European Gravity Service for Improved Emergency Management

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Geodetic Missions Workshop, 20.-24.03.2017, Banff, Canada

Horizon2020

A World full of Challenges …

Water will be one of the most critical and geopolitically most important resource of the future.

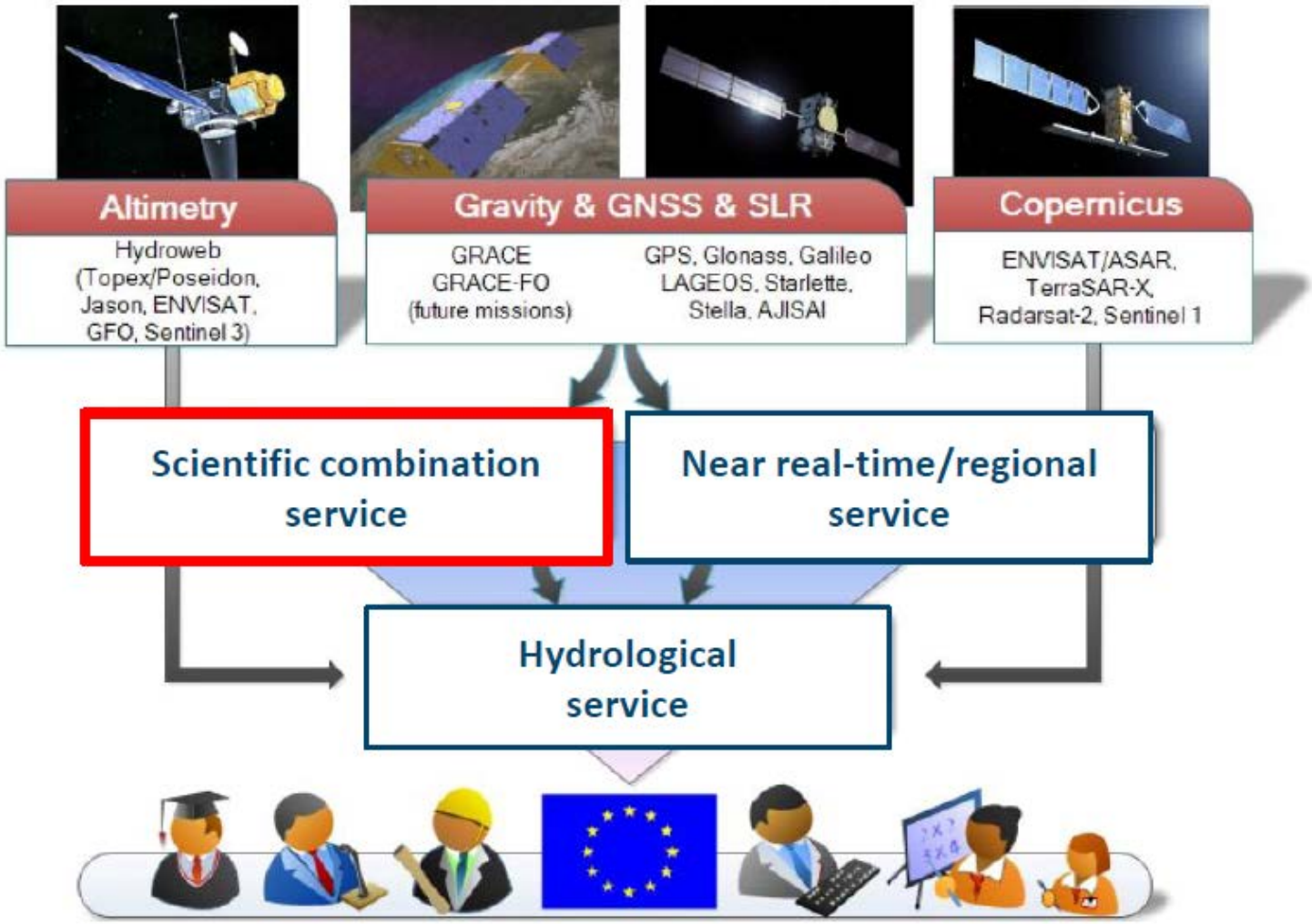
EGSIEM: Purpose of the Project

EGSIEM is promoting satellite gravimetry for new applications.

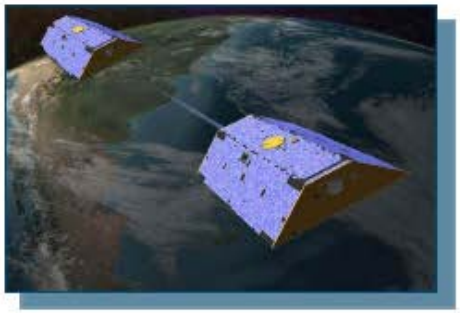
The three main objectives of EGSIEM are to

