



Technical Note: Development of an Extended Barystatic Series from 1993 to 2027 by Combining the OMB and GRACE Series

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	Name	Organisation	Date	Visa
Written by:	Judith Garnier, Julia Pfeffer	Magellium	07/07/2026	
Checked by:	Frédéric Thoumieux Alejandro Blazquez	CNES	22/07/2026	FT:Lu AB:Lu
Approved by:	Gerald Dibarboure Cyril Germineaud	CNES CNES	22/07/2026	GD:Lu CG:Lu

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Ed.	Re v.	Date	Purpose evolution	Comments
1	0	24/06/2026	First diffusion of document	The extended barystatic series V1.0 was computed from the barystatic OMB V3.0 product and the barystatic V5.0 GRACE-/FO barystatic product.

Main processing steps of the combined barystatic series over the 1993-01 to 2027-06 period: homogenization and connection of the OMB and GRACE series, supplemented by data interpolation over missing periods and forward extrapolation of the series.

Introduction and Objective

The objective of this combined series is to continuously reconstruct barystatic sea level (BSL) variations from 1993 to 2027. This is achieved by using data based on the Ocean Mass Budget (OMB) closure—computed as the sum of contributors (i.e., variations in freshwater fluxes from continents to oceans, including ice mass variations in Greenland, Antarctica, and all continental glaciers, as well as continental hydrological cycle variations) (Magellium/LEGOS, 2023a)—prior to 2002, and subsequently using observations from the GRACE/-FO satellite missions (Magellium/LEGOS, 2023b).

Prior to 2002, the extended barystatic series contains the decadal trend, the interannual variability, and the high-frequency variations of the OMB barystatic product V3.0 (Magellium/LEGOS, 2023a), from which its seasonal cycle has been removed and replaced by the GRACE seasonal signal. Over the 2002–2025 period, it consists of the GRACE/-FO barystatic series V5.0 (Magellium/LEGOS, 2023b), with dynamic data interpolation over data gaps. Finally, an extrapolation of the trend and annual cycle of the barystatic series is performed from 09-2025 to 06-2027 by extending the signal from the GRACE-FO period.

The barystatic sea level anomalies are referenced to the temporal mean over the period January 2005 to December 2014, as the GRACE/-FO barystatic series V5.0.

Steps to compute the combined barystatic series:

1. Dynamic Interpolation Over GRACE/-FO Data Gaps

There are significant data gaps in the GRACE/-FO barystatic series, particularly between the end of GRACE mission (October 2017) and the launch of GRACE-FO mission (June 2018). Other less substantial data gaps (generally 1 to 2 months) can be observed throughout the GRACE mission, mainly due to technical difficulties (solar wind, orbital resonances, instrument failures, etc.). To correct them, a dynamic linear interpolation is performed:

1. The trend and seasonal signal are co-estimated by a least-squares fit of a linear trend, an annual cycle and a semi-annual cycle to the GRACE/-FO barystatic series over the period from 04-2002 to 08-2025.
2. The trend and seasonal signal estimated in step (1) are removed from the GRACE/-FO barystatic series.
3. The barystatic series residuals obtained in step (2) are linearly interpolated over the missing periods (this applies to the following months: '2002-06', '2002-07', '2003-06', '2004-07', '2004-08', '2004-09', '2004-10', '2011-01', '2011-06', '2012-04', '2012-05', '2012-06', '2012-07', '2012-10', '2013-03', '2013-08', '2013-09', '2014-02', '2014-07', '2014-12', '2015-01', '2015-02', '2015-05', '2015-06', '2015-10', '2015-11', '2016-04',

- '2016-09', '2016-10', '2017-02', '2017-07', '2017-08', '2017-09', '2017-10', '2017-11', '2017-12', '2018-01', '2018-02', '2018-03', '2018-04', '2018-05', '2018-08', '2018-09').
4. The trend and seasonal signal estimated in step (1) are restored to the interpolated residuals obtained in step (3).

2. Connection of the OMB and GRACE-/FO Series

OMB and GRACE-/FO BSL series are expressed as anomalies to different reference values. This step consists of estimating the offset between both the OMB and GRACE-/FO BSL references and adjust both time series to ensure the continuity of the extended series at the connection point in April 2002.

