A global Ocean Bottom Pressure data base as ground-truth reference for GRACE gravity field products

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Abstract

The GRACE satellite mission provides monthly estimates of the gravity field of the Earth. Differences between the monthly solutions are induced by mass redistribution on the Earth. Over the continents, the hydrological cycle represents the largest signals, which are readily observed by GRACE. Over the oceans, however, gravity field changes are about an order of magnitude smaller, close to the accuracy limits of the present GRACE solutions. Nevertheless, GRACE measurements may prove as an important tool to obtain integral estimates of water mass redistribution, sea level changes and geostrophic current variability.

In order to validate and improve the gravity field products, GRACE is to be compared against ocean models and in-situ observations of Ocean Bottom Pressure (OBP).

Time series of OBP sensors deployed by Alfred-Wegener-Institut in the Antarctic Circumpolar Current, as well as measurements from other locations of the global ocean are included in a OBP database that is currently under development at AWI, in close cooperation with Potsdam Oceanographic Laboratory (POL, Liverpool). The mutual comparison of in-situ and ocean model data with different GRACE products provided by CSR, GFZ, GRGS, ITG and JPL will help to optimize data processing methods and corrections applied to GRACE, and to identify the performance of GRACE to detect oceanic mass flux variability in different regions of the global ocean.

Comparison of in-situ and GRACE OBP estimates

As an example, ground truth validation of GRACE data in the Antarctic Circumpolar Current (ACC) is shown here. With a transport of ~130 Sv, the ACC is the largest current of the world ocean. The ACC region is favourable for satellite measured gravity field variations:

- OBP variability 5 times larger than in tropical latitudes
- far away from continents, where oceanic data is affected by signals from hydrological cycle
- sensor satellite coverage in high latitudes

From 2002 – 2005, 2 pressure sensors were deployed in the South Atlantic part of the ACC (time series: Fig. 1). The 2-dimensional extension of the ACC array deployed in 2006 and model analysis may resolve these discrepancies.

A correlation analysis reveals a large area in the South Atlantic, where GRACE is correlated with the single point measurements at 50°S O/E (Fig. 2a). In contrast, GRACE itself shows positive auto-correlation extending further into a zonal pattern of coherent variability south of the Polar Front (Fig. 2b).

The 2-dimensional extension of the ACC array deployed in 2006 and model analysis may resolve these discrepancies.

In-situ and GRACE data (GFZ RL03) agree in amplitude (0.05 dbar) and phase; significant correlation

GRACE/GRACE ground truth validation

• Systematic comparisons of all available OBP measurements with GRACE solutions provided by CSR, GFZ, GRGS, ITG, JPL will be carried out to
  -> identify oceanic regions with high correlation levels between GRACE and in-situ data
  -> identify the effects of different degree/order solutions, spatial smoothing, temporal averaging and de-tailinging models on GRACE performance
  -> provide suggestions for further improvement of GRACE data
  -> possibly provide information on the expected performance levels of other oceanic regions that are not covered by in-situ measurements
  -> The OBP database will also be used as a constraint for the Finite Elements Ocean Model (FEOM), operated at AWI for model based validation of GRACE performance.

References


Fig. 1: Comparison of in-situ OBP (solid lines) and GRACE GFZ RL03 (dashed lines) in the ACC. Fig. 2: Correlation of OBP GFZ RL03 at 50°S 10°E (a), and OBP GFZ RL03 (b) and GRACE GFZ RL03 (c) in the ACC. Fig. 3: Standard deviations of monthly GRACE OBP anomalies from 04/2002 to 11/2003. Ground truth sites: data already compared with GRACE, a) further deployments: deployments in September/October 2006. Note the 2-dimensional layouts of the MOVE and ACC arrays. Figure adapted from Kanzer et al., JGR 2005.

Conclusions

• Observed monthly Ocean Bottom Pressure variability ranges from 0.01 dbar in the tropics to 0.05 dbar in the ACC, which is close to the accuracy limits of the present-day GRACE solutions

• Regional studies in the Antarctic Circumpolar Current reveal reasonable agreement between GRACE and in-situ observations both in amplitude (0.05 dbar) and correlation (r = 0.69), whereas in the tropical Atlantic, GRACE so far failed to realistically identify the actual oceanic variability of 0.005 dbar

• A global network of OBP sensor arrays deployed in various oceanographic projects shall be employed for a world-wide ground truth validation of GRACE

• An open access OBP database is currently under development at AWI, Bremerhaven in cooperation with the existing GLOUP OBP database at POL, Liverpool

• Systematic comparisons of all available OBP measurements with GRACE solutions provided by CSR, GFZ, GRGS, ITG, JPL will be carried out at AWI to further improve GRACE

• Future goal is to obtain accurate mass flux estimates of the world ocean based on satellite gravity field measurements