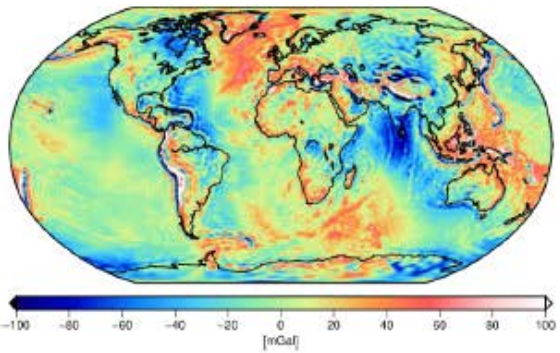
- deliver the best gravity products for applications in Earth and environmental science research
- reduce the latency and increase the temporal resolution of the gravity and therefore mass redistribution products
- develop gravity-based indicators for extreme hydrological events and demonstrate their value for flood and drought forecasting and monitoring services

EGSIEM: Three Prototype Services are being established



EGSIEM: Analysis Centers





EGSIEM Analysis Centers (ACs):

- **GFZ**
- **CNES**
- **AIUB**
- **TUG - ITSG**
- **University of Luxembourg**
- More in the future …

1. Improvements of the processing
2. Integration of complementary data
3. Harmonization of processing standards
4. Combination of the solutions

Harmonization of Processing Standards

- Common reference frame and GPS orbit constellation
- Ensemble of different background models
- Distribution of solutions at normal equation level in standard SINEX format

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+FILE/REFERENCE
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+SOLUTION/STATISTICS
+SOLUTION/NORMAL_EQUATION_VECTOR
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+SOLUTION/ESTIMATE
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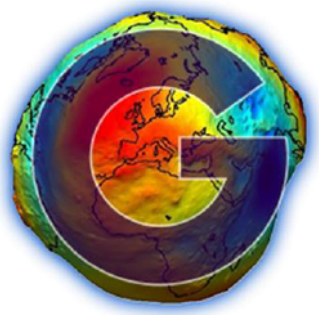
EGSIEM
European Gravity Service for Improved Emergency Management
HORIZON 2020

EO-1-2014: New ideas for Earth-relevant space applications
Research and Innoation Action

Action Acronym:	EGSIEM
Action full title:	European Gravity Service for improved Emergency Management
Grant agreement no:	637010

Deliverable 2.1
Processing Standards

Date: 27/02/2015

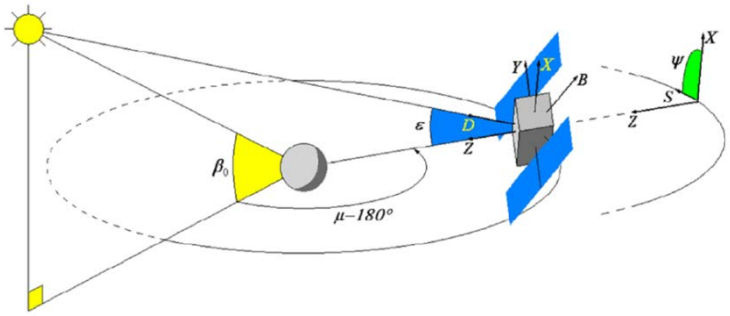


Prepared by: U. Meyer

GNSS Reprocessing

- The main motivation for the reprocessing campaign in the frame of the EGSIEM project were shortcomings in the empirical solar radiation pressure models used for GNSS orbit modeling.
- The empirical solar radiation pressure model has been updated in the operational processing at the CODE global analysis center of the IGS at the beginning of 2015 according to:

$$D(u) = D_o + D_{2c}\cos 2u + D_{2s}\sin 2u + D_{4c}\cos 4u + D_{4s}\sin 4u$$
$$Y(u) = Y_o$$
$$B(u) = B_o + B_{1c}\cos u + B_{1s}\sin u$$

