Combination of monthly gravity field solutions – transition from an EGSIEM prototype service into an IAG service

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IAG Scientific Assembly 2017
Kobe, Japan
July 31 – August 4, 2017
Contents

- EGSIEM Gravity Field Combination Service
- Individual Contributions
- Noise Assessment
- Combination on Normal Equation Level
- Transition to IAG service COST-G
EGSIEM Project – Three services are established

Altimetry
- Hydroweb (Topex/Poseidon, Jason, ENVISAT, GFO, Sentinel 3)

Gravity & GNSS & SLR
- GRACE
- GRACE-FO (future missions)
- GPS, Glonass, Galileo
- LAGEOS, Starlette, Stella, AJOSI

Copernicus
- ENVISAT/ASAR, TerraSAR-X, Radarsat-2, Sentinel 1

Scientific combination service

Near real-time/regional service

Hydrological service

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Scientific Combination Service

- Only one product for the user
- Reduced noise
The EGSIEM combination service provides monthly GRACE K-band gravity fields combined on solution/normal equation (NEQ) Level.

To ensure consistency, a set of common standards for reference frame, Earth rotation, force model and satellite geometry were defined.

EGSIEM lately was extended to also include SLR and GPS-only NEQs.

Why combine results based on the same observations?

Errors in GRACE monthly gravity fields are still dominated by analysis and background model noise, not observation noise => AC-specific errors are reduced by combination!
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

2006/01

- AIUB - GOCC05S

degree

10^{-9}

10^{-10}

10^{-11}

10 20 30 40 50 60 70 80 90
Individual Contributions

2006/01

AIUB - GOCC05S
ITSG - GOCC05S

degree

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

2006/01

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

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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
- 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)

Optimistic

Realistic (empirical)
Noise Assessment

Anomalies: differences to model
Noise Assessment

Anomalies: differences to model

Differences: differences to mean

RMS of anomalies

RMS of differences to mean
Noise Assessment

Differences to mean to derive relative weights.

Anomalies over quite 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

![Graph showing combination on normal equation level with weights and RMS values.](image)

**equalizing weight**

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<tr>
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<th>Weight</th>
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Combination: 2006/01
Combination: 2006/01

Solution:

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Eosiem
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Combination: 2006/01

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Combination results

June 2006: in case of more homogeneous quality among ACs the combination clearly outperforms the best individual contribution.

Oct. 2006: in case of cross outliers screening is necessary, otherwise the combination is degraded.
L3-Products: www.egsiem.eu -> Data -> EGSIEM-Plotter

EGSIEM graceHydrology monthly DDK3 - 2006/01/01 - 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
Transition to IAG service COST-G

- EGSIEM Scientific Combinatinin Service is ready for transition into IAG service COST-G.
- 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](http://www.icgem.de)
  - grids and de-aliasing (Level-3): [www.egsiem.eu](http://www.egsiem.eu)