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 **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>Tongji Univ.</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>
Comparison: Signal (MEWH)

60 Degree, Unfiltered
- AIUB 02 (60) (0.1648+/−0.0139)
- CSR 05 (60) (0.1608+/−0.0146)
- ITSG2016(60) (0.1642+/−0.0140)
- Tongji 02 (60) (0.1489+/−0.0133)

60 Degree, Filtered
- AIUB 02 (60) (0.1587+/−0.0132)
- CSR 05 (60) (0.1559+/−0.0136)
- ITSG2016 (60) (0.1586+/−0.0132)
- Tongji 02 (60) (0.1437+/−0.0124)

90 Degree, Unfiltered
- AIUB 02 (90) (0.1624+/−0.0144)
- CSR 05 (90) (0.1612+/−0.0150)
- GFZ 5a (90) (0.1689+/−0.0147)
- ITSG2016 (90) (0.1644+/−0.0141)
- JPL 05 (90) (0.1562+/−0.0156)

90 Degree, Filtered
- AIUB 02 (90) (0.1567+/−0.0135)
- CSR 05 (90) (0.1561+/−0.0137)
- GFZ 5a (90) (0.1619+/−0.0137)
- ITSG2016 (90) (0.1585+/−0.0131)
- JPL 05 (90) (0.1517+/−0.0140)

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

60 Degree, Unfiltered

- AIUB 02 (60) (0.125423)
- CSR 05 (60) (0.134465)
- ITSG2016(60) (0.072595)
- Tongji 02 (60) (0.115340)

60 Degree, Filtered

- AIUB 02 (60) (0.020563)
- CSR 05 (60) (0.021045)
- ITSG2016(60) (0.013423)
- Tongji 02 (60) (0.019847)

90 Degree, Unfiltered

- AIUB 02 (90) (1.090884)
- CSR 05 (90) (1.179935)
- GFZ 5a (90) (1.497817)
- ITSG2016 (90) (0.573399)
- JPL 05 (90) (1.717259)

90 Degree, Filtered

- AIUB 02 (90) (0.026219)
- CSR 05 (90) (0.027767)
- GFZ 5a (90) (0.035168)
- ITSG2016 (90) (0.016309)
- JPL 05 (90) (0.032679)
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

(without C20)

NEW

Higher weights on ITSG solution

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

**OLD**

![Graph showing weights from VCE method for OLD data]

**NEW**

![Graph showing weights from VCE method for NEW data]

(without C20)
Field-wise Weights: Degree 90

OLD

NEW

Higher weights on ITSG solution

(without C20)
Weights from VCE method: Degree 90

OLD

(without C20)

NEW

Weights from VCE method: Degree 90

OLD

(without C20)

NEW

Weights from VCE method: Degree 90

OLD

(without C20)

NEW

Weights from VCE method: Degree 90

OLD

(without C20)

NEW

Weights from VCE method: Degree 90

OLD

(without C20)

NEW

Weights from VCE method: Degree 90
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

90 Degree, Unfiltered

60 Degree, Filtered

90 Degree, Filtered

AIUB 02 (60) (0.125423)
CSR 05 (60) (0.134466)
ITSG 2016 (60) (0.072586)
Tongji 02 (60) (0.116340)
Mean (60) (0.081231)
wMean Field-wise (60) (0.077148)
wMean VCE (60) (0.074646)

AIUB 02 (60) (0.020553)
CSR 05 (60) (0.021046)
ITSG 2016 (60) (0.013423)
Tongji 02 (60) (0.019847)
Mean (60) (0.013665)
wMean Field-wise (60) (0.013011)
wMean VCE (60) (0.012716)

AIUB 02 (90) (1.090884)
CSR 05 (90) (1.179535)
GFZ 5a (90) (1.497817)
ITSG 2016 (90) (0.573999)
JPL 06 (90) (1.717250)
Mean (90) (0.819655)
wMean Field-wise (90) (0.733961)
wMean VCE (90) (0.706702)

AIUB 02 (90) (0.026219)
CSR 05 (90) (0.027787)
GFZ 5a (90) (0.035166)
ITSG 2016 (90) (0.016309)
JPL 06 (90) (0.032679)
Mean (90) (0.020617)
wMean Field-wise (90) (0.018776)
wMean VCE (90) (0.019775)
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

Astronomical Institute, University of Bern
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.