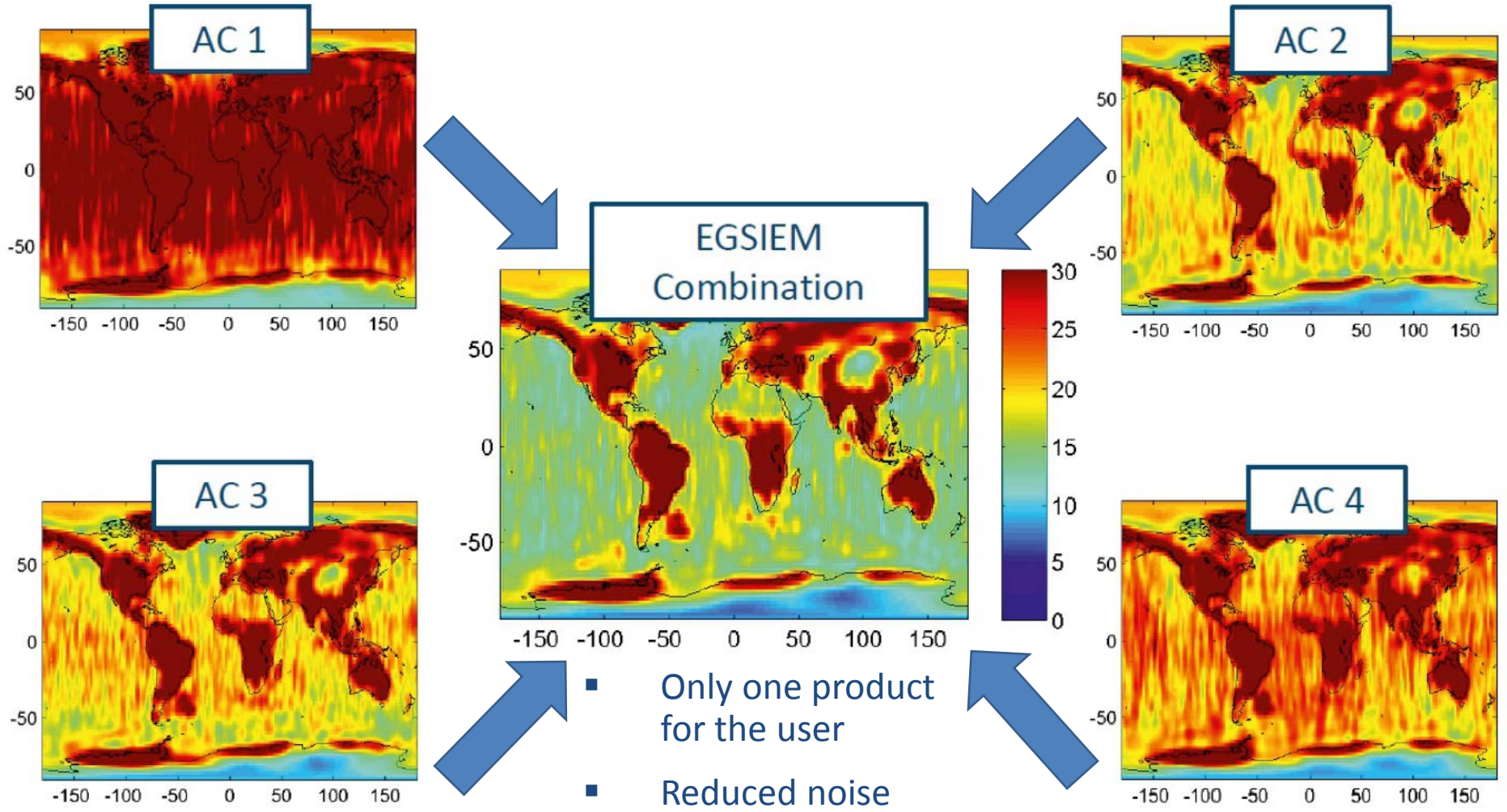


GNSS Reprocessing

- Reprocessed products are based on CODE processing strategy as used in spring 2015
- GPS orbits are reprocessed since 1994, GLONASS orbits since 2002
- GPS 5 second clock corrections are reprocessed since 2003
  GLONASS 30 second clock corrections since 2008,
  GLONASS 5 second corrections from end of 2010 onwards

