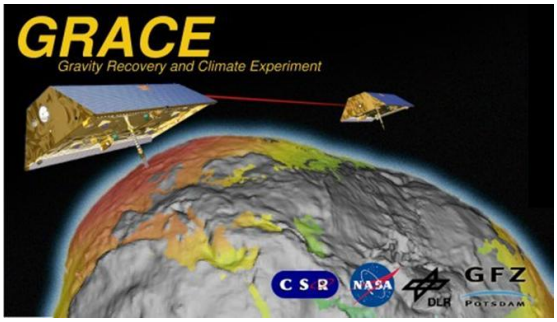
GRACE Science Data System Monthly Report March 2017



Prepared by:
Frank Flechtner GFZ flechtne@gfz-potsdam.de

Contributions by:
Srinivas Bettadpur UTCSR srinivas@csr.utexas.edu
Gerhard Kruizinga JPL gerhard.kruizinga@jpl.nasa.gov
Christoph Dahle GFZ dahle@gfz-potsdam.de

Approved by:
Byron Tapley UTCSR tapley@csr.utexas.edu

Highlights:

- CSR, GFZ and JPL have generated and delivered RL05 Level-2 products for March 2017 based on 29 days of data between March 17 and April 14.
- **The quality of these products is impacted by the facts that**
  - **a) No accelerometer data for GRACE-B are available for this month (switched-off since September 3, 2016, see newsletter for October 2016); therefore, the GRACE-A accelerometer data was used as a "transplant" to derive non-gravitational accelerations acting on GRACE-B.**
  - **b) On March 29 the pitch angles were set to 0° on both spacecraft to improve the quality of the transplanted GRACE-B ACC1B product.**

  For further details see also the Level-1 and Level-2 Sections below.
- The next GRACE Science Team Meeting will take place in Austin, Texas, between October 10 and 12. Further details are available on the UTCSR GRACE web page at http://www2.csr.utexas.edu/grace/GSTM. Abstracts are now being accepted, the submission deadline is Sunday, October 1. Please register as soon as you know you will be attending. Housing information is now available.

Satellite Science Relevant Events:

- Operations in Science Mode throughout the month except for the periods highlighted in the L1B Data Processing section below.
- The actual mission status can be monitored at http://www.csr.utexas.edu/grace/operations/mission_status/.

- The GRACE-A Brouwer mean orbital elements on March 31, 2017 00:00:00 are as follows:
  A[m] = 6713090.286
  E[-] = 0.000507
  I[°] = 88.994335
- The satellites separation was 216.2 km on March 31, 2017 with a rate of -0.56 km/d.

Level-0 raw data dump reception statistics at DLR ground stations Weilheim and Neustrelitz:

GRACE-A Housekeeping:	100.0 %	GRACE-B Housekeeping:	100.0 %
GRACE-A Science:	100.0 %	GRACE-B Science:	100.0 %

Level-1 Data Processing:

- Since October 2016, the GRACE-B accelerometer is powered off due to battery limitations within the spacecraft. However, all other science measurements are periodically available - starting from November 2016 - for both spacecraft, resulting in the need to synthesize GRACE-B accelerometer data to allow gravity recovery analysis during this period. Synthetic measurements for GRACE-B accelerometer have been created using the GRACE-A accelerometer measurements, after appropriately accounting for a variable separation between the two satellites, and the small differences in the orientation of the two spacecraft relative to each other. This synthetic ACC measurement is labeled GRACE-B ACC1B R3 dataset, and is delivered together with the other Level-1B datasets.
- Level-1B Release 02 instrument data have been processed at JPL and archived at GFZ ISDC and JPL PO.DAAC. Please refer to the statistics below.
  - On 2017-03-17 The GRACE KBR was turned on again at 11:16. Initially it is on 42 minutes per each orbit. The on time duration was continuously increased throughout the month as eclipse duration was getting shorter.
  - On 2017-03-29 a pitch bias was commanded on GRACE-A (21:07) and GRACE-B (21:08) in Science Mode. This will result in an angle of attack with Earth's atmosphere of approximately zero degree for both spacecrafts. These pitch biases will result in similar non-conservative forces on each spacecraft and will aid in the transplant of the ACC data from GRACE-A to GRACE-B. The commanded pitch biases will stay in place for the remainder of the mission. Prior to 21:07:30 the ACC data is transplanted with a 3.2 deg pitch rotation, after 21:07:30 the ACC data is transplanted with 0 deg pitch rotation.