To do so, we consider the OMB and GRACE BSL series from which we have removed their respective seasonal signals, estimated by a least-squares fit of an annual and semi-annual cycle over the 04-2002 to 12-2012 period.

Over the 2002–2012 period, the offset of the OMB series relative to GRACE is estimated by

calculating the mean of the differences: $offset = \frac{\sum_{i=2002}^{2012} SLB(t_i) - GRACE(t_i)}{n_i}$. Subsequently subtracting this offset from the OMB signal over 1993–2002 allows the latter to be realigned with respect to GRACE, thereby ensuring continuity at the connection point. An offset of -0.3 mm is found. This step is equivalent to correcting the time mean of the OMB series so that it equals that of GRACE over the 2002–2012 period, after removing their respective seasonal cycles.

The uncertainty associated with the offset is estimated to be 1 mm using different methods for calculating the offset.

The GRACE BSL seasonal signal calculated over 2002–2012 is added to the OMB BSL series over 01-1993 to 04-2002. It is worth noting that the seasonal signal of the OMB product is largely underestimated compared to GRACE, hence the decision to remove it and replace it with the GRACE signal. This decision is confirmed by comparing the annual cycles estimated from the OMB (Magellium/LEGOS, 2023a) and GRACE (Magellium/LEGOS, 2023b) series with those of the SLB (Sea Level Budget) series, which is calculated as the difference between the altimetry and Argo Magellium/LEGOS series (Magellium/LEGOS, 2023a). The GRACE and SLB annual cycles are close in both phase and amplitude, whereas the OMB annual cycle has a smaller amplitude and a phase shift of +2 months (visible in Figure 1).

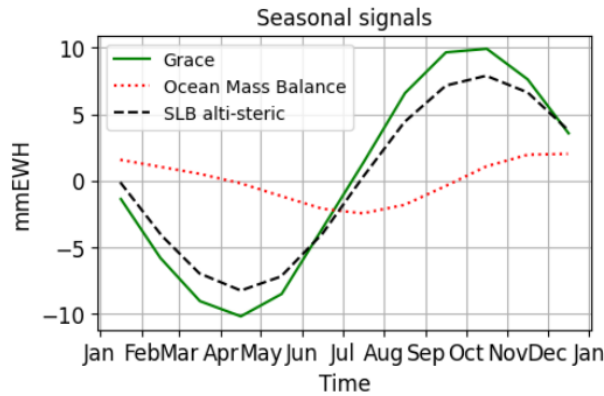


Figure 1: Seasonal signals composed of the annual and semi-annual cycles for each of the following time series: the one obtained from GRACE/-FO observations, the one from the OMB method, and finally the one from the SLB method.

3. Extrapolation

The BSL time series is extrapolated from 09-2025 to 06-2027 by projecting the linear trend, annual cycle, and semi-annual cycle calculated from the gravimetry series over the GRACE-FO period from 06-2018 to 08-2025.

The combined barystatic series is shown in Figure 2, and the overlay with the original signals from OMB and GRACE/-FO is shown in Figure 3.