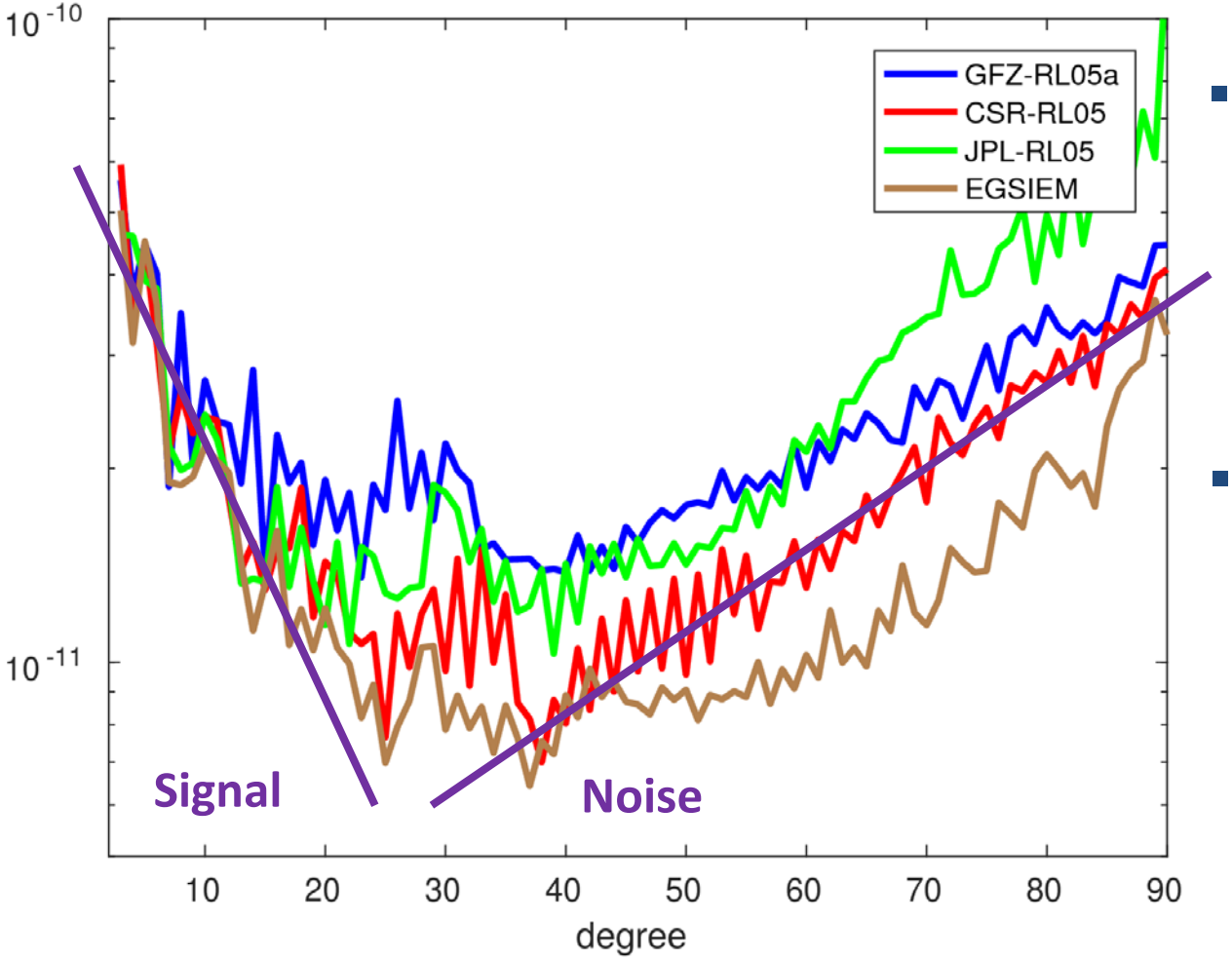
Products will be released at EGU 2017

Scientific Combination Service



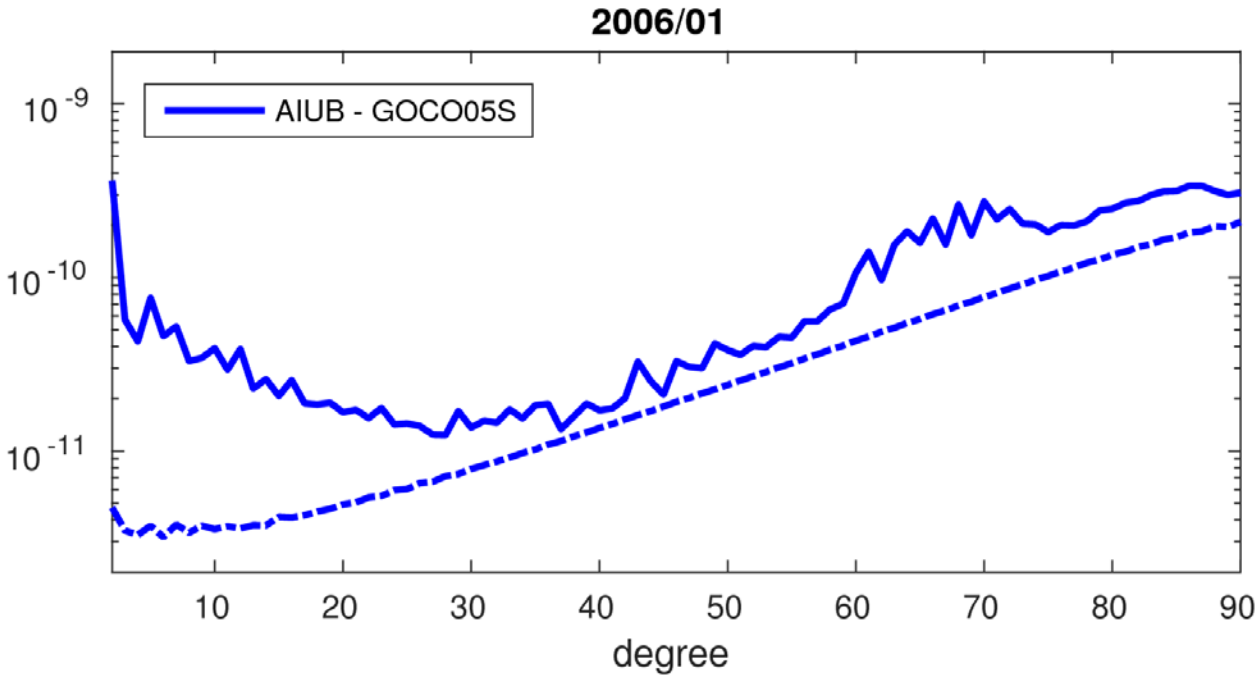
- Only one product for the user
- Reduced noise

Comparison to official solutions (2006/01)



