



GRACE Follow-On

Science Data System Newsletter

Period: Oct-2022 – Mar-2023 (No. 23)

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GRACE Follow-On Science Data System: Highlights & Updates

- The latest NASA Earth Observer Jan/Feb newsletter issue features a summary of the 2022 GRACE-FO Science Team Meeting – read it [here](#).
- The GRACE-FO JPL team, with support from UT-CSR, has submitted a 2023 NASA Senior Review proposal to extend the mission through 2026, beyond the 5-year prime mission phase (06/2018 – 05/2023). GFZ will continue to fund & support mission operations and SDS activities through 2026.
- The following **Level-1, 2 & 3 SDS data products** are now available at NASA's Physical Oceanography Distributed Active Archive Center ([PO.DAAC](#)) and GFZ's Information System and Data Center ([ISDC](#)):
 - **Level-1** SDS data products through **Mar 2023**.
 - Update frequency: weekly
 - The improved ACX-L1B Accelerometer transplant data are available through **Feb 2023**; please note that this ACC product bundle will be updated on a monthly cadence, with a latency similar to L2 products.
 - While the weekly L1A/B delivery bundle will still contain the [ACT1B] product, we recommend the use of [ACH1B] for the generation of monthly L2 and higher data products.
 - **Level-2 & 3** data products through **Feb 2022**.
 - Update frequency: monthly.
 - The current operational data release for L2 and L3 is RL06.1. Release RL06 will no longer be updated past Dec-2022.
- The following **Level-3 data** products (global, land, ocean, ice) are available:
 - JPL Tellus global mascon products: https://grace.jpl.nasa.gov/data/get-data/jpl_global_mascons/
 - GFZ GravIS land, ocean and ice products: <http://gravis.gfz-potsdam.de/>
 - UT-CSR global mascon solutions:



http://www2.csr.utexas.edu/grace/RL06_mascons.html

- At GFZ's Gravis portal, a prototype of a new satellite-based groundwater product spanning the period Apr-2002 through Dec-2020 is available (<http://gravis.gfz-potsdam.de/gws>). This product has been developed within the EU Horizon 2020 Project G3P (Global Gravity-based Groundwater Product, see <https://www.g3p.eu/> for more information).
- **Attention:** JPL/NASA PO.DAAC has migrated all data sets, technical notes, and documentation files to the PO.DAAC AWS Cloud environment:
 - Please visit <https://podaac.jpl.nasa.gov/cloud-datasets/about> for instructions on how to update your data retrieval / downloads accordingly.
 - All GRACE-FO documentation, Technical Notes (TN-*), and ancillary files are available for download at <https://podaac.jpl.nasa.gov/gravity/gracefo-documentation>
- GRACE-FO science data collection and processing updates:
 - During **Jan/Feb 2023**, the two spacecraft operated in a relaxed AOCS pointing mode, with pointing offsets up to +/- 2 deg. Consequently, the LRI was not tracking (diagnostic mode). The goal of this test was to assess the impact of reduced thruster usage, viability of data collection & quality, and the impact on Cold Gas Propulsion System (CGPS) leak rates. The analysis is ongoing, and results will be discussed at the IUGG (Jul-2023) and GFO-STM (Oct-2023 – see below!). We welcome any feedback from other data users and processing centers.
 - GRACE-FO is currently decaying through the 5-day repeat orbit band around 485 (+/-1.2) km altitude. Groundtrack coverage has been reduced accordingly (see Fig. 2 below), which will impact the L2 & L3 data quality for Apr-May, 2023.
 - Continuous collection of science data in nominal fine-pointing mode (except for Jan/Feb-2023 - see note above), no major events.
- **Solar Cycle #25:** Increased solar activity is resulting in increased orbit altitude decay rates (Fig.1), as well as increased non-gravitational acceleration on the two GRACE-FO satellites. From April/May-2023, the satellites are in a repeat-orbit altitude band (Fig.2).
- Do you have new GRACE-FO results, a conference presentation or paper publication you would like to share? Please send a copy of your GRACE and GRACE-FO related publications to landerer@jpl.nasa.gov and flechtne@gfz-potsdam.de (please also consider a 1-slide highlight summary of the main findings).
- **References:**

When using GRACE-FO data, please cite the **GRACE-FO Mission reference paper:**

 - Landerer, F.W., Flechtner, F., et al., 2020, Extending the global mass change data record: GRACE Follow-On instrument and science data performance, *Geophys. Res. Lett.*, <https://doi.org/10.1029/2020GL088306>.



