

Title: NASA GSFC SLR C20 and C30 solutions

Version: 3 (see Notes)

Date created: 13 Nov 2025

Data span: 4 Apr 2002 - 1 Sep 2025 (beginning of solution)

Authors: B.D. Loomis and K.E. Rachlin

Contact: bryant.d.loomis@nasa.gov

Description:

This file contains SLR-derived C20 and C30 values for replacing GRACE/GRACE-FO GSM

Values prior to MJD 53039 use 5 satellites: LAGEOS-1/2, Stella, Starlette, AJISAI

Values beginning on MJD 53039 use 6 satellites: Larets added

Values beginning on MJD 55987 use 7 satellites: LARES added

Values beginning on MJD 59792 use 8 satellites: LARES-2 added

C30 values are not provided prior to MJD 55987

Estimated gravity parameters: 5x5+C61,S61

Citation:

Loomis et al., 2020, Geophys. Res. Lett., <https://doi.org/10.1029/2019GL085488>

Notes:

AOD1B RL06 model applied for dealiasing

C20 is zero tide

Sigmas were calibrated with C30 differences to dual-accelerometer GRACE values

The background time variable gravity model was updated for Version 3 (beginning 8 Nov 2023)

Format: (F7.1,F10.4,E22.13,2F8.4,E22.13,2F8.4,F8.1,F10.4)

Column 1: MJD of BEGINNING of solution data span (matches JPL GSM)

Column 2: Year and fraction of year of BEGINNING of solution data span

Column 3: Replacement C20

Column 4: Replacement C20 - mean C20 (1.0E-10)

Column 5: C20 Sigma (1.0E-10)

Column 6: Replacement C30

Column 7: Replacement C30 - mean C30 (1.0E-10)

Column 8: C30 Sigma (1.0E-10)

Column 9: MJD of END of solution data span (matches JPL GSM)

Column 10: Year and fraction of year of END of solution data span

Constants:

Mean C20: -4.841694573200E-04

Mean C30: +9.571647583412E-07

GM: 0.3986004415E+06 (km<sup>3</sup>/s<sup>2</sup>)

R: 6378.1363 (km)

Product:

|                                                                    |     |     |             |
|--------------------------------------------------------------------|-----|-----|-------------|
| 52368.0 2002.2548 -4.8416934147454E-04 1.1585 0.1628<br>2002.3288  | NaN | NaN | NaN 52395.0 |
| 52396.0 2002.3315 -4.8416936114948E-04 0.9617 0.1546<br>2002.3781  | NaN | NaN | NaN 52413.0 |
| 52487.0 2002.5808 -4.8416948381112E-04 -0.2649 0.1472<br>2002.6658 | NaN | NaN | NaN 52518.0 |
| 52518.0 2002.6658 -4.8416947729975E-04 -0.1998 0.1632<br>2002.7479 | NaN | NaN | NaN 52548.0 |
| 52548.0 2002.7479 -4.8416945249136E-04 0.0483 0.1560<br>2002.8329  | NaN | NaN | NaN 52579.0 |
| 52579.0 2002.8329 -4.8416943057140E-04 0.2675 0.1493<br>2002.9151  | NaN | NaN | NaN 52609.0 |
| 52609.0 2002.9151 -4.8416940588781E-04 0.5143 0.1755<br>2003.0000  | NaN | NaN | NaN 52640.0 |
| 52640.0 2003.0000 -4.8416937381752E-04 0.8350 0.1576<br>2003.0849  | NaN | NaN | NaN 52671.0 |
| 52671.0 2003.0849 -4.8416939590675E-04 0.6141 0.1597<br>2003.1616  | NaN | NaN | NaN 52699.0 |
| 52699.0 2003.1616 -4.8416935238291E-04 1.0494 0.1392<br>2003.2466  | NaN | NaN | NaN 52730.0 |
| 52730.0 2003.2466 -4.8416936461738E-04 0.9270 0.1582<br>2003.3288  | NaN | NaN | NaN 52760.0 |
| 52760.0 2003.3288 -4.8416937519356E-04 0.8213 0.1483<br>2003.3863  | NaN | NaN | NaN 52781.0 |