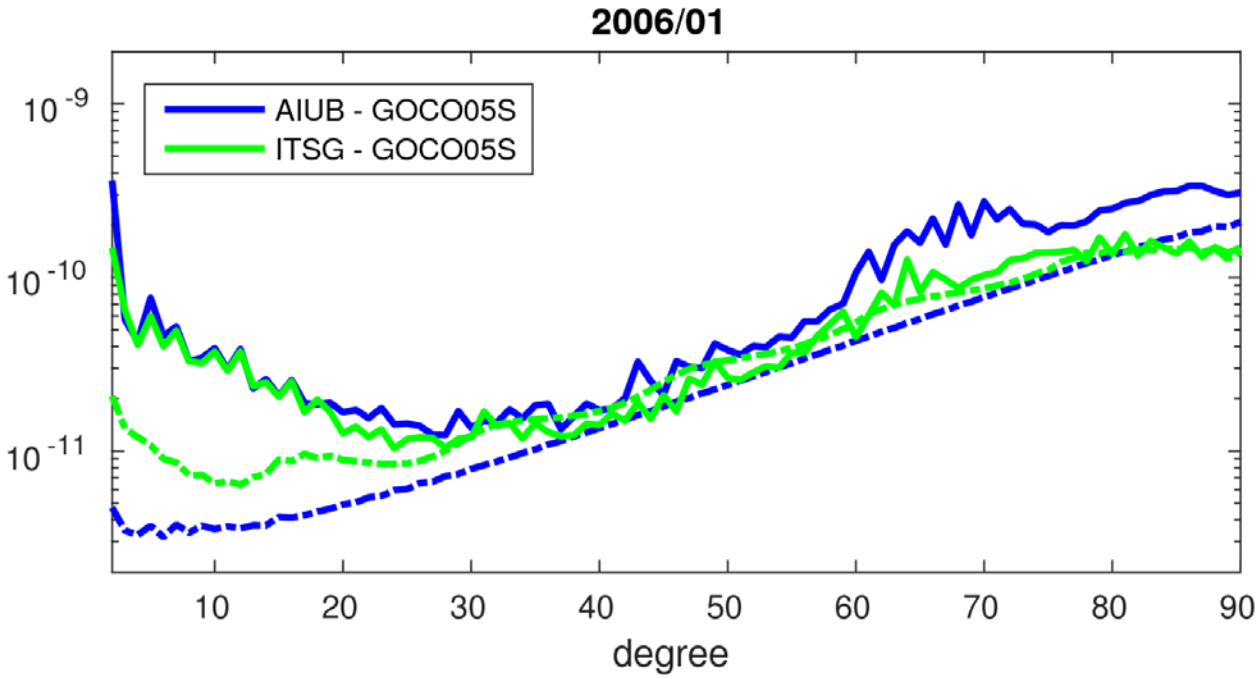
- Degree amplitudes of anomalies with respect to modeled secular and seasonal variations
- Only orders 0 … 29 are considered, i.e., evaluation of that part of the spectrum that is determined most meaningful.

Individual Contributions: AIUB



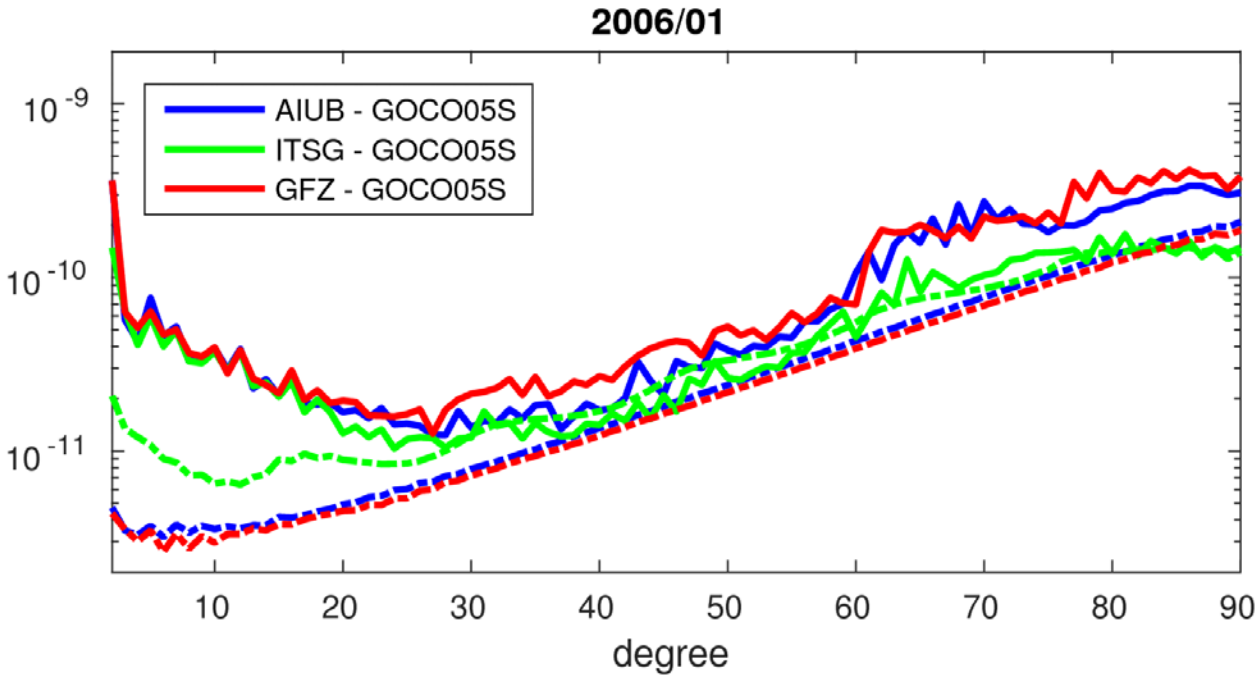
- **AIUB:** dynamic approach (dense pseudo-stochastic accelerations)
  - **~ 500‘000 KRR observations per month**
  - **~ 500‘000 kinematic positions (30s) per month**