- RL02 Notes:
  - KBR statistics:

    A) KBR1B product name

    B) Total arc length with data (hours)

    C) Number of observations used in residual calculation

    D) KBR-GPS range residual RMS (cm)

    E) minimum KBR-GPS range residual (cm)

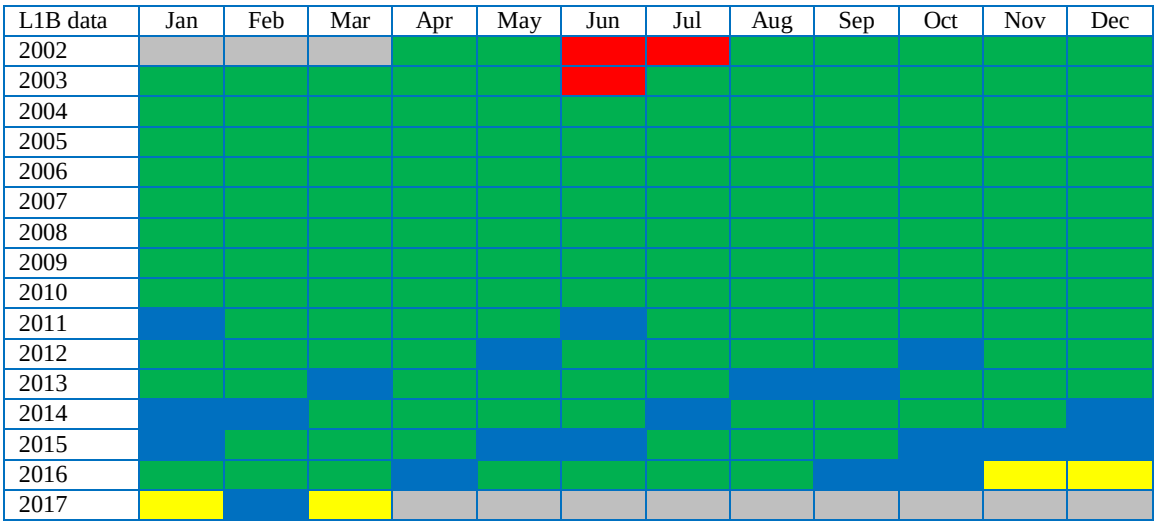
    F) maximum KBR-GPS range residual (cm)