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|--------------------------------------------------------------------|---------------------|
| 52821.0 2003.4959 -4.8416948608952E-04 -0.2877 0.1379<br>2003.5808 | NaN NaN NaN 52852.0 |
| 52852.0 2003.5808 -4.8416952981452E-04 -0.7249 0.1298<br>2003.6658 | NaN NaN NaN 52883.0 |
| 52883.0 2003.6658 -4.8416951191122E-04 -0.5459 0.1321<br>2003.7479 | NaN NaN NaN 52913.0 |
| 52913.0 2003.7479 -4.8416949585268E-04 -0.3853 0.1413<br>2003.8301 | NaN NaN NaN 52943.0 |
| 52944.0 2003.8329 -4.8416945086743E-04 0.0645 0.1597<br>2003.9151  | NaN NaN NaN 52974.0 |
| 52974.0 2003.9151 -4.8416941986701E-04 0.3745 0.1569<br>2004.0000  | NaN NaN NaN 53005.0 |
| 53005.0 2004.0000 -4.8416940354753E-04 0.5377 0.1566<br>2004.0355  | NaN NaN NaN 53018.0 |
| 53039.0 2004.0929 -4.8416942093729E-04 0.3638 0.1640<br>2004.1639  | NaN NaN NaN 53065.0 |
| 53065.0 2004.1639 -4.8416941511161E-04 0.4221 0.1799<br>2004.2486  | NaN NaN NaN 53096.0 |
| 53096.0 2004.2486 -4.8416939582307E-04 0.6150 0.1889<br>2004.3306  | NaN NaN NaN 53126.0 |
| 53126.0 2004.3306 -4.8416937755168E-04 0.7977 0.1662<br>2004.4153  | NaN NaN NaN 53157.0 |
| 53157.0 2004.4153 -4.8416939756808E-04 0.5975 0.1781<br>2004.4973  | NaN NaN NaN 53187.0 |
| 53187.0 2004.4973 -4.8416947774596E-04 -0.2043 0.1925<br>2004.5820 | NaN NaN NaN 53218.0 |
| 53218.0 2004.5820 -4.8416948821076E-04 -0.3089 0.1571<br>2004.6667 | NaN NaN NaN 53249.0 |
| 53249.0 2004.6667 -4.8416948810152E-04 -0.3078 0.1735<br>2004.7486 | NaN NaN NaN 53279.0 |
| 53279.0 2004.7486 -4.8416944679540E-04 0.1052 0.1682<br>2004.8333  | NaN NaN NaN 53310.0 |
| 53310.0 2004.8333 -4.8416943400091E-04 0.2332 0.1654<br>2004.9153  | NaN NaN NaN 53340.0 |

|                                                                   |                     |
|-------------------------------------------------------------------|---------------------|
| 53340.0 2004.9153 -4.8416937706939E-04 0.8025 0.1776<br>2005.0000 | NaN NaN NaN 53371.0 |
| 53371.0 2005.0000 -4.8416939217967E-04 0.6514 0.1491<br>2005.0849 | NaN NaN NaN 53402.0 |
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| 53430.0 2005.1616 -4.8416934113342E-04 1.1619 0.1822<br>2005.2466 | NaN NaN NaN 53461.0 |
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| 53491.0 2005.3288 -4.8416931076156E-04 1.4656 0.1438<br>2005.4137 | NaN NaN NaN 53522.0 |
| 53522.0 2005.4137 -4.8416933184571E-04 1.2547 0.1369<br>2005.4959 | NaN NaN NaN 53552.0 |
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| 53644.0 2005.7479 -4.8416942883898E-04 0.2848 0.1475<br>2005.8329 | NaN NaN NaN 53675.0 |
| 53675.0 2005.8329 -4.8416942727329E-04 0.3005 0.1613<br>2005.9151 | NaN NaN NaN 53705.0 |
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| 53736.0 2006.0000 -4.8416941798757E-04 0.3933 0.1636<br>2006.0849 | NaN NaN NaN 53767.0 |
| 53767.0 2006.0849 -4.8416941753626E-04 0.3978 0.1639<br>2006.1616 | NaN NaN NaN 53795.0 |
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| 53826.0 2006.2466 -4.8416938800036E-04 0.6932 0.1521<br>2006.3288 | NaN NaN NaN 53856.0 |