Individual Contributions: ITSG



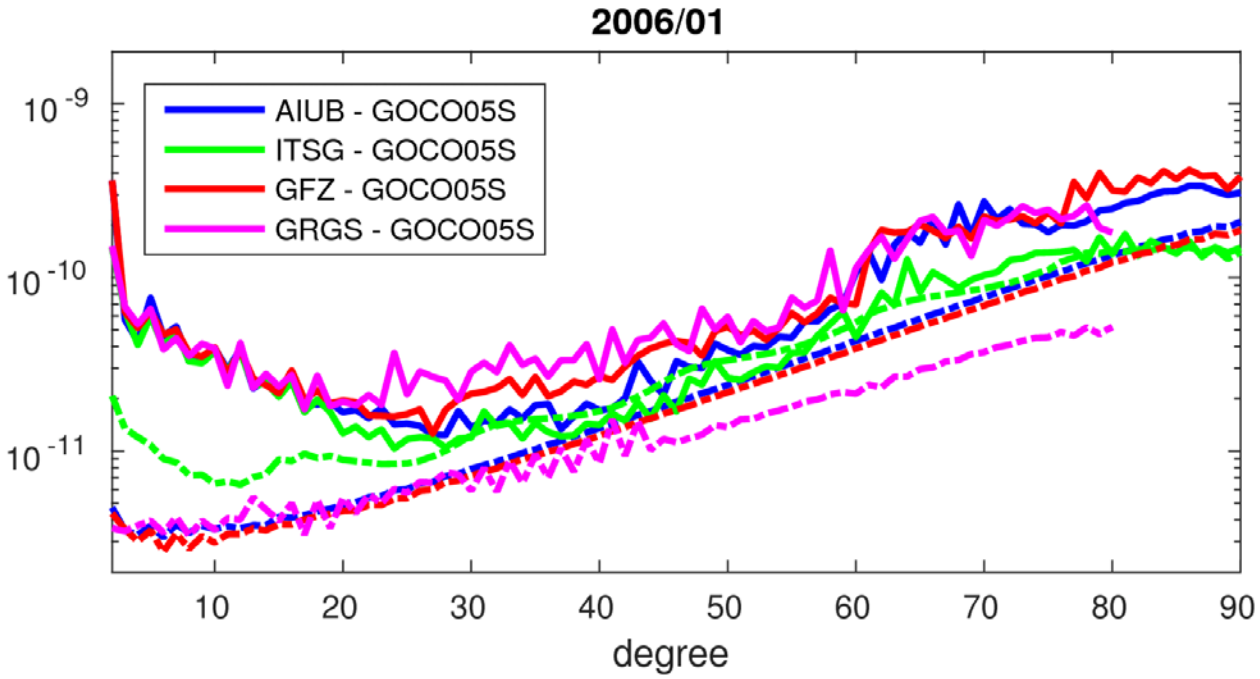
- **ITSG**: originally a short arc approach, empirical noise models used
  - **~ 500‘000 KRR observations per month**
  - **~ 50‘000 kinematic positions (300s) per month**

Individual Contributions: GFZ



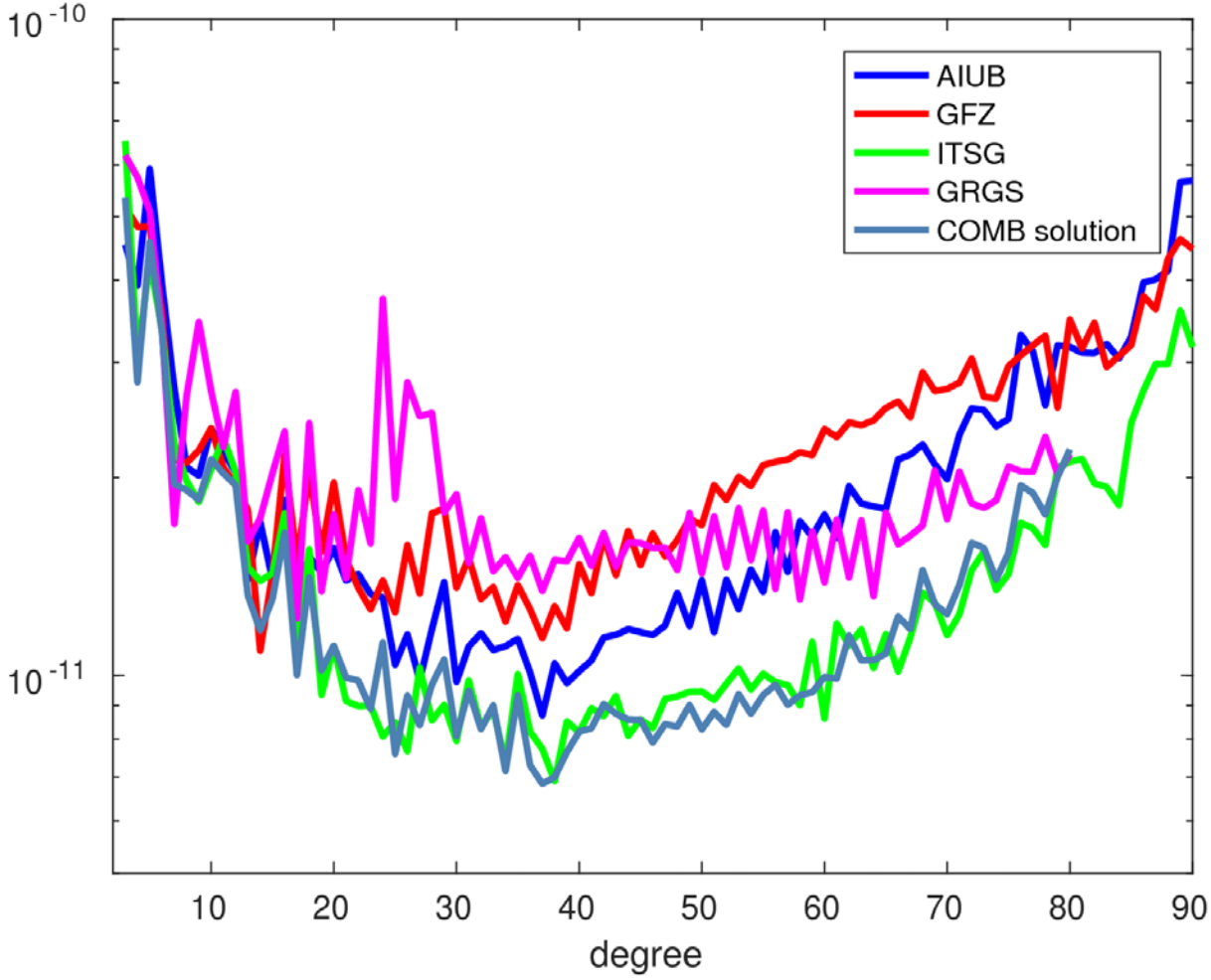
- **GFZ:** dynamic approach, dense accelerometer parametrization
  - **~ 500‘000 KRR observations per month**
  - **~ 2‘500‘000 GPS observations per month**

