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 Proudman 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

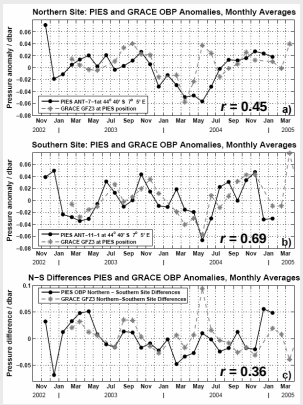
As an example, ground truth validation of GRACE data in the Antarctic Circumpolar Current (ACC) is shown here.
With a transport of ~130 Sv, the ACC is the largest current of the world ocean. The ACC region is favourable for satellite measured gravity field variations:

•OBP variability 5 times larger than in tropical latitudes

•far away from continents, where GRACE data is affected by signals from hydrological cycle

•denser 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).



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

Fig. 1: Comparison of in-situ OBP (solid lines) and GRACE GFZ RL03 (d/o -30, 500 km Gauss filter; grey dashed lines) in the ACC.

A correlation analysis reveals a large area in the South Atlantic, where GRACE is correlated with the single point measurements at 50°S 0°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.

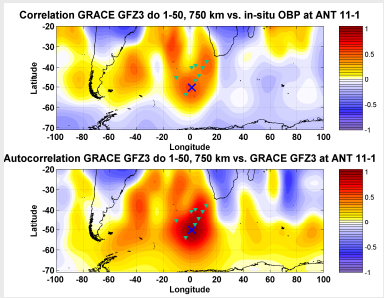
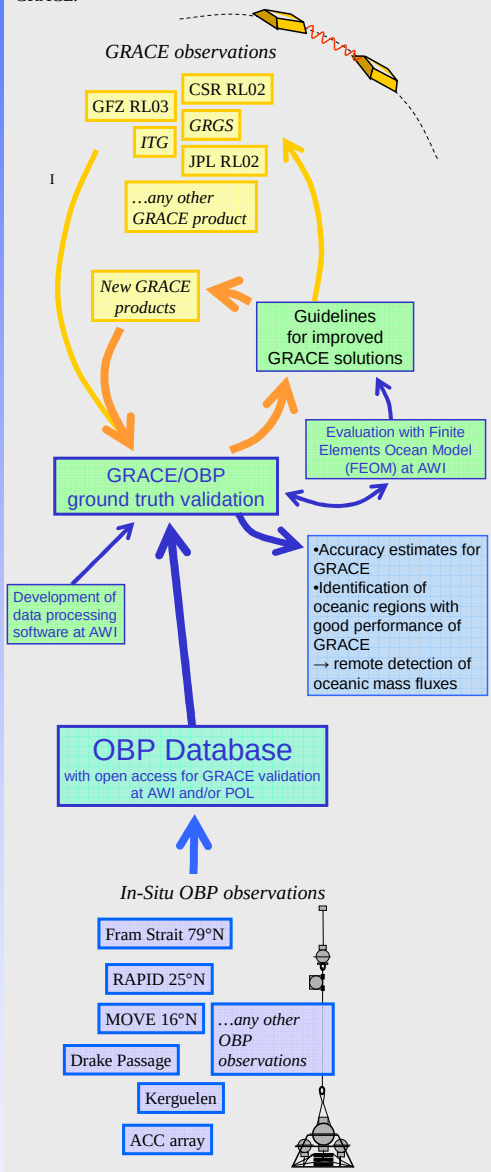


Fig. 2: Spatial coherence patterns of OBP variability. a) Correlation of in-situ OBP at 50°S 0°E (X, see Fig. 1b) with GRACE GFZ RL03. b) Autocorrelation of GRACE GFZ RL03 at the same position. ▼ ACC array extension from 2006.

OBP database

In order to improve the detection of oceanic variability by satellite gravity field measurements, GRACE is to be validated against in-situ OBP measurements all over the global ocean.

An open access OBP database is currently under development at AWI Bremerhaven, in cooperation with the existing GLOUP OBP database at POL, Liverpool, serving as ground-truth reference for GRACE.



GRACE/OBP 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-aliasing and de-tiding models on GRACE performance

→ provide suggestions for further improvement of GRACE data

→ possibly provide information on the expected performance levels of GRACE and error estimates for 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.

Global network of OBP sensor arrays

OBP sensors are deployed for oceanographic applications at various locations (Fig. 3). These are also suited as ground-truth sites for GRACE.

•2-dimensional arrays specially designed for optimized comparison of point-measurement with large scale GRACE data are deployed in the MOVE and ACC arrays.

•Collaboration with other projects observing OBP in the Indian and Pacific oceans intended.

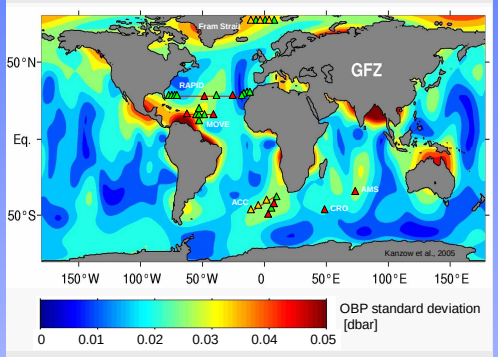


Fig. 3: Standard deviations of monthly GRACE OBP anomalies from 04/2002 to 11/2003. Ground truth sites: ▲ data already compared with GRACE ▲ further deployments ▲ deployments in September/October 2006. Note the 2-dimensional layouts of the MOVE and ACC arrays. Figure adopted from *Kanzow* et al., JGR 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 O(0.01 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

Acknowledgements

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The intended collaboration with various institutions operating OBP sensor arrays is highly appreciated.
So far, the following projects have agreed on cooperation for GRACE ground-truth validation:
C.W. Hughes, POL Liverpool, UK: GLOUP OBP database, including records from Kerguelen and Drake passage
T. Kanzow, NOC Southampton, UK: RAPID array, 25°N, Atlantic
J. Karstensen, IFM-GEOMAR Kiel, Germany: MOVE array, 16°N, Atlantic
R. Rietbroek, Delft University, The Netherlands: GRACE/OBP validation in Kerguelen region

References

Kanzow, T., F. Flechtner, A. Chave, R. Schmidt, P. Schwintzer, and U. Send (2005), Seasonal variation of ocean bottom pressure derived from Gravity Recovery and Climate Experiment (GRACE): Local validation and global patterns, J. Geophys. Res., 110, C09001, doi:10.1029/2004JC002772

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