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|--------------------------------------------------------------------|---------------------|
| 53856.0 2006.3288 -4.8416939514533E-04 0.6217 0.1529<br>2006.4137  | NaN NaN NaN 53887.0 |
| 53887.0 2006.4137 -4.8416939377638E-04 0.6354 0.1306<br>2006.4959  | NaN NaN NaN 53917.0 |
| 53917.0 2006.4959 -4.8416945705389E-04 0.0027 0.1344<br>2006.5808  | NaN NaN NaN 53948.0 |
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| 53979.0 2006.6658 -4.8416946333812E-04 -0.0602 0.1428<br>2006.7479 | NaN NaN NaN 54009.0 |
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| 54191.0 2007.2466 -4.8416939845699E-04 0.5886 0.1343<br>2007.3288  | NaN NaN NaN 54221.0 |
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| 54313.0 2007.5808 -4.8416948447653E-04 -0.2716 0.1475<br>2007.6658 | NaN NaN NaN 54344.0 |
| 54344.0 2007.6658 -4.8416946496202E-04 -0.0764 0.1475<br>2007.7479 | NaN NaN NaN 54374.0 |

|                                                                    |     |     |             |
|--------------------------------------------------------------------|-----|-----|-------------|
| 54374.0 2007.7479 -4.8416950664207E-04 -0.4932 0.1440<br>2007.8329 | NaN | NaN | NaN 54405.0 |
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| 54710.0 2008.6667 -4.8416950988708E-04 -0.5257 0.1443<br>2008.7486 | NaN | NaN | NaN 54740.0 |
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| 54863.0 2009.0849 -4.8416948400818E-04 -0.2669 0.1632<br>2009.1616 | NaN | NaN | NaN 54891.0 |

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|--------------------------------------------------------------------|-----|-----|-------------|
| 54891.0 2009.1616 -4.8416947265130E-04 -0.1533 0.1562<br>2009.2466 | NaN | NaN | NaN 54922.0 |
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| 55044.0 2009.5808 -4.8416951174748E-04 -0.5443 0.1534<br>2009.6658 | NaN | NaN | NaN 55075.0 |
| 55075.0 2009.6658 -4.8416952176244E-04 -0.6444 0.1458<br>2009.7479 | NaN | NaN | NaN 55105.0 |
| 55105.0 2009.7479 -4.8416950080182E-04 -0.4348 0.1653<br>2009.8329 | NaN | NaN | NaN 55136.0 |
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| 55166.0 2009.9151 -4.8416944150798E-04 0.1581 0.1707<br>2010.0000  | NaN | NaN | NaN 55197.0 |
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|                                                                    |     |     |             |
|--------------------------------------------------------------------|-----|-----|-------------|
| 55409.0 2010.5808 -4.8416957335410E-04 -1.1603 0.1695<br>2010.6658 | NaN | NaN | NaN 55440.0 |
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| 55470.0 2010.7479 -4.8416957641240E-04 -1.1909 0.1585<br>2010.8329 | NaN | NaN | NaN 55501.0 |
| 55501.0 2010.8329 -4.8416953190792E-04 -0.7459 0.1631<br>2010.9151 | NaN | NaN | NaN 55531.0 |
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| 55600.0 2011.1041 -4.8416949114429E-04 -0.3382 0.1903<br>2011.1616 | NaN | NaN | NaN 55621.0 |
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| 55652.0 2011.2466 -4.8416950431886E-04 -0.4700 0.1708<br>2011.3288 | NaN | NaN | NaN 55682.0 |
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| 55747.0 2011.5068 -4.8416956574768E-04 -1.0843 0.1743<br>2011.5808 | NaN | NaN | NaN 55774.0 |
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| 55851.0 2011.7918 -4.8416958156697E-04 -1.2425 0.1574<br>2011.8767 | NaN | NaN | NaN 55882.0 |
| 55912.0 2011.9589 -4.8416957668108E-04 -1.1936 0.1908<br>2012.0410 | NaN | NaN | NaN 55942.0 |
| 55927.0 2012.0000 -4.8416958450565E-04 -1.2719 0.1658<br>2012.0847 | NaN | NaN | NaN 55958.0 |
| 55958.0 2012.0847 -4.8416957929997E-04 -1.2198 0.1598<br>2012.1639 | NaN | NaN | NaN 55987.0 |