    G) number of continuous segments in the KBR product

	A	B	C	D	E	F	G
KBR1B_2017-03-01_X_02.dat	0.0	0	0.00	0.0	0.0	0	
KBR1B_2017-03-02_X_02.dat	0.0	0	0.00	0.0	0.0	0	
KBR1B_2017-03-03_X_02.dat	0.0	0	0.00	0.0	0.0	0	
KBR1B_2017-03-04_X_02.dat	0.0	0	0.00	0.0	0.0	0	
KBR1B_2017-03-05_X_02.dat	0.0	0	0.00	0.0	0.0	0	
KBR1B_2017-03-06_X_02.dat	0.0	0	0.00	0.0	0.0	0	
KBR1B_2017-03-07_X_02.dat	0.0	0	0.00	0.0	0.0	0	
KBR1B_2017-03-08_X_02.dat	0.0	0	0.00	0.0	0.0	0	
KBR1B_2017-03-09_X_02.dat	0.0	0	0.00	0.0	0.0	0	
KBR1B_2017-03-10_X_02.dat	0.0	0	0.00	0.0	0.0	0	
KBR1B_2017-03-11_X_02.dat	0.0	0	0.00	0.0	0.0	0	
KBR1B_2017-03-12_X_02.dat	0.0	0	0.00	0.0	0.0	0	
KBR1B_2017-03-13_X_02.dat	0.0	0	0.00	0.0	0.0	0	
KBR1B_2017-03-14_X_02.dat	0.0	0	0.00	0.0	0.0	0	
KBR1B_2017-03-15_X_02.dat	0.0	0	0.00	0.0	0.0	0	
KBR1B_2017-03-16_X_02.dat	0.0	0	0.00	0.0	0.0	0	
KBR1B_2017-03-17_X_02.dat	5.8	4156	1.16	-3.8	5.3	9	
KBR1B_2017-03-18_X_02.dat	9.5	6842	0.49	-2.1	1.5	16	
KBR1B_2017-03-19_X_02.dat	10.4	7481	0.80	-3.0	2.6	16	
KBR1B_2017-03-20_X_02.dat	10.7	7728	1.06	-3.2	4.7	16	
KBR1B_2017-03-21_X_02.dat	10.5	7606	0.81	-2.0	3.4	16	
KBR1B_2017-03-22_X_02.dat	8.9	6407	1.23	-3.4	7.4	15	
KBR1B_2017-03-23_X_02.dat	10.0	7191	1.06	-3.2	4.2	16	
KBR1B_2017-03-24_X_02.dat	11.1	8001	1.27	-4.4	3.8	16	
KBR1B_2017-03-25_X_02.dat	11.0	7968	0.82	-2.9	2.5	16	
KBR1B_2017-03-26_X_02.dat	10.6	7656	1.02	-2.9	2.7	16	
KBR1B_2017-03-27_X_02.dat	10.9	7861	0.85	-2.5	2.8	16	
KBR1B_2017-03-28_X_02.dat	11.1	7972	1.06	-4.0	3.6	16	
KBR1B_2017-03-29_X_02.dat	11.2	8108	1.21	-5.0	3.8	16	
KBR1B_2017-03-30_X_02.dat	11.3	8129	0.75	-3.1	2.3	16	
KBR1B_2017-03-31_X_02.dat	11.7	8430	1.18	-5.1	5.2	16	
KBR1B_2017-04-01_X_02.dat	11.7	8462	1.15	-6.0	4.3	16	
KBR1B_2017-04-02_X_02.dat	10.9	7848	0.62	-1.8	4.9	15	
KBR1B_2017-04-03_X_02.dat	11.9	8557	0.43	-1.2	2.1	17	
KBR1B_2017-04-04_X_02.dat	12.0	8629	0.57	-1.5	2.1	17	

```
KBR1B_2017-04-05_X_02.dat   13.5    9723   0.59     -2.3     2.0   16
KBR1B_2017-04-06_X_02.dat   13.5    9714   0.77     -2.2     2.4   16
KBR1B_2017-04-07_X_02.dat   13.1    9415   0.44     -1.7     2.2   16
KBR1B_2017-04-08_X_02.dat   13.2    9470   0.60     -2.1     2.4   17
KBR1B_2017-04-09_X_02.dat   13.4    9665   0.87     -4.0     3.3   16
KBR1B_2017-04-10_X_02.dat   13.5    9739   0.58     -2.4     2.2   16
KBR1B_2017-04-11_X_02.dat   13.3    9610   0.66     -2.6     2.8   16
KBR1B_2017-04-12_X_02.dat   14.4   10376   0.62     -2.0     3.2   18
KBR1B_2017-04-13_X_02.dat   15.4   11108   0.68     -2.9     2.7   16
KBR1B_2017-04-14_X_02.dat   15.9   11497   0.60     -2.8     2.1   16
```

Following JPL RL02 L1B products are publicly available (green). June and July 2002 and June 2003 (red) are not provided due to accelerometer problems. For several months a significant number of Level-1 data is not available (blue): January and June 2011 (accelerometer data), May and October 2012, March and August 2013 (accelerometer and K-Band data), January and February 2014 (K-Band data), July 2014, December 2014, and May/June 2015, October-December 2015, April 2016, September and October 2016 (accelerometer and K-Band data) and February 2017 (accelerometer and K-band data). RL00 and RL01 production has stopped with December 2004 and April 2012, respectively. See also corresponding newsletters. For several months sufficient K-band data are available to produce a monthly solution, but transplant GRACE-A accelerometer data had to be used on GRACE-B. These months are marked in yellow.



