GFZ: GRACE and GRACE-FO Level-2/-3 Overview

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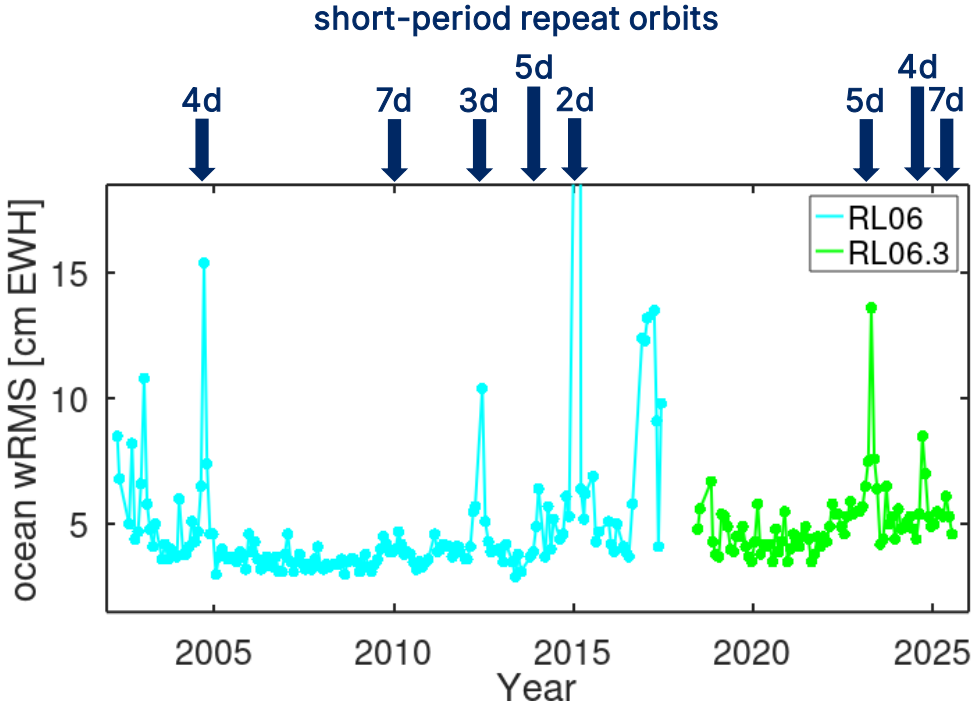
Level-2: Operational GFZ RL06 time series

- GRACE-FO:
  - Continuous processing of RL06.3 Level-2 products
    - Using the GF2 ACC transplant products provided with the ACX2 bundles
  - Current Level-2 processing status: 84 GFZ RL06.3 monthly solutions from June 2018 through July 2025

- Entire GRACE + GRACE-FO GFZ RL06 time series:
  - 247 monthly solutions, consistently processed
  - Available at ISDC and PO.DAAC archives
  - GFZ RL06/RL06.1/RL06.3 normal equations in SINEX format are provided at ISDC

Level-2: GFZ RL06/RL06.3 noise level



wRMS over open ocean (DDK5 filtered, residuals relative to a GRACE/GRACE-FO climatology)

- Noise level of GRACE-FO is quite consistent compared to GRACE, almost reaching the level of the best GRACE years (2005 - 2012)
- Increased solar activity since 2022: recent GRACE-FO solutions with slightly higher noise level than before 2022
- Larger peaks in the ocean RMS time series mostly due to short-period repeat orbits

Level-2: GFZ RL07 reprocessing

- Reprocessing of an improved GFZ RL07 time series is currently ongoing, aiming at
  - Reduced noise level of gravity field solutions
  - Reduced temporal aliasing errors
  - More realistic formal error estimates

- Results presented at GSTM2025 are based on a preliminary **GFZ RL07p** time series
  - Currently, 12 years (2003 through 2014) of GRACE have been processed