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56006.0 2012.2158 -4.8416952247158E-04 -0.6515 0.1526 9.5722070341916E-07 0.5595  
0.2020 56037.0 2012.3005

56079.0 2012.4153 -4.8416957039933E-04 -1.1308 0.1549 9.5724029998526E-07 0.7554  
0.2731 56109.0 2012.4973

56109.0 2012.4973 -4.8416963921412E-04 -1.8189 0.1424 9.5714778034623E-07 -0.1698  
0.2564 56140.0 2012.5820

56140.0 2012.5820 -4.8416963565692E-04 -1.7834 0.1409 9.5708068379799E-07 -0.8407  
0.1934 56171.0 2012.6667

56171.0 2012.6667 -4.8416964357891E-04 -1.8626 0.1358 9.5705887537777E-07 -1.0588  
0.2038 56195.0 2012.7322

56237.0 2012.8470 -4.8416957187441E-04 -1.1455 0.1671 9.5712503035309E-07 -0.3973  
0.2612 56262.0 2012.9153

56262.0 2012.9153 -4.8416959051686E-04 -1.3320 0.1960 9.5713722200387E-07 -0.2754  
0.3174 56293.0 2013.0000

56293.0 2013.0000 -4.8416955952589E-04 -1.0221 0.1840 9.5718396036652E-07 0.1920  
0.3538 56324.0 2013.0849

56324.0 2013.0849 -4.8416958851350E-04 -1.3119 0.1610 9.5721229972723E-07 0.4754  
0.2293 56350.0 2013.1562

56393.0 2013.2740 -4.8416952624349E-04 -0.6892 0.1439 9.5720144322645E-07 0.3668  
0.2055 56413.0 2013.3288

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0.2458 56505.0 2013.5808

56566.0 2013.7479 -4.8416962799073E-04 -1.7067 0.1614 9.5709236260039E-07 -0.7240  
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56597.0 2013.8329 -4.8416963913438E-04 -1.8181 0.1686 9.5712910559263E-07 -0.3565  
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0.2140 56675.0 2014.0466

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0.2467 56778.0 2014.3288

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0.2711 56809.0 2014.4137

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0.1941 56833.0 2014.4795

56870.0 2014.5808 -4.8416964621732E-04 -1.8890 0.1523 9.5708147952128E-07 -0.8328  
0.2342 56901.0 2014.6658

56901.0 2014.6658 -4.8416967159489E-04 -2.1427 0.1562 9.5707818952604E-07 -0.8657  
0.2369 56931.0 2014.7479

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0.2225 56962.0 2014.8329

56962.0 2014.8329 -4.8416959435291E-04 -1.3703 0.1497 9.5714683583113E-07 -0.1792  
0.2987 56994.0 2014.9205

57035.0 2015.0329 -4.8416962687938E-04 -1.6956 0.1828 9.5718243456906E-07 0.1768  
0.2838 57054.0 2015.0849

57054.0 2015.0849 -4.8416960413084E-04 -1.4681 0.1978 9.5717440530508E-07 0.0965  
0.2914 57082.0 2015.1616

57082.0 2015.1616 -4.8416958786791E-04 -1.3055 0.1722 9.5719104904111E-07 0.2629  
0.2545 57113.0 2015.2466

57113.0 2015.2466 -4.8416958639070E-04 -1.2907 0.1514 9.5723745640219E-07 0.7270  
0.2335 57143.0 2015.3288

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