Community Announcements & Upcoming Events:

- The next **GRACE-FO Science Team Meeting 2023** will take place from **Oct 16-18, 2023** in Boulder, CA, USA – more details forthcoming at: <https://grace.jpl.nasa.gov/events/19/2023-grace-fo-science-team-meeting/>
- In the framework of the ESA-funded project QSG4EMT (Quantum Space Gravimetry for monitoring Earth’s Mass Transport Processes), a **survey on user requirements for future satellite gravity missions** is currently conducted. Users interested in water storage, sea level, ice sheets, crust-mantle dynamics or any other mass change signals are invited to participate and **complete the survey until Jun 18, 2023 using the following link:** https://www.soscisurvey.de/mass_change/.
- The 28th IUGG General Assembly (IUGG2023) will be held from 11 to 20 July 2023 in Berlin, Germany. Check out the program for many GRACE and GRACE-FO related presentations (<https://www.iugg2023berlin.org/iag/>).

Science Team Resources:

- The next **GRACE-FO Science Team Meeting 2023** will take place from **Oct 16-18, 2023** in Boulder, CA, USA – more details forthcoming at: <https://grace.jpl.nasa.gov/events/19/2023-grace-fo-science-team-meeting/>
- The [2023 NASA ROSES GRACE-FO Science Team](#) is competed this year - proposals are due Jul-14, 2023.
- Proceedings and presentations from the **2022 GRACE/GRACE-FO Science Team Meeting** are available [online](#).
- Proceedings and presentations from previous **GRACE/GRACE-FO Science Team Meetings** are also available at [JPL](#) and at [GFZ](#).



GRACE Follow-On: Mission Status

GRACE Follow-On: Orbit

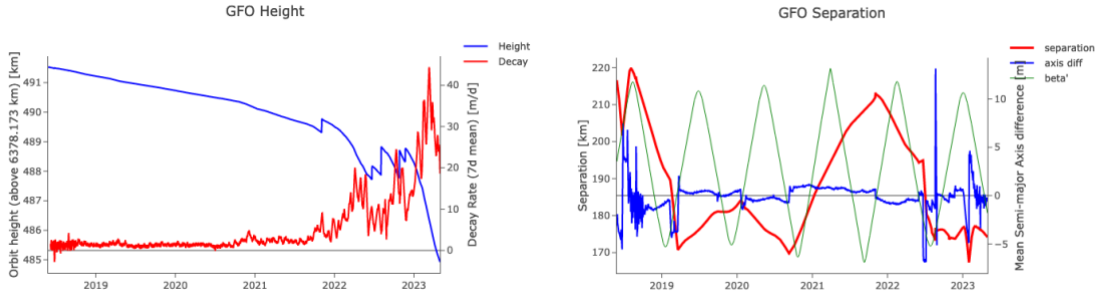


Figure 1: (left) Orbit altitude and daily decay rates [m/d] since launch. (right) Spacecraft separation distance and semi-major axis difference between GF1 and GF2, as well as beta-prime angle of the orbit plane (data and plots provided by K. Snopek, GFZ).

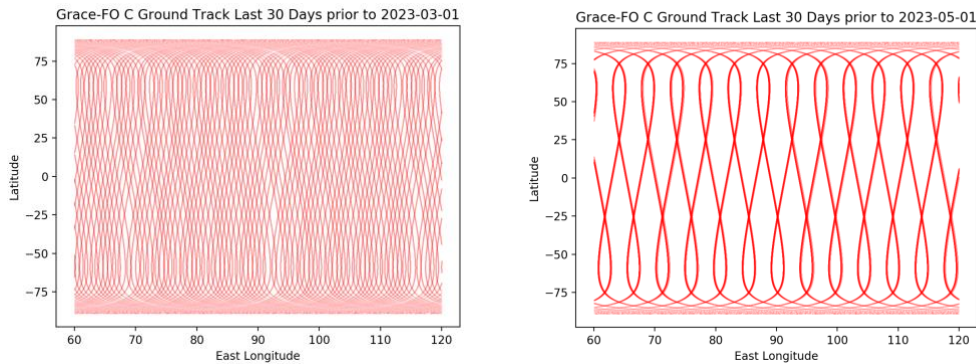


Figure 2: Groundtrack for Feb-2023 (left) vs Apr-2023 (right) associated with the 485 +/-1.2 km 5-day repeat orbit (plots by H. Save, CSR).

