Combination of the Latest Releases of GRACE Monthly Gravity Field Solutions

Yoomin Jean, Ulrich Meyer, Adrian Jäggi

Astronomical Institute
University of Bern

Geodätische Woche 2016
11-13 October, 2016
Hamburg, Germany
Combination of GRACE Monthly Gravity Solutions

GRACE MISSION

• To make use of the solutions from different processing strategies
• Reduced systematic errors specific for certain processing centers
• Reliable and consistent solutions
• Benefits for users of GRACE gravity solutions without advanced knowledge or preference
• Project Eosiem: European Gravity Service for Improved Emergency Management
### Available GRACE Monthly Gravity Solutions

The official **GRACE monthly gravity solutions** available at the ICGEM website ([http://icgem.gfz-potsdam.de/ICGEM](http://icgem.gfz-potsdam.de/ICGEM)):

<table>
<thead>
<tr>
<th>Processing Center</th>
<th>Maximum Degree</th>
<th>Release #</th>
<th>New Release in 2016</th>
<th>In the Combination</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIUB</td>
<td>60,90</td>
<td>RL02</td>
<td>-</td>
<td>Included</td>
</tr>
<tr>
<td>CSR</td>
<td>60,96</td>
<td>RL05</td>
<td>-</td>
<td>Included</td>
</tr>
<tr>
<td>GFZ</td>
<td>90</td>
<td>RL05</td>
<td>-</td>
<td>Included</td>
</tr>
<tr>
<td><strong>ITSG</strong></td>
<td>60,90,120</td>
<td>2014</td>
<td><strong>2016 (60,90,120)</strong></td>
<td>Included</td>
</tr>
<tr>
<td>JPL</td>
<td>60,90</td>
<td>RL05</td>
<td>-</td>
<td>Included</td>
</tr>
<tr>
<td><strong>Tongji Univ.</strong></td>
<td>60</td>
<td>RL01</td>
<td><strong>RL02 (60)</strong></td>
<td>Included</td>
</tr>
<tr>
<td>DMT</td>
<td>120</td>
<td>RL01</td>
<td>-</td>
<td>Not Included (∵ Pre-filtered)</td>
</tr>
<tr>
<td>GRGS</td>
<td>80</td>
<td>RL03</td>
<td>-</td>
<td>Not Included (∵ Pre-filtered)</td>
</tr>
</tbody>
</table>

The official GRACE monthly gravity solutions available at the ICGEM website ([http://icgem.gfz-potsdam.de/ICGEM](http://icgem.gfz-potsdam.de/ICGEM)).
Comparison: Signal (MEWH)

60 Degree, Unfiltered
- AIUB 02 (60) \(0.1648\pm0.0139\)
- CSR 05 (60) \(0.1608\pm0.0146\)
- ITSG2016(60) \(0.1642\pm0.0140\)
- Tongji 02 (60) \(0.1489\pm0.0133\)

60 Degree, Filtered
- AIUB 02 (60) \(0.1587\pm0.0132\)
- CSR 05 (60) \(0.1559\pm0.0136\)
- ITSG2016 (60) \(0.1586\pm0.0132\)
- Tongji 02 (60) \(0.1437\pm0.0124\)

90 Degree, Unfiltered
- AIUB 02 (90) \(0.1624\pm0.0144\)
- CSR 05 (90) \(0.1612\pm0.0150\)
- GFZ 5a (90) \(0.1680\pm0.0147\)
- ITSG2016 (90) \(0.1644\pm0.0141\)
- JPL 05 (90) \(0.1562\pm0.0156\)

90 Degree, Filtered
- AIUB 02 (90) \(0.1567\pm0.0135\)
- CSR 05 (90) \(0.1561\pm0.0137\)
- GFZ 5a (90) \(0.1619\pm0.0137\)
- ITSG2016 (90) \(0.1585\pm0.0131\)
- JPL 05 (90) \(0.1517\pm0.0140\)

Tongji’s new solution shows attenuated signal.
Comparison: Variability (wSTD over Oceans)

60 Degree, Unfiltered

60 Degree, Filtered

90 Degree, Unfiltered

90 Degree, Filtered
## Combination: Weighting Schemes

<table>
<thead>
<tr>
<th>Combined Solution (Max. Deg.)</th>
<th>Involved Individual Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined Solution (60)</td>
<td>AIUB 02, CSR 05, ITSG2016, Tongji 02</td>
</tr>
<tr>
<td>Combined Solution (90)</td>
<td>AIUB 02, CSR 05, GFZ 5a, ITSG2016, JPL 05</td>
</tr>
</tbody>
</table>

- **Equal weight**: (arithmetic mean)

- **Field-wise Single weight**: using \((\text{Individual} – \text{Arithmetic Mean})^{-2}\)

- **Weights using VCE** (Variance Component Estimation):
  - Iterative process
  - Weights and \(w\text{Mean}\) are updated in each iteration step
Field-wise Weights: Degree 60

OLD

Higher weights on ITSG solution

NEW

Difference in Tongji Solution: higher weights until 2010
Weights from VCE method: Degree 60

OLD

NEW

(without C20)
Field-wise Weights: Degree 90

**OLD**

<table>
<thead>
<tr>
<th>Weight</th>
<th>Time [year]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>2004</td>
</tr>
<tr>
<td>0.4</td>
<td>2005</td>
</tr>
<tr>
<td>0.3</td>
<td>2006</td>
</tr>
<tr>
<td>0.2</td>
<td>2007</td>
</tr>
<tr>
<td>0.1</td>
<td>2008</td>
</tr>
</tbody>
</table>

**NEW**

<table>
<thead>
<tr>
<th>Weight</th>
<th>Time [year]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>2004</td>
</tr>
<tr>
<td>0.4</td>
<td>2005</td>
</tr>
<tr>
<td>0.3</td>
<td>2006</td>
</tr>
<tr>
<td>0.2</td>
<td>2007</td>
</tr>
<tr>
<td>0.1</td>
<td>2008</td>
</tr>
</tbody>
</table>

*Higher weights on ITSG solution (without C20)*
Weights from VCE method: Degree 90

OLD

NEW

(without C20)
Amplitude of Annual Signal

in MEWH of Amazon River Basin (60 Degree, Unfiltered)

Individual Solutions

Combined Solutions

OLD

NEW
Variability: wSTD over Oceans

60 Degree, Unfiltered

60 Degree, Filtered

90 Degree, Unfiltered

90 Degree, Filtered

Y. Jean et al.: Combination of latest releases of GRACE monthly gravity field solutions
Geodätische Woche 2016, 11-13 October, 2016, Hamburg, Germany
Variability: wSTD over Oceans

60 Degree, Unfiltered

60 Degree, Filtered

90 Degree, Unfiltered

90 Degree, Filtered
Summary and Conclusions

- **GRACE Monthly gravity field solutions**
  
  *New release in 2016:* ITSG2016 (60,90,120), Tongji U (60)

- **Comparison** (signal and variability)
  
  - Both ITSG and Tongji solutions are **improved** in the new releases.
  
  - **Tongji solution** shows slightly attenuated signal.

- **Combination** including the **newly released solutions**:
  
  - Weighting schemes: equal weights, Field-wise weights, and weights from **VCE** method

  - Involved individual solutions have different levels of variability
    - Combined solutions are not stronger in terms of variability

  - Better combined solutions are expected if the other processing centers also improve their solutions in the next releases.