Individual Contributions: GRGS



- **GRGS:** another dynamic approach
  - **~ 500‘000 KRR observations per month**
  - **~ 2‘500‘000 GPS observations per month**

Combination on Solution Level



Combinations may be performed by using a Variance Component Estimation (VCE) scheme

Solution:	weight
GRGS	0.14
GFZ	0.19
AIUB	0.29
ITSG	0.38

Combination on Solution Level

Formulas of Variance Component Estimation (VCE) may be adopted to the resulting (trivial) normal equations when using SH coefficients from individual ACs to compute the combined solution by a simple weighted average. The following explicit formulas result:

Iteration 0

$$\hat{\mathbf{x}}_0 = \frac{1}{n}\sum_k \mathbf{x}_k \qquad \text{with} \qquad w_{k,0} = \frac{1}{n} \quad \forall k,\ k = 1,\ldots,n$$

Iteration $i > 0$

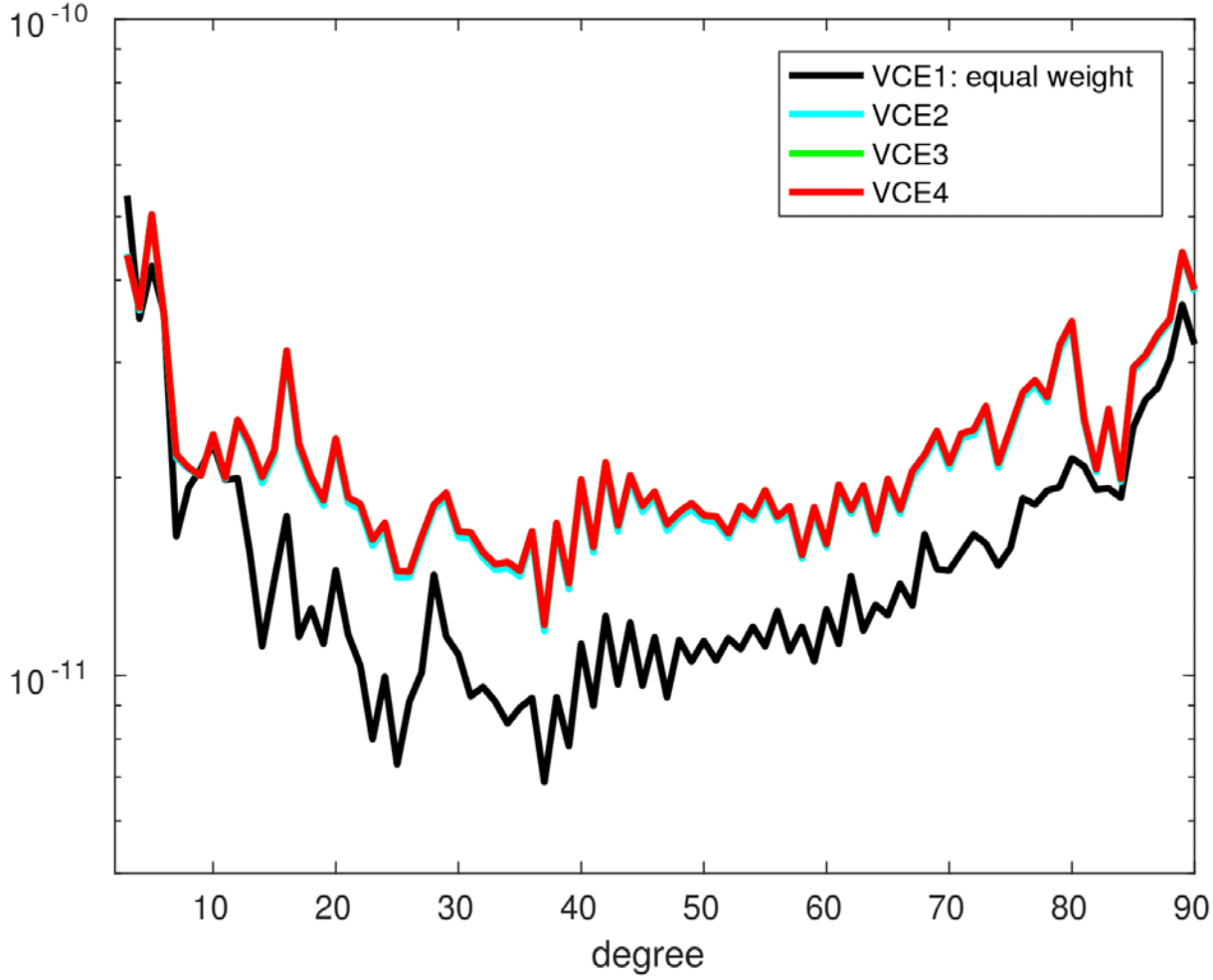
$$\hat{\mathbf{x}}_i = \frac{1}{\sum_k w_{k,i}} \sum_k w_{k,i}\mathbf{x}_k \qquad \text{with} \qquad w_{k,i} = \left(1 - \frac{w_{k,i-1}}{\sum_k w_{k,i-1}}\right) / \mathrm{RMS}(\mathbf{d}_{k,i-1})^2$$

