 unevenly spaced levels in the vertical. The ocean model solves the standard set of hydrostatic ocean dynamics primitive equations. The details of the data assimilation algorithm are described in Janjic et al 2011a, 2011b. The mean MDT resulting from the data assimilation reflects the impacts of the geodetic MDT data used, of the forcing, and of the physical and dynamical properties of the ocean model.



Geostrophic velocities from the free ocean model run (left) and model run including the MDT data (right). The MDT data through data assimilation correctly modifies model results to show the appropriate turning of the Subantartic front.

CONCLUSIONS

From only 6 months of GOCE data, oceanographic fields like mean dynamic topography and geostrophic velocities are given in a fine spatial scale that has been poorly resolved previously. This is especially true in the areas of strong currents like Agulhas, Gulf, Kuroshio and Antarctic Circumpolar Current. Geostrophic velocities derived from only satellite data show very good agreement with geostrophic velocities measured by drifters. In addition the assimilation of this data set allows us to obtain all surface and subsurface ocean variables consistent with new MDT, giving promising results in comparison to the free model.

REFERENCES

Albertella A, Savcenko R, Bosch W, Rummel R: *Dynamic ocean topography - the geodetic approach*. IAPG/FESG-Schriftenreihe, No. 27, IAPG and FESG, TU München, ISBN (Print) 978-3-934205-26-0, ISSN 1437-8280, 2008

Janjic T, Schroeter J, Albertella A, Bosch W, Rummel R, Savcenko R, Schwabe J, Scheinert M: Assimilation of geodetic dynamic ocean topography using ensemble based Kalman filter, *J Geodyn*, doi:10.1016/j.jog.2011.07.001, 2011

Janjic T, Schroeter J, Savcenko R, Bosch W, Albertella A, Rummel R, Klatt O: Impact of combining GRACE and GOCE gravity data on ocean circulation estimates, *Ocean Sci Discuss* 8, 1535-1573, 2011

Pail R, Goiginger H, Schuh W-D, Höck E, Brockmann JM, Fecher T, Gruber T, Mayer-Gürr T, Kusche J, Jäggi A, Rieser D: Combined satellite gravity field model GOCO01S derived from GOCE and GRACE. *Geophys Res Lett*, 37:L20314, DOI: 10.1029/2010GL044906, 2010

This research is part of the Priority Research programme "Mass Transport and Mass Distribution in the Earth System" of the German Research Foundation. The project **GEO-TOP** is a cooperation of **IAPG**, the Deutsches Geodätisches Forschungsinstitut München (**DGFI**) and the Alfred-Wegener-Institut für Polar- und Meeresforschung Bremerhaven (**AWI**).

IAPG DGFI AWI

AGU Fall Meeting, December 5-9, **2011** San Francisco, CA

CGE TUM