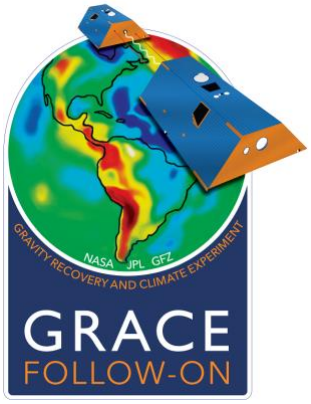

GRACE Follow-On

Science Data System Newsletter

Period: Aug 2023 – Jan 2024 (No. 25)

Contact: gracefo@jpl.nasa.gov

Felix Landerer[1], Frank Flechtner[2], Himanshu Save[3], Christoph Dahle[2], Rob Gaston[1]

[1] Jet propulsion Laboratory / California Institute of Technology, Pasadena, CA
[2] GFZ German Research Centre for Geosciences, Potsdam, Germany
[3] Center for Space Research, University of Texas, Austin, TX

GRACE Follow-On Mission: Highlights & Updates

Community Updates, News & Announcements

- The next **2024 GRACE-FO Science Team Meeting** (hybrid) will take place October 8-10, 2024, at GFZ in Potsdam, Germany. Please already mark these dates in your calendar. More meeting information and details will be forthcoming in a few weeks.
- The **2023 GRACE-FO Science Team Meeting** proceedings and presentations are available at https://grace.jpl.nasa.gov/events/19/2023-grace-fo-science-team-meeting/.
- **EGU24** (14–19 April): Several project team and science team members will be at EGU24. Frank Flechtner (GFZ) will present GRACE-FO: science results, project status and further plans on Thursday, 18 Apr, 08:35–08:45 (CEST).
- The NASA 2023-ROSES GRACE-FO Science Team has been announced. Selected proposals abstracts can be viewed on the NSPIRES portal.
- The NASA Project Team successfully completed the NASA *End of Prime Mission Review* on March-29, 2024. The mission is now in the extended mission phase through 2026, when the next NASA Senior Review will take place.

Science & Applications Data Updates, Resources & News

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 2024:**

- Update frequency: weekly
- ACX-L1B Accelerometer transplant data are available through **Feb 2024**; this ACC product bundle is updated on a monthly cadence, with a latency similar to L2 products.
- For the wide deadband (WDB) months (see also Table 1.A in the Appendix and bullet 1 in 'Mission Updates & News'), an improved ACC product has been developed. This

includes updated modeling to account for large attitude deviations and their effect on solar radiation pressure, drag, and winds. These updates yield improved Level-2 products. These data products will be released by May 2024.

- ACX-bundles at PO.DAAC & ISDC already contain improved ACH1B WDB data for all days since 2023-12-01.
- For Jan/Feb-2023 and Jul-2023 through Nov-2023, new ACX-bundles will be released by May 2024 (already existing ones will be archived).
- New bundles will be distinguishable by their names: *.ACX.tgz → *.**ACX2**.tgz (product filenames within the tar-bundles will remain the same).

Level-2 & 3 data products through **Feb 2024:**

- Update frequency: monthly.
- The current operational data release for L2 and L3 is RL06.1 for JPL and GFZ and RL06.2 for CSR.
- Once **ACX2-L1B** bundles (see above) are released, L2/L3 versions will be reprocessed and updated to **RL06.3** for all SDS centers.

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

Additional Data Resources:

- 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).
- A new GFZ information portal on satellite gravimetry monitoring of global mass changes is now online: https://globalwaterstorage.info
- All JPL/NASA PO.DAAC data sets, technical notes, and documentation files are available via 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

Mission Updates & News

GRACE-FO science data collection and processing updates:

- Since **Jul-2023**, the two spacecraft are collecting science data in a relaxed AOCS pointing mode (a.k.a. 'wide deadband' [WDB], similar to the mode during the **Jan/Feb 2023** test), with pointing offsets up to +/- 2 deg. While the MWI is tracking nominally, the LRI is not collecting inter-satellite ranging data, but is ON in diagnostic mode. The goal of the relaxed pointing mode is to reduce thruster activation and overall fuel usage. In this mode, the AOCS thrust activity is significantly reduced and the fuel leak has stabilized.
- Solar Cycle #25: Solar activity continues at high levels, resulting in orbit altitude decay rates between 20-38 m/day since mid-2023 (Fig.1), as well as increased non-gravitational forces on the two GRACE-FO satellites.