Level-2: GFZ RL07 reprocessing

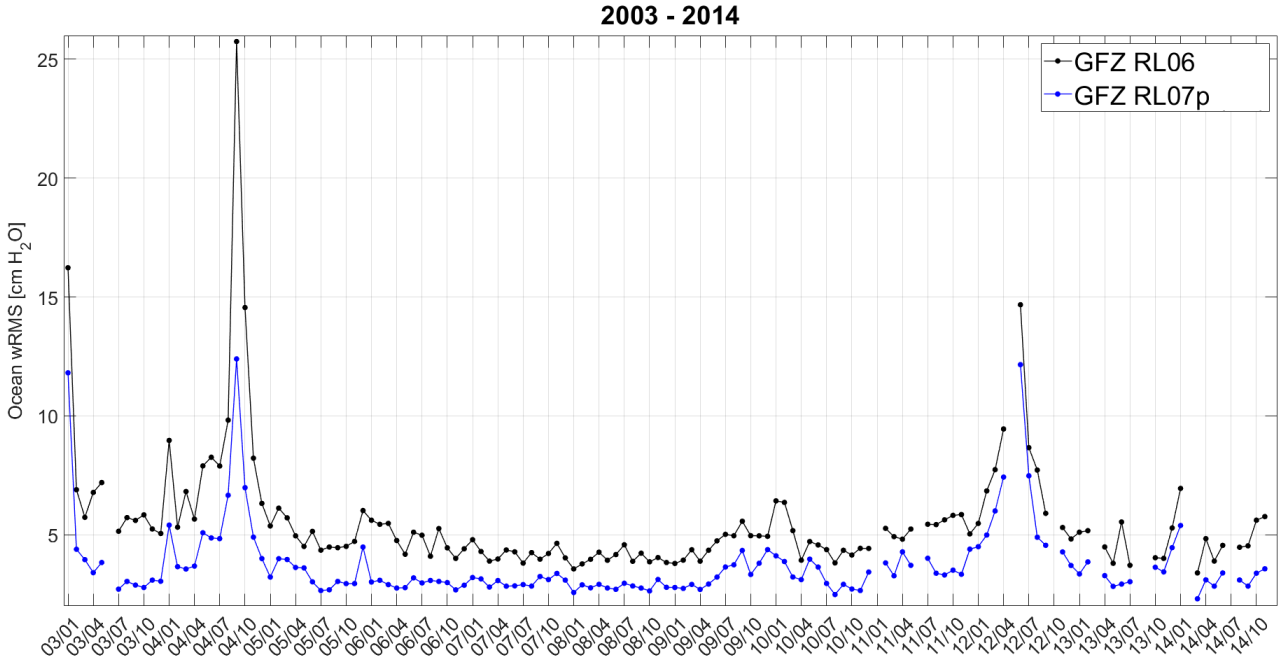
- Changes from RL06 to RL07 include:
  - Reprocessed V05 Level-1B products
  - Reprocessed GPS constellation
  - Updated background models
  - Stochastic modelling of observations & AOD background model
  - Optimized relative weighting between KBR/LRI and GPS observations by means of arc-wise variance component estimation

Level-2: GFZ RL07 reprocessing

- Changes from RL06 to RL07 include:
  - Reprocessed V05 Level-1B products → Final products not yet available
  - Reprocessed GPS constellation → Processing currently ongoing
  - Updated background models
  - Stochastic modelling of observations & AOD background model
  - Optimized relative weighting between KBR/LRI and GPS observations by means of arc-wise variance component estimation

RL07p time series

Level-2: GFZ RL07 reprocessing



wRMS over open ocean (300 km Gaussian smoothing, residuals relative to a GRACE/GRACE-FO climatology)

- All monthly **RL07p** solutions processed so far show an improvement compared to **RL06**
- mean reduction of ocean RMS ~ 32%

➢ For more GFZ RL07 details and results: see **GSTM2025 presentation by Markus Hauk**

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Level-2: GFZ RL07 reprocessing