- The L1B Read software has been updated to accommodate 64-bit machines but the software will also work on 32 bit machines. Please change RELEASE_2008-03-20 to RELEASE_2010-03-31 available at ftp://podaac.jpl.nasa.gov/allData/grace/sw/.
- Level-1B Release 01 generation has stopped with 30 April 2012.
- L1B De-aliasing Products Status (for details see AOD1B Product Description Document):

- Release 01: Generation has been stopped June 30, 2007.
- Release 03: Generation has been stopped January 31, 2007.
- Release 04: Generated until April 30, 2012 and extended to 1976-2000 (see newsletter for December 2008). Generation has been stopped April 30, 2012.
- Release 05: Generated for 1 January 1979 till 12 August 2017. **The data for the period 25 June 2013 till 27 July 2014 have been reprocessed (see Newsletter August 2014) and substituted in the archives.** The reprocessed products can be recognized by a processing time stamp later than 26 August 2014 in the header. Further information is available at http://www.gfz-potsdam.de/AOD1B.
- Following AOD1B products are publicly available (yellow: RL01, RL03 and RL04; green: RL01 and RL04, blue: RL04 only, 'x' RL05):

AOD1B	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976												
1977												
1978												
1979	x	x	x	x	x	x	x	x	x	x	x	x
…	x	x	x	x	x	x	x	x	x	x	x	x
1999	x	x	x	x	x	x	x	x	x	x	x	x
2000	x	x	x	x	x	x	x	x	x	x	x	x
2001	x	x	x	x	x	x	x	x	x	x	x	x
2002	x	x	x	x	x	x	x	x	x	x	x	x
2003	x	x	x	x	x	x	x	x	x	x	x	x
2004	x	x	x	x	x	x	x	x	x	x	x	x
2005	x	x	x	x	x	x	x	x	x	x	x	x
2006	x	x	x	x	x	x	x	x	x	x	x	x
2007	x	x	x	x	x	x	x	x	x	x	x	x
2008	x	x	x	x	x	x	x	x	x	x	x	x
2009	x	x	x	x	x	x	x	x	x	x	x	x
2010	x	x	x	x	x	x	x	x	x	x	x	x
2011	x	x	x	x	x	x	x	x	x	x	x	x
2012	x	x	x	x	x	x	x	x	x	x	x	x
2013	x	x	x	x	x	x	x	x	x	x	x	x
2014	x	x	x	x	x	x	x	x	x	x	x	x
2015	x	x	x	x	x	x	x	x	x	x	x	x
2016	x	x	x	x	x	x	x	x	x	x	x	x
2017	x	x	x	x	x	x	x	x				

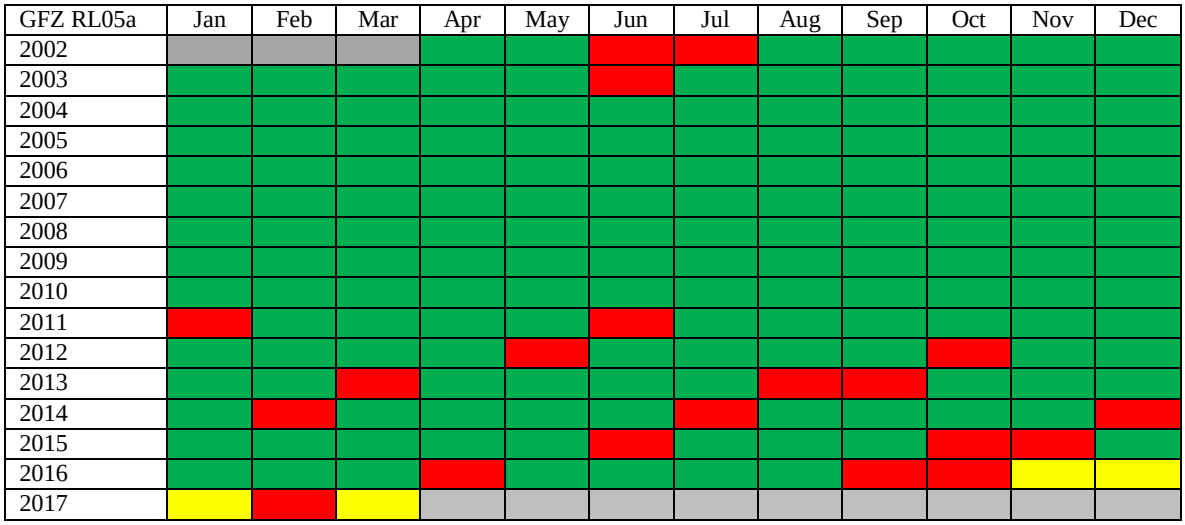
Level-2 Product Generation and Distribution:

Level-2 products for the mission period after November 2016 have been generated using synthetic GRACE-B ACC1B R3 data as described above and other routine mission data. We believe that users whose analysis domain is smaller than 750-km radius will see considerably more noise than they would have in the mid-mission data (up to 2010); and noticeably more noise than they would have through 2015-16 data. At spatial scales longer than 750 km, the products since November 2016 are slightly degraded relative to the Level-2 products from earlier in 2016.

The Level-3 mascon or gridded data products derived from the project Level-2 gravity field models may be more suited for use at smaller spatial scales.

Besides historical RL00 till RL04 and GFZ's RL05 time-series (see below) the following RL05 L2 products are presently available to the public (green: available, red: missing due to accelerometer data or accelerometer and K-band data problems, yellow: based on transplant GRACE-1 accelerometer data):

- **GFZ RL05a:** GSM solutions are available for April 2002 until March 2017. Corresponding background GAA, GAB, GAC and GAD products and calibrated errors (GSM*.txt) have been provided too. **Products for June 2013 till July 2014 and February 2016 have been reprocessed and replaced in the archives (see August 2014 and April 2016 Newsletter)**. Further details are listed in the GFZ L2 Release Notes.



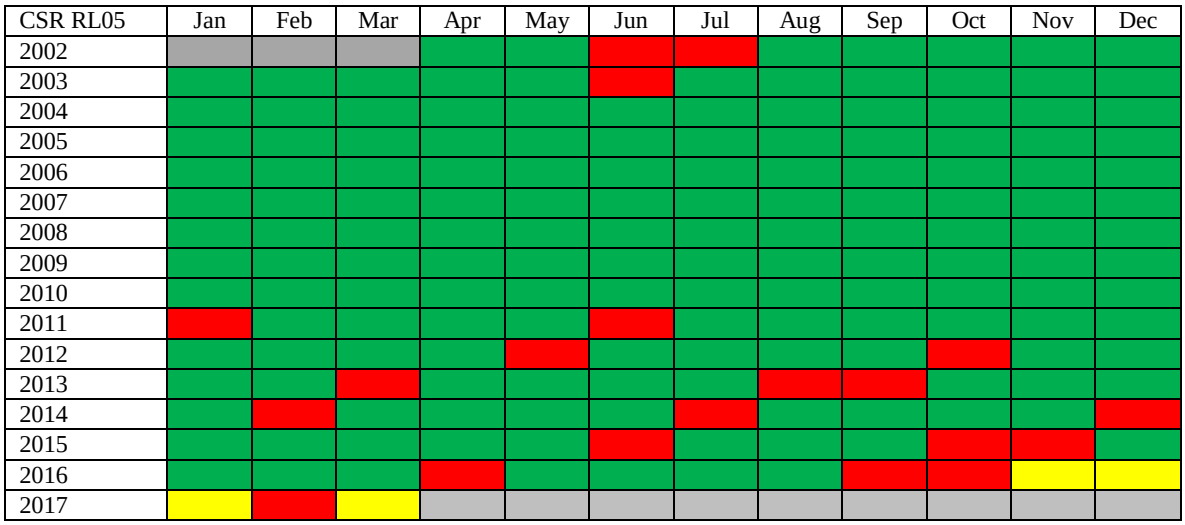
GFZ RL05a	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2002												
2003												
2004												
2005												
2006												
2007												
2008												
2009												
2010												
2011												
2012												
2013												
2014												
2015												
2016												
2017												

GFZ provides also full variance-covariance matrices for the whole RL05a time series. These so-called CSM-products are provided to users on request. For more information, please read the 'Release Notes for GFZ GRACE Level-2 Products - version RL05' which are available in the GRACE archives.