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). Corresponding short blog articles may also be published at globalwaterstorage.info.

Mission 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.

Science Team Resources:

- The next **2024 GRACE-FO Science Team Meeting** will take place from **Oct 8-10, 2024** in GFZ Potsdam, Germany.
- Proceedings and presentations from previous **GRACE/GRACE-FO Science Team Meetings** are available at JPL and at GFZ.

GRACE Follow-On: Mission Status

GRACE Follow-On: Orbit

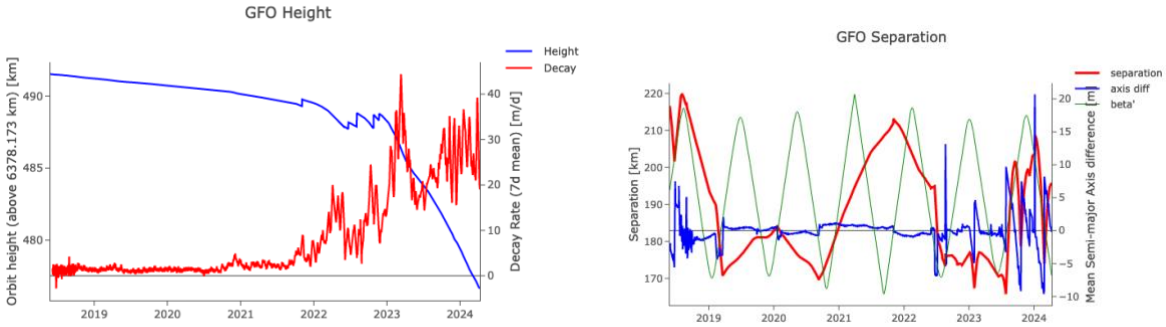

Figure 1: (left) Orbit altitude and daily decay rates [m/day] since launch. (right) Spacecraft separation distance and semi-major axis difference between GF1 and GF2, as well as beta-prime angle of the orbit plane (data and plots provided by K. Snopek, GFZ).

The GRACE Follow-On orbital parameters on 2024-04-12 were as follows:

Mean Altitude (>6378.1 km)	476.6
Altitude difference (GF2-GF1, m)	-0.5
Decay Rate (GF1/GF2) (7d mean, m/d)	19.7 / 19.8
Absolute Distance (km)	195.5
Drift (km/d)	-0.04
Sun Beta (deg)	-70.1

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).

  - NOTE: for Jan/Feb-2023 & Jul-2023 onwards, the ACT1B products for GF2 (only) are currently *empty*; to generate L2 and higher data products, we recommend the use of the calibrated ACH1B products.
- Center-of-Mass (CM) offset determinations are performed approx. every 6 months (see SOE/SCE TN 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: L1A/B_v04 weekly; 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).

MWI Performance Statistics

MWI-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://isdcftp.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://isdcftp.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

Level-1 A/B	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2002												
2003												
2004												
2005												
2006												
2007												
2008												
2009												
2010												
2011												
2012												
2013												
2014												
2015												
2016												
2017												
2018												
2019												
2020												
2021												
2022												
2023												
2024												

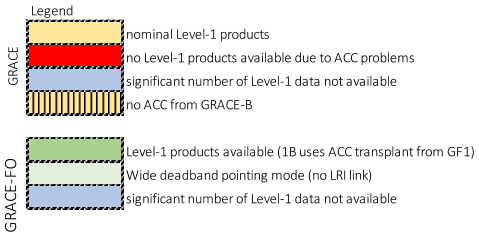

Table 1: Current version: Level-1A/B v04.

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

AOD1B	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976												
1980												
…												
2017												
2018												
2019												
2020												
2021												
2022												
2023												
2024												

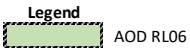

Table 2: AOD1B dealiasing model availability (current version used in GRACE-FO: RL06).

- 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://isdcftp.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	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+	56+	57+	58+	59+	60+	61+	62+	63+	64+	65+
2024	66+	67+										

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-3	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+	56+	57+	58+	59+	60+	61+	62+	63+	64+	65+
2024	66+	67+										

GRACE
Level-3 products
no Level-3 products available

GRACE-FO
Level-3 products available

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