The GRACE Follow-On orbital parameters on 2023-05-01 (day 121) were as follows:

Sun Beta (deg)	-40
Absolute Distance (km)	174.2
Drift (km/d)	-0.06
Mean Altitude (>6378.1 km)	484.9
Decay Rate (GF1/GF2) (7d mean, m/d)	19.8 / 19.8



Science-relevant Mission Events & Plans:

- Both accelerometers (ACCs) are operating and collecting observations in their nominal mode, Normal Range Mode (NRM). GF1 ACC data are used to generate an ACC transplant data product which is provided as the ACT1B product and can be used to substitute the GF2 ACC measurements (please refer to the ACT-Readme document for details at PO.DAAC). In addition to the ‘full’ ACT-transplant, updated calibrated data information from the GF2 accelerometer is incorporated into the ACH1B product. This product is recommended for use in generating monthly gravity L2 products (SDS L2-RL06.1 uses L1-ACH).
- Center-of-Mass (CM) offset determinations are performed approx. every 6 months (See SOE/SCE files for details).
- Additional calibration periods, spacecraft activities and events are highlighted in the Level-1 release notes and event logs.

Level-1, Level-2, Level-3 Data Products and Processing

Level-1 Data Processing & Delivery

- Level-1 data products (current operational version: v04; ACX-1B bundle on a monthly basis), which are available at NASA’s Physical Oceanography Distributed Active Archive Center (PO.DAAC) and GFZ’s Information System and Data Center (ISDC), are continuously updated approximately every 7 days. The Level-1 data includes all data required for the generation of Level-2 gravity field products. Please refer to Level-1 release notes, documentation, as well as to the Sequence-of-Events (SOE) logfile for important updates, comments and detailed description of the data, file formats, and conventions ([PO.DAAC](#) / [ISDC](#)).

KBR Performance Statistics

KBR-GPS performance statistics are available in file [TN-01b_KBR_GPS] at ([PO.DAAC](#) / [ISDC](#)).

Level-1 Data Product Availability

- [see Appendix 1A (p. 8) for GRACE-FO Level-1 data]
- [see Appendix 1B (p. 8) for de-aliasing AOD1B model data]

Level-1 Release Notes & Sequence of Events

- [see Appendix 1C (p. 8)]



Level-2 Data Processing & Delivery

Level-2 Data availability

- Level-2 Release 06 data have been processed at JPL, GFZ and CSR and are archived at JPL PO.DAAC and GFZ ISDC. The Level-2 products include the monthly gravity fields from the three mission Science Data System centers (JPL, GFZ, CSR), as well as the corresponding atmosphere and ocean dealiasing (AOD) background model data.
- Please refer to the Level-2 Release Notes and documentation description of the data for file formats, updates, conventions, as well as important processing recommendations ([PO.DAAC](#) / [ISDC](#)).
- [see Appendix 2A (p. 9) for overview tables on data availability].

Level-2 Ancillary Products, Technical Notes and Comments

- TN-14 contains C20 & C30 estimates derived from SLR and using Level-2 RL06 standards, updated in synch with Level-2 monthly releases. It is recommended to replace the native GRACE & GRACE-FO C20 & C30 coefficients with this product (Loomis et al., 2019).

TN-14 Data Access:

- @PO.DAAC: <https://podaac.jpl.nasa.gov/gravity/gracefo-documentation>
 - @GFZ: ftp://isdctftp.gfz-potsdam.de/grace-fo/DOCUMENTS/TECHNICAL_NOTES
- TN-13[a,b,c] contains geocenter estimates using the methods of Swenson et al. (2010) and Sun et al. (2016), and is updated in synch with Level-2 monthly releases. It is recommended to augment the GRACE / GRACE-FO geocenter with this product for surface mass change estimation.

TN-13[a,b,c] Data Access:

- @PO.DAAC: <https://podaac.jpl.nasa.gov/gravity/gracefo-documentation>
- @GFZ: ftp://isdctftp.gfz-potsdam.de/grace-fo/DOCUMENTS/TECHNICAL_NOTES

Level-3 Data Processing & Delivery & Availability

- The following SDS-generated **Level-3 data** products (global, land, ocean, ice) are available:
 - JPL Tellus global mascon & SDS harmonic products: https://grace.jpl.nasa.gov/data/get-data/jpl_global_mascons/
 - GFZ GravIS land, ocean and ice products: <http://gravis.gfz-potsdam.de/>
 - UT-CSR global mascon solutions: http://www2.csr.utexas.edu/grace/RL06_mascons.html
 - GSFC global mascon products: <https://earth.gsfc.nasa.gov/geo/data/grace-mascons>
- Interactive GRACE & GRACE-FO data browsers (Level-3):



- NASA/JPL: <https://grace.jpl.nasa.gov/data-analysis-tool>
- GFZ: <http://gravis.gfz-potsdam.de/>

Resources and Links:

SDS Data Archives (Level 1-3):

