Technical Note

GravIS Ocean Bottom Pressure Variability Level-3 Products

for

GFZ GravIS RL06 (V. 0006)

COST-G GravIS RL01 (V. 0005)

Created: 28 April 2025

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1. Introduction

This Technical Note describes the processing scheme and product details of the Ocean Bottom Pressure (OBP) Variability Level-3 products that are visualized at the GFZ web portal GravIS (https://gravis.gfz.de) and provided at GFZ's data archive ISDC.

2. Data Product Details

2.1 Gridded Products

The OBP product based on GFZ GRACE/GRACE-FO monthly gravity field models contains the complete available time series, whereas the OBP products based on COST-G GRACE/GRACE-FO monthly gravity field models are divided into yearly batches.

Filenames: GFZ: **GRAVIS-3_ccccc_rrrr_OBP_GRID_GFZ_vvvv.nc**

COST-G: **GRAVIS-3_YYYY-----------_ccccc_rrrr_OBP_GRID_GFZ_vvvv.nc**

where:

YYYY is the corresponding year (note that files may contain partial years)

ccccc is either GFZOP if the product is based on GFZ GRACE/GRACE-FO monthly gravity field models, or COSTG if the product is based on combined GRACE/GRACE-FO monthly gravity field models from COST-G rrrr is the corresponding 4-digit release number of the underlying monthly gravity field models (either 0600 for GFZ or 0100 for COST-G)

vvvv is the 4-digit version number of the most recent product release

Format: **NetCDF**

Product links: GFZ: **ftp://isdcftp.gfz-potsdam.de/grace/GravIS/GFZ/Level-3/OBP**

COST-G: **ftp://isdcftp.gfz-potsdam.de/grace/GravIS/COST-G/Level-3/OBP**

2.2 Regional Average Products

Spatially averaged products over predefined regions (see Appendix A in Dahle et al. (2025) for further details) can be downloaded directly from the dedicated OBP subpage at the GravIS web portal. Here, these products are offered via the download button above the time series plot in terms of two zip archives (one for products based on GFZ, the other for products based on COST-G) which each contain several ASCII files in csv format for different available OBP product variables.

Filenames: **OBP_ccccc_rrrr_<layer>_vvvv.csv**

where:

ccccc is either GFZOP if the product is based on GFZ GRACE/GRACE-FO monthly gravity field models, or COSTG if the product is based on combined GRACE/GRACE-FO monthly gravity field models from COST-G

rrrr is the corresponding 4-digit release number of the underlying monthly gravity field models (either 0600 for GFZ or 0100 for COST-G)

<layer> is the name of the specific variable, i.e. either 'barslv', 'resobp', 'leakage', 'model_ocean', or 'model_atmosphere' (see Section 3.1 below for further details about the content of these variables)

vvvv is the 4-digit version number of the most recent product release

Format: **csv**

Product links: **https://gravis.gfz.de/obp** (via download button above time series plot)

3. Processing Details

3.1 Gridded Products

OBP estimates obtained from GRACE and GRACE-FO are provided at 1° latitude-longitude grids as defined over the world's ocean basins. The reference surface for the spherical harmonic synthesis to the 1° grid is the reference ellipsoid as defined in the IERS Conventions (2010) Tab 1.1.

The files each contain seven different variables (see variable names of the NetCDF files marked in **bold** below) providing

1) gravity-based barystatic sea-level pressure (**barslv**)
2) gravity-based barystatic sea-level pressure uncertainties (**std_barslv**)
3) gravity-based residual ocean circulation pressure (**resobp**)
4) gravity-based residual ocean circulation pressure uncertainties (**std_resobp**)
5) gravity-based bottom pressure variations likely caused by spatial leakage (**leakage**)
6) background-model ocean circulation pressure (**model_ocean**)
7) background-model atmospheric surface pressure (**model_atmosphere**).

Layer "barslv":

We use GravIS Level-2B coefficients (https://gravis.gfz.de/corrections), either for GFZ RL06 (Dahle & Murböck, 2019) or COST-G RL01 (Dahle & Murböck, 2020), filtered with VDK5 and VDK2 and estimate trend as well as annual and semi-annual harmonics for both filter versions. In view of the less dominant annual and semi-annual signals over the ocean compared to trend, we combine the trend component from VDK5 with the annual and semi-annual components and the remaining month-to-month and inter-annual variations from VDK2. As an additional correction which is not part of the Level-2B processing, co- and post-seismic deformations from megathrust earthquakes (magnitude > 8.8) are removed. Thus, the seismic events (i) Sumatra-Andaman 2004, (ii) Chile 2010, and (iii) Tohoku-Oki 2011 are taken into account. The empirical correction is based on a step function which is fitted to all available monthly solutions in a spherical cap with a radius of 1000 km centered at the epicenter and an exponential decay function which is fitted over two years following the main event (note that solutions from subsequent epochs are no longer statistically independent as soon as earthquake signals were empirically estimated and removed). The resulting sea-level variations contain both a distinct annual variation of the global mean sea-level, a pronounced positive trend, and additional strong seasonal pattern in regions characterized by Monsoon circulations in the atmosphere.

Layer "std_barslv":

The uncertainty of the barystatic sea-level data is provided as the temporal standard deviation at each grid point.