Additionally to the standard monthly solutions, GFZ also provides weekly RL05a solutions (aligned to GPS weeks) which contain spherical harmonic coefficients complete up to degree and order 30. Currently, available weekly solutions cover the time span from 2003/01/05 till 2013/07/28. The weekly Level-2 products (GSM + GAx files) can be downloaded at ISDC and PO.DAAC. When making your request at the ISDC retrieval pages, please choose "GFZ Potsdam weekly" as "Processing Facility" to obtain these

products. At the PO.DAAC archive, they can be found in the directory "allData/grace/L2/GFZ/RL05_WEEKLY". Weekly products can be identified by the string "GW30" instead of "G---" in the product name.

- **CSR RL05:** GSM solutions for maximum degree and order 60 (incl. calibrated errors GSM*.txt) and 96 (except for January till March 2015) along with the GAC and GAD background model files are available for the period April 2002 until March 2017. **Products for June 2013 till July 2014 have been reprocessed and replaced in the archives (see August 2014 Newsletter)**. Further details are listed in the CSR L2 Release Notes. Ongoing updates on CSR RL05 are provided at http://www.csr.utexas.edu/grace/RL05.html.



CSR RL05	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												

- **JPL RL05.1:** GSM solutions along with the GAA, GAB, GAC and GAD background model files and calibrated errors (GSM*.txt) are available for the period April 2002 until March 2017. Details are listed in the JPL L2 Release Notes. **For new release RL05.1 see also comments in the August 2014 Newsletter.**

JPL RL05.1	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												

JPL has released in August 2015 a constrained mascon solution which is now available on the GRACE Tellus website at http://grace.jpl.nasa.gov/. A Version 2.0 of the JPL Mascon solution, processed through January 2017, is available at the GRACE Tellus website at http://grace.jpl.nasa.gov/.

- Additional L2 comments:
  - GFZ has stopped RL05 processing end of July 2013 (now substituted by RL05a). For further details see Newsletter October 2013.
  - JPL has stopped RL05 processing end of June 2014 (now substituted by RL05.1). For further details see Newsletter August 2014.
  - GFZ and CSR have stopped RL04 processing end of April 2012
  - JPL has stopped RL04 processing end of January 2012
  - GFZ has stopped RL03 processing (Feb 2003 until Jan 2007 available at the archives. For further details refer to the GFZ RL03 release notes for Level-2 products).
  - CSR has stopped RL01 processing. (Apr. 2002 until Dec 2006 available at the archives. For further details refer to the CSR RL01 release notes for Level-2 products).
  - JPL has stopped RL02 processing (January 2003 until November 2005 available at the archives. For further details refer to the JPL RL02 release notes for Level-2 products).
  - TN05/TN07 containing C20 estimates derived from SLR and using GRACE RL04/RL05 standards is periodically updated.

Miscellaneous:

- The proceedings of all GRACE Science Team Meetings are available at the meeting web sites http://www.csr.utexas.edu/grace/GSTM/ and http://www.gfz-potsdam.de/en/grace/gstm/gstm-2016/.
- Lecture material from the 2011 and 2014 summer schools of the DFG Special Priority Program "Mass transport and mass distribution in the system Earth" can be downloaded at www.massentransporte.de. Before using, please read the agreements on the cover page.
- The following acknowledgement shall be added to any new GRACE related publication (paper, poster etc.): *Acknowledgement: We would like to thank the German Space Operations Center (GSOC) of the German Aerospace Center (DLR) for providing continuously and nearly 100% of the raw telemetry data of the twin GRACE satellites.*
- A list of GRACE related publications which can be sorted by author or date is available at http://www.gfz-potsdam.de/en/section/globalgeomonitoringandgravityfield/topics/development-operation-and-analysis-of-gravity-field-satellite-missions/grace/grace-related-publications/, alternatively the list can be accessed via http://www.gfz-potsdam.de/en/grace and one further click on 'GRACE related publications' in the left column. The current status is 1674 papers. This list may be still incomplete. If you are missing a publication please send an e-mail to Frank Flechtner (flechtne@gfz-potsdam.de).
- Science data users are encouraged to submit citations of their own and other works related with GRACE to the bibliography web page implemented at PO.DAAC: https://grace.jpl.nasa.gov/publications/.