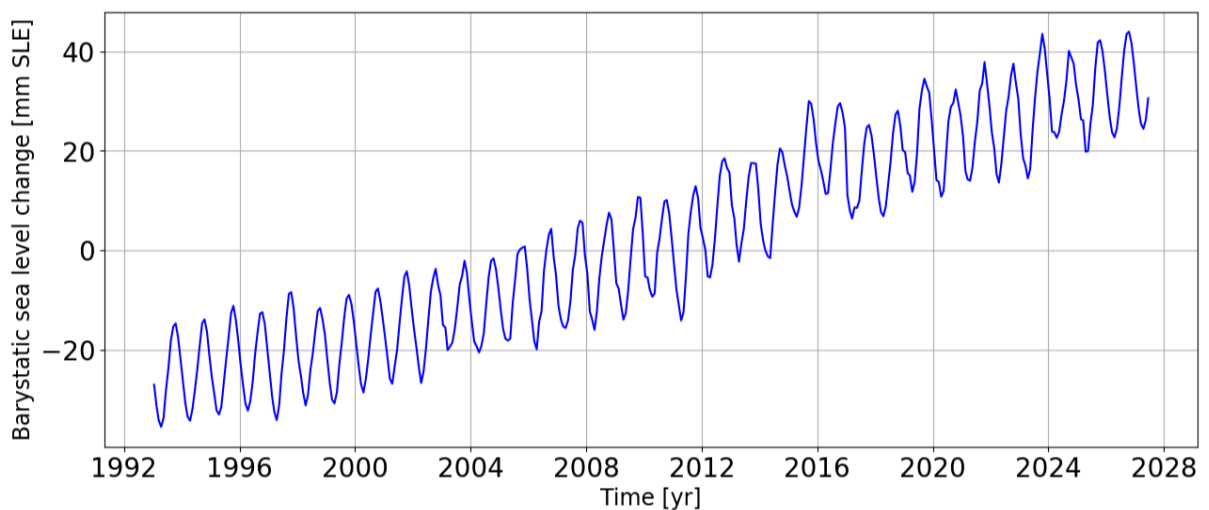


Figure 2: Barystatic sea level variations continuously from 01-1993 to 06-2027, made from the connection between the OMB and GRACE/-FO products.

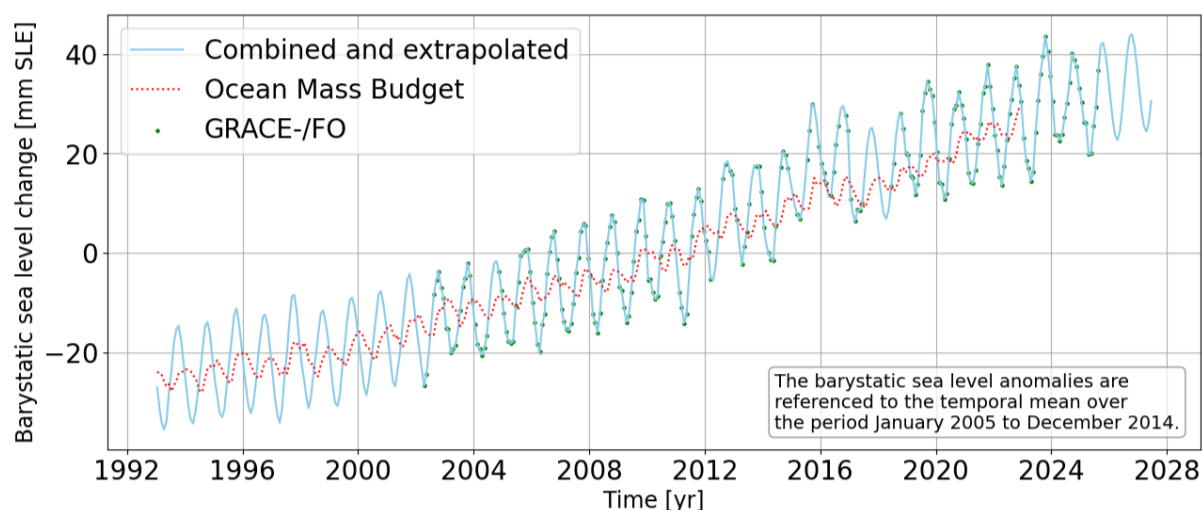


Figure 3: Continuous extended BSL time series in blue. The red dotted series is derived from the OMB method, and the green dots correspond to the barystatic signal observed by GRACE-/FO.

Product Description

The product is provided on the 16th of each month and is delivered as a Network Common Data Form version 4 (netCDF4) file. The product follows the naming standard:

OMB_GRACE_MAGELLUM_EXTENDED_BARYSTATIC_V<VERSION>.nc

where:

- <VERSION> is the version number, here 'V1-0' for the first major version. The first digit changes each time a major version is released ('V2-0', 'V3-0'), while changes in the second digit indicate reprocessing versions or minor versions ('V1-2', 'V1-3').
- .nc: standard NetCDF filename extension

ACRONYMS

Acronym	Description
GRACE	Gravity Recovery and Climate Experiment
GRACE FO	GRACE Follow-On
OMB	Ocean Mass Budget
SLB	Sea Level Budget

REFERENCES

Magellium/LEGOS. (2023a). *Barystatic and manometric sea level changes from a sea level budget approach* (Version 3) [NetCDF]. CNES.

<https://doi.org/10.24400/527896/A01-2023.012>

Magellium/LEGOS. (2023b). *Barystatic and manometric sea level changes from GRACE and GRACE-FO* (Version 2) [NetCDF]. CNES.

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