- Plans & time schedule for **final RL07** reprocessing:
  - Finish **RL07p** reprocessing for the complete GRACE/GRACE-FO period
    - Estimate residual ocean tide parameters from on **RL07p** ➔ update ocean tide model to be used for **RL07**
    - Use **RL07p** KBR post-fit residuals to refine assumption of observation noise on a monthly basis
  - Wait until reprocessed V05 Level-1B products & reprocessed GPS constellation are available
  - ➢ Repeat reprocessing to obtain **final RL07 time series**

  - Expected date for publication of first **GFZ RL07** GRACE products is end of 2025; GRACE-FO will follow later in 2026

Level-3: GravIS portal

gravis.gfz.de

- Dedicated mass change products for:
  - **Terrestrial water storage** over non-glaciated regions (TWS)
  - **Ocean bottom pressure** variations (OBP)
  - **Ice-mass changes** in **Antarctica** and **Greenland** (in collaboration with AWI & TU Dresden)

- Additional product: **Global Gravity-based Groundwater Product** (G3P) prototype
  - Current version v1.12
  - Covering the period 2002/04 through 2023/09

www.g3p.eu

Level-3: GravIS products

gravis.gfz.de

- Overview on available products:
  - Level-2B:
    - SH coefficients, with the following corrections already applied: (optional) VDK filtering, replacement of specific low degree harmonics, geocenter, GIA, S2 tidal alias signal) ➔ https://isdc-data.gfz.de/grace/GravIS/
  - Level-3:
    - Gridded data (NetCDF format) ➔ https://isdc-data.gfz.de/grace/GravIS/
    - Regional averages (csv files) ➔ directly from corresponding GravIS subpages
    - Both may contain several variables, such as, e.g., uncertainties
- All GravIS products
  - are extended on a regular basis
  - are occasionally updated to incorporate Level-2/3 processing improvements

Level-3: News & updates

gravis.gfz.de

- Continuous efforts by GFZ related to GravIS and G3P successfully led to contributions to operational **Copernicus Climate Change Service** (C3S)
  - *TWS Anomaly* and *Groundwater Storage Change* were selected as new Climate Data Records, with GFZ as lead
  - KO meeting in January 2025, duration of current contract until March 2028

- Publication of GravIS reference paper
  - ➢ https://essd.copernicus.org/articles/17/611/2025/

Level-3: News & updates

GravIS Gravity Information Service
gravis.gfz.de

- Product updates:
  - Products based on GFZ Level-2 products
    - January 16th, 2025: new versions of Level-2B & Level-3 products
      - Switch to GFZ RL06.3 Level-2 products
      - TWS & OPB products are no longer provided in yearly batches but one single file
  - Products based on COST-G Level-2 products
    - July 22nd, 2025: new release of Level-2B products
      - Switch to COST-G RL02 (Version 2.1) Level-2 products
    - August 14th, 2025: new release of Level-3 products for TWS & OBP
      - Switch to COST-G RL02 (Version 2.1) Level-2 products
      - Products are no longer provided in yearly batches but one single file

Level-2/Level-3: ISDC archive

- Since June 10th, 2025, publicly available data at GFZ's ISDC archive is made available for download via HTTPS protocol
  - This includes all GRACE/GRACE-FO SDS data & documentation, as well as GravIS Level-3 products
  - New links:
    - GRACE archive: https://isdc-data.gfz.de/grace/
    - GRACE-FO archive: https://isdc-data.gfz.de/grace-fo/

- **Important remark:** Access to ISDC via **FTP will be deactivated** on December 31st, 2025!
  - Make sure to change any automated download scripts from FTP to HTTPS before the end of this year

Summary

- Continuous processing of operational GRACE-FO RL06.3 Level-2 products
- Ongoing reprocessing effort for an **improved RL07 Level-2 time series**
  - Preliminary RL07p solutions show a **significant noise reduction** and **more realistic formal errors**
  - More details: see **GSTM2025 presentation by Markus Hauk**

- **Level-3 mass change products** are provided at **GravIS** portal
  - Products have been updated recently: switch to GFZ RL06.3 and COST-G RL02

- **FTP access to ISDC will be deactivated end of 2025, use HTTPS instead!**