EGSIEM combination service: combination of GRACE monthly K-band solutions on normal equation level

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Motivation

Degree Amplitudes of Anomalies 01/2006: orders 0 - 29
SH coefficients – model fit of secular/seasonal variations
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Degree Amplitudes of Anomalies 01/2006: orders 0 - 29
SH coefficients – model fit of secular/seasonal variations

Includes non-seasonal signal

Represents mainly noise
Individual Contributions

![Graph showing individual contributions](image)

**Title:** 2006/01

**Graph:**
- **Y-axis:** Logarithmic scale from $10^{-9}$ to $10^{-11}$
- **X-axis:** Degree from 10 to 90
- **Legend:**
  - Blue line: AIUB - GOCO05S
Individual Contributions

2006/01

- AIUB - GOCO05S
- ITSG - GOCO05S

degree

10^{-9} - 10^{-11}
Individual Contributions

2006/01

- AIUB - GOCO05S
- ITSG - GOCO05S
- GFZ - GOCO05S
- GRGS - GOCO05S

degree

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Why are formal errors so different?

Formal errors depend on the noise model applied!

Error propagation of kinematic orbits and K-band observations

Optimistic

Errors of observations:
GPS, K-band, accelerometers, star cameras

Errors of background models and de-aliasing:
ocean tides, short periodic atmosphere and ocean variations (AOD)

Realistic (empirical)
Noise Assessment

Anomalies: differences to model

[Graph showing RMS values for geoid height]
Noise Assessment

Anomalies: differences to model
Differences: differences to mean
Noise Assessment

Differences to mean to derive relative weights.
Anomalies over quiet regions to independently assess quality.
Variance component estimation on solution level taking into account all SH coefficients up to degree and order 80 with equal weight.

RMS of anomalies restricted to ocean areas as quality criterion.
Combination on Normal Equation Level

Achieve equal impact of individual contributions on pairwise combinations:

\[(N_{\text{ref}} + w_i N_i) dx = b_{\text{ref}} + w_i b_i\]

The impact is measured by:

\[\text{RMS}_i = \sqrt{\frac{\sum_{l,m} \left(K_{l,m}^{\text{comb}} - K_i^{l,m}\right)^2}{n_{\text{coef}}}}\]

Equal impact is achieved for:

\[\frac{\text{RMS}_i}{\text{RMS}_{\text{ref}}} = 1\]
Combination on Normal Equation Level

- **Equalizing weight**
  - GRGS: 1.60
  - GFZ: 1.00
  - AIUB: 7.81
  - ITSG: 2.21

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**RMS to reference (GFZ, w=1)**

**RMS to other contribution**

$\times 10^{-12}$
Combination: 2006/01

Solution:

<table>
<thead>
<tr>
<th>Solution</th>
<th>weight</th>
</tr>
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<tbody>
<tr>
<td>GRGS</td>
<td>0.14</td>
</tr>
<tr>
<td>GFZ</td>
<td>0.19</td>
</tr>
<tr>
<td>AIUB</td>
<td>0.29</td>
</tr>
<tr>
<td>ITSG</td>
<td>0.38</td>
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### Combination: 2006/01

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- AIUB: 0.29
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L3-Products: [www.egsiem.eu](http://www.egsiem.eu) -> Data -> EGSIEM-Plotter

EGSIEM graceOceanography monthly DDK3 - 2006/01/01 - 2006/01/31
Equivalent Water Heights comparison to time series mean (degree 2 to 90)
min -20.25 cm / max 24.79 cm / weighted rms 3.31 cm / oceans 2.34 cm
EGSIEM graceHydrology monthly DDK3 - 2005/01/01 - 2006/01/31
Equivalent Water Heights comparison to time series mean (degree 2 to 90)
min -24.86 cm / max 23.89 cm / weighted rms 3.16 cm / oceans 1.91 cm
Conclusions

• EGSIEM monthly gravity field combination on NEQ-level is operational.
• Noise assessment by variance component estimation on solution level.
• Relative weights based on noise levels.
• The EGSIEM combination service provides two test years (2006 + 2007):
  – SH-coefficients (Level-2): www.icgem.de
  – grids and de-aliasing (Level-3): www.egsiem.eu