Release Notes for GFZ GRACE-FO Level-2 Products - version RL06

Last update: 08.10.2020

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General Remarks:

- A GFZ GRACE-FO RL06 time series is being routinely processed and is currently available at the two GRACE archives GFZ/ISDC (Information System and Data Centre) and JPL/PO.DAAC (Physical Oceanography Distributed Active Archive Center) for the period from June 2018 through August 2020.
- GRACE-FO RL06 is the initial release of GRACE-FO Level-2 products indicating consistency and continuity with the current GRACE RL06 time series.
- Details on modifications w.r.t. GFZ GRACE RL06 [1] can be found in the GFZ GRACE-FO Level-2 Processing Standards Document for Level-2 Product Release 06 [2] which is also available at the GRACE archives.
- The GRACE-FO RL06 Level-2 filename convention is the same as for GRACE RL06, except for the “mission”-string which is changed from “GRAC” to “GRFO” (see GRACE-FO Level-2 Gravity Field Product User Handbook [3]).
- As for GRACE RL06, a linear mean pole is used during GRACE-FO RL06 Level-2 processing that negates the need for the correction of the $C_{21}$ and $S_{21}$ coefficients recommended by Wahr et al. (2015) [4], which was applicable for GRACE RL05 solutions.
- The following two versions of GFZ GRACE-FO RL06 monthly solutions are provided: (1) up to degree/order 60 and (2) up to degree/order 96 (in case of sufficient satellite ground track coverage).
- The uncertainties of the spherical harmonic coefficients provided with the GFZ GRACE-FO RL06 gravity field solutions have not been calibrated and represent the formal errors.

User Recommendations & Requests:

- **Geocenter:** Consistent with GRACE, GRACE-FO is not sensitive to degree 1 harmonics (geocenter). GRACE/GRACE-FO Technical Note TN-13 [5] contains geocenter estimates using the methods of Swenson et al. (2008) [6] and Sun et al. (2016) [7], and is updated in synthesis with Level-2 monthly releases. These have been reprocessed for the entire GRACE and GRACE-FO time span to be consistent with the below-mentioned TN-14, so users need to replace the entire TN-13 time series. It is recommended to augment the GRACE and GRACE-FO geocenter with this product for surface mass change estimation.
- **$C_{20}$ coefficient:** Consistent with the GRACE SDS recommendations, GRACE-FO SDS recommends the replacement of the native GRACE-FO $C_{20}$ coefficient with that from SLR. Note that GRACE Technical Note TN-11 will no longer be updated; it is replaced by GRACE/GRACE-FO Technical Note TN-14 [8] and contains both $C_{20}$ and $C_{30}$ estimates derived from SLR using...
Level-2 RL06 standards. TN-14 is updated in synch with Level-2 monthly releases. It is recommended to replace the native GRACE and GRACE-FO $C_{20}$ coefficients with this product for all months (April 2002 – current) [9].

- **$C_{30}$ coefficient:** The GRACE-FO SDS has determined that the $C_{30}$ coefficient in GRACE-FO shows comparatively more variability relative to the long-term climatology derived from the GRACE $C_{30}$ coefficient. Therefore, SDS recommends that users assess the impact on regional mass budgets of substituting the GRACE-FO $C_{30}$ coefficient with one derived from SLR (similar to the $C_{20}$ approach). It is recommended to replace the native GRACE and GRACE-FO $C_{30}$ coefficients with the aforementioned Technical Note TN-14 [8] from August 2016 onwards (August 2016 – current) [10].

- **Feedback Request:** The GRACE-FO project SDS is looking for feedback from the Science Team and wider community on the impact of $C_{20}$ and $C_{30}$ replacements, either from these or other candidate SLR time series, on regional mass balances to support the project in further improving the handling of low-degree harmonics in GRACE and GRACE-FO data processing.

**Products:**

There are usually 6 Level-2 product files available for each month where YYYY corresponds to a 4-digit year and DDD corresponds to a 3-digit day of year (for details regarding the product names see the GRACE-FO Level-2 Gravity Field Product User Handbook [3]):

- **GSM-2_YYYYDDD-YYYYDDD_GRFO_GFZOP_BA01_0600**
  Unconstrained monthly gravity field solution estimated up to degree/order 60.

- **GSM-2_YYYYDDD-YYYYDDD_GRFO_GFZOP_BB01_0600**
  Unconstrained monthly gravity field solution estimated up to degree/order 96.
  *Note that for months with short-period repeat orbits, this solution might not always be published.*

- **GAA-2_YYYYDDD-YYYYDDD_GRFO_GFZOP_BC01_0600**
  The average of the “atm” coefficients from the AOD1B RL06 product up to degree/order 180 over the same time span as the GSM products.

- **GAB-2_YYYYDDD-YYYYDDD_GRFO_GFZOP_BC01_0600**
  The average of the “ocn” coefficients from the AOD1B RL06 product up to degree/order 180 over the same time span as the GSM products.

- **GAC-2_YYYYDDD-YYYYDDD_GRFO_GFZOP_BC01_0600**
  The average of the “glo” coefficients from the AOD1B RL06 product up to degree/order 180 over the same time span as the GSM products; these harmonic coefficients are used as background model during Level-2 processing.