Layer "resobp":

GRACE-based terrestrial water storage estimates and the associated atmospheric mass distributions as given by AOD1B (Dobslaw et al., 2017) are used to calculate a gravitationally consistent sea-level anomaly for each month based on the theory of Tamisiea et al. (2010). Differences between this sea-level pattern and ocean bottom pressure directly inferred from the Level-2B coefficients are interpreted as residual ocean circulation signals. Preliminary analysis indicates that numerous features contained in those fields are likely related to instrument noise or gravity field modelling errors and thus should not be interpreted in terms of ocean dynamics. Bottom pressure variations likely caused by spatial leakage are provided separately to the users (see layer "**leakage**").

Layer "std_resobp":

The uncertainty of the residual OBP data is spatially constant for each time step and is calculated as the standard deviation of the VDK2 filtered OBP grids reduced by the deterministic signals.

Layer "leakage":

This additional layer is provided to enable a spatial leakage correction of the residual ocean circulation data if needed. The spatial leakage is estimated from differences of a combination of VDK filters with different filter strengths. The spatial leakage estimation is separated into spatial leakage of the deterministic signals (VDK5) and interannual variability (VDK3). The spatial leakage of VDK5 is estimated from scaled differences between VDK6 and VDK4, likewise for VDK3 the differences between VDK4 and VDK2 are used. Further details are reported in Dobslaw et al. (2020).

The following scaling factors are used:

GFZ GravIS RL06	
Leakage VDK3	3.9
Leakage VDK5	4.0
COST-G GravIS RL01	
Leakage VDK3	2.2
Leakage VDK5	1.4

Layers "model_ocean" and "model_atmosphere":

It should be noted that a certain fraction of the time-variable gravity signal picked up by a satellite gravimetry mission is caused by atmospheric mass variability and the corresponding oceanic response to changes in, e.g., surface winds. The non-tidal de-aliasing product AOD1B (Dobslaw et al., 2017) has been used to subtract the atmospheric contribution – and to a large extent also the ocean contribution – already during the processing of the Level-2 monthly gravity fields. In order to provide users with some flexibility to restore those signals, the monthly mean estimates of both the atmospheric and the oceanic background models are provided as well.

3.2 Regional Average Products

The regional average products are provided separately for the layers 'barslv', 'resobp', 'leakage', 'model_ocean', and 'model_atmosphere'.

In case of the layer 'barslv', each value is accompanied by its uncertainty which is variance-propagated from the point standard deviations in layer "**std_barslv**" of the gridded products.

In case of the layer 'resobp', each value is accompanied by the same (spatially constant) uncertainty value taken from the layer "**std_resobp**" of the gridded products.

4. Citation

The GravIS OBP Level-3 products are published as data publication via GFZ Data Services and should be cited as follows:

GFZ RL06 products:
Dobslaw, H., Boergens, E., Dill, R. (2019): GFZ GravIS RL06 Ocean Bottom Pressure Anomalies. V. 0006. GFZ Data Services. https://doi.org/10.5880/GFZ.GRAVIS_06_L3_OBP

COST-G RL01 products:
Dobslaw, H., Boergens, E., Dill, R. (2020): COST-G GravIS RL01 Ocean Bottom Pressure Anomalies. V. 0005. GFZ Data Services. https://doi.org/10.5880/COST-G.GRAVIS_01_L3_OBP

When generally referring to the GravIS portal and its products, please cite Dahle et al. (2025).

5. References

Dahle, C., Murböck, M. (2019): Post-processed GRACE/GRACE-FO Geopotential GSM Coefficients GFZ RL06 (Level-2B Product). V. 0003. GFZ Data Services. https://doi.org/10.5880/GFZ.GRAVIS_06_L2B

Dahle, C., Murböck, M. (2020): Post-processed GRACE/GRACE-FO Geopotential GSM Coefficients COST-G RL01 (Level-2B Product). V. 0003. GFZ Data Services. https://doi.org/10.5880/COST-G.GRAVIS_01_L2B

Dahle, C., Boergens, E., Sasgen, I., Döhne, T., Reißland, S., Dobslaw, H., Klemann, V., Murböck, M., König, R., Dill, R., Sips, M., Sylla, U., Groh, A., Horwath, M., and Flechtner, F. (2025): GravIS: mass anomaly products from satellite gravimetry, Earth Syst. Sci. Data, 17, 611–631, https://doi.org/10.5194/essd-17-611-2025

Dobslaw, H., Bergmann-Wolf, I., Dill, R., Poropat, L., Thomas, M., Dahle, C., Esselborn, S., König, R., Flechtner, F. (2017): A new high-resolution model of non-tidal atmosphere and ocean mass variability for de-aliasing of satellite gravity observations: AOD1B RL06. Geophysical Journal International, 211, 1, pp. 263-269. http://doi.org/10.1093/gji/ggx302

Dobslaw, H., Dill, R., Bagge, M., Klemann, V., Boergens, E., Thomas, M., Dahle, C., Flechtner, F. (2020): Gravitationally Consistent Mean Barystatic Sea Level Rise From Leakage-Corrected Monthly GRACE Data. J. Geophys. Res.: Solid Earth, 125, e2020JB020923. https://doi.org/10.1029/2020JB020923

Tamisiea, M., Hill, E., Ponte, R., Davis, J., Velicogna, I., Vinogradova, N. (2010): Impact of self-attraction and loading on the annual cycle in sea level. J. Geophys. Res., 115, C07004. http://doi.org/10.1029/2009JC005687

IERS Conventions (2010). Gérard Petit and Brian Luzum (eds.). (IERS Technical Note ; 36) Frankfurt am Main: Verlag des Bundesamts für Kartographie und Geodäsie, 2010. 179 pp., ISBN 3-89888-989-6