- JPL/NASA PO.DAAC (<http://podaac.jpl.nasa.gov>)
- GFZ ISDC (<https://isdc.gfz-potsdam.de/grace-fo-isdc>)

Miscellaneous Links:

- For GRACE Follow-On mission updates and news, please visit <https://gracefo.jpl.nasa.gov> and <http://gfz-potsdam.de/en/grace-fo>.
- The proceedings of previous GRACE / GRACE-FO Science Team Meetings are available at <https://www.gfz-potsdam.de/en/grace/> or at <https://grace.jpl.nasa.gov/events/>
- **GRACE and GRACE-FO related publications** are available via searchable databases:
 - http://www-app2.gfz-potsdam.de/pb1/op/grace/references/sort_date.html
 - <https://grace.jpl.nasa.gov/publications/>
 - For missing publications in the database, please contact Frank Flechtner (flechtne@gfz-potsdam.de) and the JPL team (grace_feedback@jpl.nasa.gov)



Appendix

1.A – Level-1 GRACE-FO Data Availability

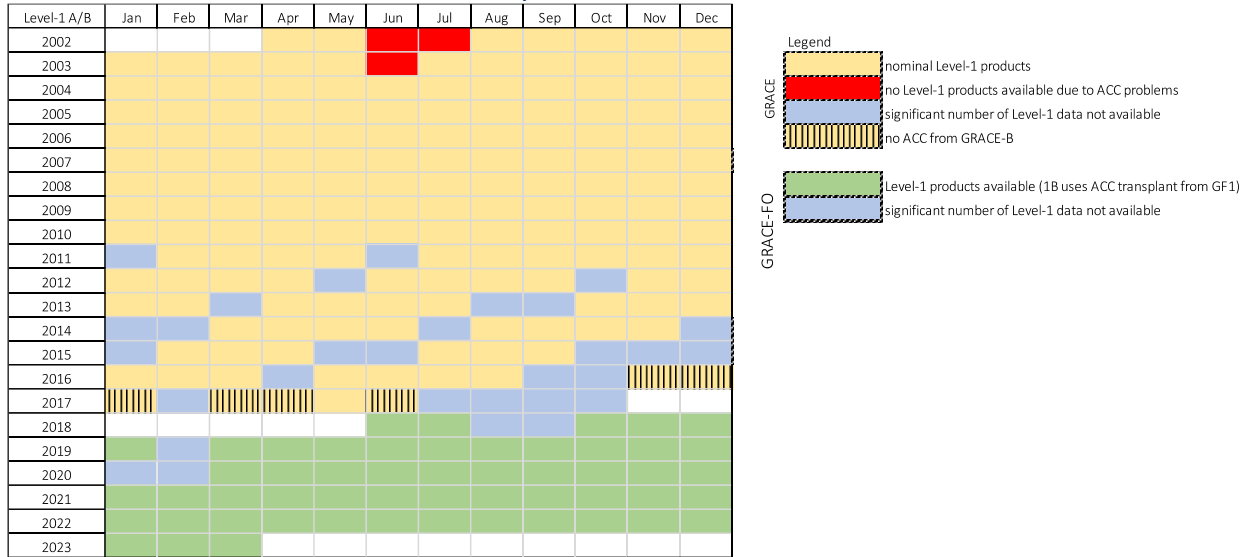


Table 1: Current version: Level-1 v04.

1.B – Level-1 De-aliasing Model AOD1B Data Availability

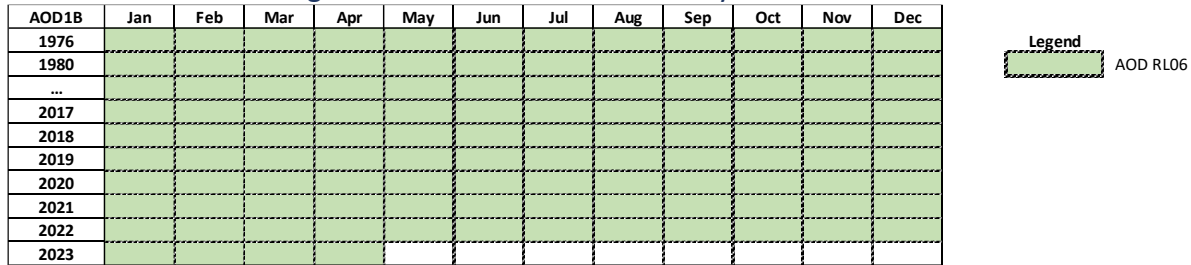


Table 2: AOD1B de-aliasing model availability (current version RL06).

- For more information on the AOD de-aliasing AOD1B model please visit <https://www.gfz-potsdam.de/en/aod1b/>.