- **GAD-2_YYYYDDD-YYYYDDD_GRFO_GFZOP_BC01_0600**
  The average of the “oba” coefficients from the AOD1B RL06 product up to degree/order 180 over the same time span as the GSM products.

*Note that the GAA/GAB/GAC/GAD products contain coefficients for degree 0 and 1; however, these coefficients are not used in the GFZ GRACE-FO Level-2 processing.*
Also note that the averaging of the GAA/GAB/GAC/GAD products is computed over entire days, regardless of whether the full day (as opposed to a partial day) was included in Level-2 processing.

For further details about AOD1B see the Product Description Document for AOD1B Release 06 [11].

Additional Level-2 product files (available only at ISDC):

**GSM-2_YYYYDDD-YYYYDDD_GRFO_GFZOP_BB01_0600.snx**
Monthly normal equation of gravity field parameters up to degree/order 96 in SINEX format, available here: ftp://isdcftp.gfz-potsdam.de/grace-fo/Level-2/GFZ/RL06_NEOs_SINEX/

**Citation:**

Please use the following reference when using the time series of GFZ RL06 Level-2 products:

Dahle, Christoph; Murböck, Michael; Flechtner, Frank; Dobslaw, Henryk; Michalak, Grzegorz; Neumayer, Karl H.; Abrykosov, Oleh; Reinhold, Anton; König, Rolf; Sulzbach, Roman; Förste, Christoph (2019). The GFZ GRACE RL06 Monthly Gravity Field Time Series: Processing Details and Quality Assessment. Remote Sens. 11(18):2116. https://doi.org/10.3390/rs11182116

The GFZ GRACE-FO RL06 Level-2 products are published as data publication via GFZ Data Services:

**GSM-Products:**
Dahle, Christoph; Flechtner, Frank; Murböck, Michael; Michalak, Grzegorz; Neumayer, Hans; Abrykosov, Oleh; Reinhold, Anton; König, Rolf (2019): GRACE-FO Geopotential GSM Coefficients GFZ RL06. V. 6.0. GFZ Data Services. http://doi.org/10.5880/GFZ.GRACEFO_06_GSM

**GAA-Products:**
Dobslaw, Henryk; Dill, Robert; Dahle, Christoph (2019): GRACE-FO Geopotential GAA Coefficients GFZ RL06. V. 6.0. GFZ Data Services. http://doi.org/10.5880/GFZ.GRACEFO_06_GAA

**GAB-Products:**
Dobslaw, Henryk; Dill, Robert; Dahle, Christoph (2019): GRACE-FO Geopotential GAB Coefficients GFZ RL06. V. 6.0. GFZ Data Services. http://doi.org/10.5880/GFZ.GRACEFO_06_GAB

**GAC-Products:**
Dobslaw, Henryk; Dill, Robert; Dahle, Christoph (2019): GRACE-FO Geopotential GAC Coefficients GFZ RL06. V. 6.0. GFZ Data Services. http://doi.org/10.5880/GFZ.GRACEFO_06_GAC

**GAD-Products:**
Dobslaw, Henryk; Dill, Robert; Dahle, Christoph (2019): GRACE-FO Geopotential GAD Coefficients GFZ RL06. V. 6.0. GFZ Data Services. http://doi.org/10.5880/GFZ.GRACEFO_06_GAD
Overview of available solutions:

The following table shows the currently available monthly Level-2 GFZ GRACE-FO RL06 products, where

- **Release Date** is chronologically starting from first provision of GFZ RL06 data till today.
- **Product Name** is in agreement with the Level-2 Gravity Field Product User Handbook [3].
- **Month** is the calendar month the Level-2 products are assigned to (usually one complete month of data is used, exact start and end epochs are provided in the Level-2 product headers).
- **Reference epoch** is the proper mean epoch of the Level-2 products taking into account complete or partial days between start and end epoch which were not used during the generation of the Level-2 products; the reference epoch is given in civilian date and UTC time (rounded to minutes).
- **Arcs & Days** are the number of orbital arcs used for the generation of the Level-2 products and the accumulated number of actual days over these orbital arcs (i.e. the amount of days where GRACE data has been incorporated in the Level-2 processing).
- **Max. d/o** is the maximum degree and order for the corresponding Level-2 product.
- **GAX** is yes, if the corresponding GAA, GAB, GAC and GAD products are available, too (nominal case).
- **Comments**, which are explained in detail further below.

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<tr>
<th>Release Date</th>
<th>Product Name</th>
<th>Month</th>
<th>Reference epoch</th>
<th>Arcs &amp; Days</th>
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<th>GAX</th>
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Comments:

1) During gravity field estimation for this month, the fully-populated accelerometer scale factor matrix has been estimated once per orbital arc.
2) During gravity field estimation for this month, the fully-populated accelerometer scale factor matrix has been estimated globally once per month.

References:


of Geophysical Research: Solid Earth, 120, 6, 4597-4615. DOI:
http://doi.org/10.1002/2015JB011986


