Gravity field models derived from Swarm GPS data

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Introduction

The Swarm satellites collect hl-SST data, which can be exploited to derive the monthly temporal variations of Earth’s gravity field.

A number of institutes (see table) are routinely producing gravity field models representing the mass transport processes at long wavelengths. Each institute uses a different gravity field inversion approach. This study illustrates how these approaches compare when the same kinematic orbit solution is considered, from AIUB.

The individual models (estimated with data from all three Swarm satellites) are analysed as well as the combined model, computed as the arithmetic average. The GRACE KBR-derived models are regarded as the “truth” to derive error estimates (Figure 1).

Swarm gravity field models

<table>
<thead>
<tr>
<th>Inst.</th>
<th>Location</th>
<th>Approach</th>
<th>Max. Degree</th>
<th>Ref. Gravity Field</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIUB</td>
<td>Bern, Switzerland</td>
<td>Celestial Mechanics Approach</td>
<td>90</td>
<td>EGM2008</td>
<td>Jäggi et al. (2016)</td>
</tr>
<tr>
<td>ASTU</td>
<td>Prague, Czech Rep.</td>
<td>Acceleration approach</td>
<td>40, 60</td>
<td>ITG-Grace2010s</td>
<td>Bezděk et al. (2016)</td>
</tr>
<tr>
<td>IIG</td>
<td>Graz, Austria</td>
<td>Short-arc approach</td>
<td>60</td>
<td>GOCO05S</td>
<td>Zehentner and Mayer-Gürr (2015)</td>
</tr>
</tbody>
</table>

Error estimates

Figure 1 – Time series of the cumulative amplitude of the error truncated at degree 12 (i.e. no smoothing considered) of the gravity field models considered in the study, for the considered months, estimated from GRACE data (top) and provided with the Swarm models (bottom).

Smoothed models

Figure 2 – On the first row: geoid height of the time-variable signal represented by the Swarm models after 833 km Gaussian smoothing for May 2014; on the second row: difference between Swarm and (smoothed) GRACE models; on the third row: 2D correlation between the Swarm models and the GFZ GRACE model (dimensionless coefficients). Global statistics are shown in the sub-title for the top row and continental statistics for the middle and bottom rows. On the first column: the combined Swarm model; On the second column: the AIUB Swarm model; on the third column: the ASTU Swarm model; on the forth column: the IIG Swarm model.

Conclusions

- Combined model systematically superior (in general, in spite of the same input data being used
- Exceptionally, individual solutions are in better agreement with GRACE than combined solutions, e.g. Jan and Apr 2014 => better combination scheme desirable
- Variances provided with the Swarm models (Figure 1, bottom) may predict residuals to GRACE (Figure 1, top) but calibration is required
- Residual to GRACE (which can be as low as 4 mm) generally smaller than signal amplitude, cf. Figure 2 first and second rows
- Good agreement in the spatial correlation between the smoothed Swarm and GRACE models (Figure 2, bottom row)

Bibliography