1.C - Level-1 Release Notes & Sequence of Events

A machine-readable Sequence-of-Events file is available: [TN-01_SOE.txt]. An additional Spacecraft-Event log from JPL Level-1 operators is available as [TN-01a_SCE.txt].

- <https://podaac.jpl.nasa.gov/gravity/gracefo-documentation>
- <ftp://isdctf.gfz-potsdam.de/grace-fo/>



2.A – Level-2 Product and Data Availability

JPL, GFZ & CSR

- Current Level-2 version: **RL06.1**
- All centers provide GSM solutions
 - Please check the individual Level-2 Release Notes for further details
- JPL and GFZ provide corresponding monthly de-aliasing models [GAA, GAB, GAC, GAD]; CSR provides [GAC, GAD].

Level-2 (JPL)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
2002				1	2			3	4	5	6	7	
2003	8	9	10	11	12			13	14	15	16	17	18
2004	19	20	21	22	23	24	25	26	27	28	29	30	
2005	31	32	33	34	35	36	37	38	39	40	41	42	
2006	43	44	45	46	47	48	49	50	51	52	53	54	
2007	55	56	57	58	59	60	61	62	63	64	65	66	
2008	67	68	69	70	71	72	73	74	75	76	77	78	
2009	79	80	81	82	83	84	85	86	87	88	89	90	
2010	91	92	93	94	95	96	97	98	99	100	101	102	
2011		103	104	105	106		107	108	109	110	111	112	
2012	113	114	115	116		117	118	119	120		121	122	
2013	123	124		125	126	127	128			129	130	131	
2014	132		133	134	135	136		137	138	139	140		
2015	141	142	143	144	145		146	147	148			149	
2016	150	151	152		153	154	155	156			157*+	158*+	
2017	159*+		160*+	161*+	162*	163*+							
2018						1*	2*+			3*+	4+	5+	
2019	6+	7*+	8+	9+	10+	11+	12+	13+	14+	15+	16+	17+	
2020	18*+	19*+	20+	21+	22+	23+	24+	25+	26+	27+	28+	29+	
2021	30+	31+	32+	33+	34+	35+	36+	37+	38+	39+	40+	41+	
2022	42+	43+	44+	45+	46+	47+	48+	49+	50+	51+	52+	53+	
2023	54+	55+											

GRACE
 Level-2 products
 no Level-2 products available

GRACE-FO
 Level-2 products available

Current Level-2 Release: RL06

+ Level-2 products (with ACC transplant)
 * partial / overlapping calendar-months

Table 3: GRACE and GRACE-FO Level-2 product availability.



3.A – Level-3 Product and Data Availability

JPL, GFZ & CSR

- JPL provides Land (LND) and Ocean (OCN) global data grids for all three SDS centers (JPL, GFZ, CSR) via PO.DAAC.

Level-2 (JPL)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2002				1	2			3	4	5	6	7
2003	8	9	10	11	12		13	14	15	16	17	18
2004	19	20	21	22	23	24	25	26	27	28	29	30
2005	31	32	33	34	35	36	37	38	39	40	41	42
2006	43	44	45	46	47	48	49	50	51	52	53	54
2007	55	56	57	58	59	60	61	62	63	64	65	66
2008	67	68	69	70	71	72	73	74	75	76	77	78
2009	79	80	81	82	83	84	85	86	87	88	89	90
2010	91	92	93	94	95	96	97	98	99	100	101	102
2011		103	104	105	106		107	108	109	110	111	112
2012	113	114	115	116		117	118	119	120		121	122
2013	123	124		125	126	127	128			129	130	131
2014	132		133	134	135	136		137	138	139	140	
2015	141	142	143	144	145		146	147	148			149
2016	150	151	152		153	154	155	156			157*+	158*+
2017	159*+		160*+	161*+	162*	163*+						
2018						1*	2*			3*+	4+	5+
2019	6+	7*+	8+	9+	10+	11+	12+	13+	14+	15+	16+	17+
2020	18+*	19+*	20+	21+	22+	23+	24+	25+	26+	27+	28+	29+
2021	30+	31+	32+	33+	34+	35+	36+	37+	38+	39+	40+	41+
2022	42+	43+	44+	45+	46+	47+	48+	49+	50+	51+	52+	53+
2023	54+	55+										

GRACE

Level-3 products (white)

no Level-3 products available (red)

GRACE-FO

Level-3 products available (blue)

Current Level-2 Release: RL06

+ Level-3 products (with ACC transplant)

* partial / overlapping cal-months

Table 4: GRACE and GRACE-FO Level-3 product availability