GRACE gravity field determination with the Celestial Mechanics Approach at AIUB

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• GRACE:
  ▪ static field
  ▪ time variable gravity signal
• Celestial Mechanics Approach:
  ▪ key features
  ▪ constraining pulses and relative weighting
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CHAMP: static 8y field AIUB-CHAMP03S
CHAMP: temporal variations

CHAMP: monthly solutions from 2007

CHAMP: stacked solutions (8 years), only significant terms (Davis et al., 2008)

GRACE: corresponding monthly solutions (for reference)
GRACE: static 6y field AIUB_6YR

Difference degree amplitudes to ITG_GRAY2010

- ITG_GRAY2010
- AIUB_6YR
- GGM03S
- EIGEN5S
- AIUB_6YR (1.1.2005)
GRACE: periodic time variations

significant terms (1-yearly, ½-yearly)
Celestial Mechanics Approach

Key features:

• Kinematic orbits (from GPS) as pseudo-observations (efficiency)
• Reduced dynamic orbits (GPS & K-Band) with stochastic pulses (flexibility)
• Intelligent way to compute variational equations (efficiency)
• NEQ-manipulation: relative weighting in combination, parameter pre-elimination, accumulation (flexibility and efficiency)
Pulses: spacing and constraints
GPS via K-Band: RMS and rel. weighting

K-Band-only solution:
- solved for difference $\frac{1}{2}(r_1 - r_2)$
- mean value $\frac{1}{2}(r_1 + r_2)$ slightly constrained to kin. positions (from GPS)

Theoretical weighting factor
$\sigma_{KBD}^2/\sigma_{GPS}^2 = 2...3 \times 10^{-8} \text{ s}^{-2}$
(better agreement with other GRACE-fields is achieved using $1 \times 10^{-10} \text{ s}^{-2}$, i.e. down-weighting GPS)
Impact of GPS on combined solution

Impact of GPS mainly on very low degree and close to sectorial coefficients.

Relative weighting:

$$\frac{\sigma_{KBD}^2}{\sigma_{GPS}^2} = 10^{-8} \text{ s}^{-2}$$
Range-Differences and Correlation

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<tr>
<th>Symbol</th>
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<tbody>
<tr>
<td>R</td>
<td>Range</td>
<td>RC</td>
<td>correlated</td>
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<td>RR</td>
<td>Range-Rate</td>
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<td>RA</td>
<td>Range-Acceleration</td>
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<td>RD</td>
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<td>DD</td>
<td>Double-Difference</td>
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\[
R \approx RC
\]
\[
RR \approx RD = \frac{R(t_2) - R(t_1)}{\Delta t}
\]
\[
R = RDC \approx RRC
\]
\[
P_R = k \cdot I
\]
\[
P_{RD} = ( (\partial RD/\partial R)^T \cdot P_R \cdot \partial RD/\partial R )^{-1}
\]
Uncorrelated RD-solution outperforms R-solution (contradictory to formal errors).

Introducing frequent (5 min.) constrained pulses results in a competitive R-solution.