$$\mathbf{d}_{k,i-1} = \mathbf{x}_k - \hat{\mathbf{x}}_{i-1}$$

Differences to the combined solution from $\hat{\mathbf{x}}_{i-1}$ **the previous iteration**

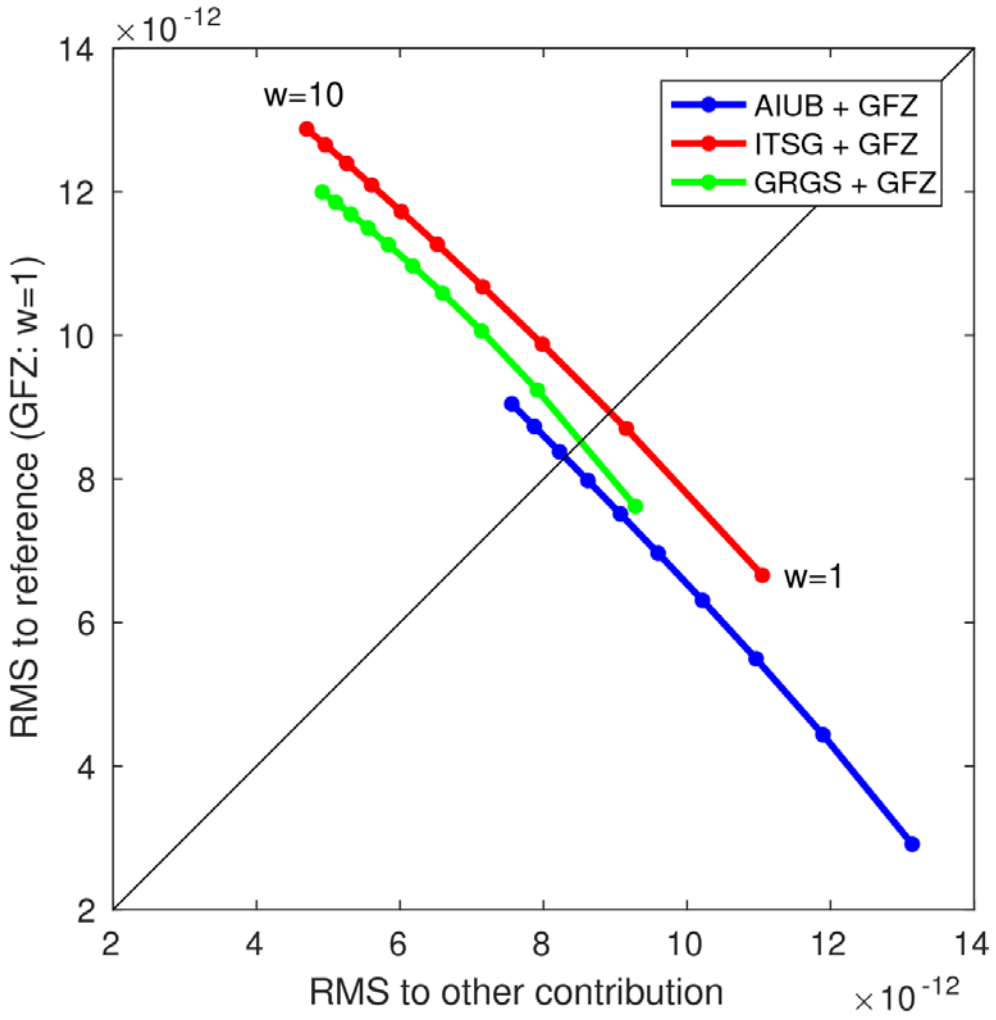
Iteration 0 is equivalent to a simple average, iteration 1 is equivalent to the simple weighted average. Further iterations are required until the procedure converges.

Combination on Normal Equation Level



VCE	weight
GRGS	3.23
GFZ	0.87
AIUB	5.88
ITSG	1.08

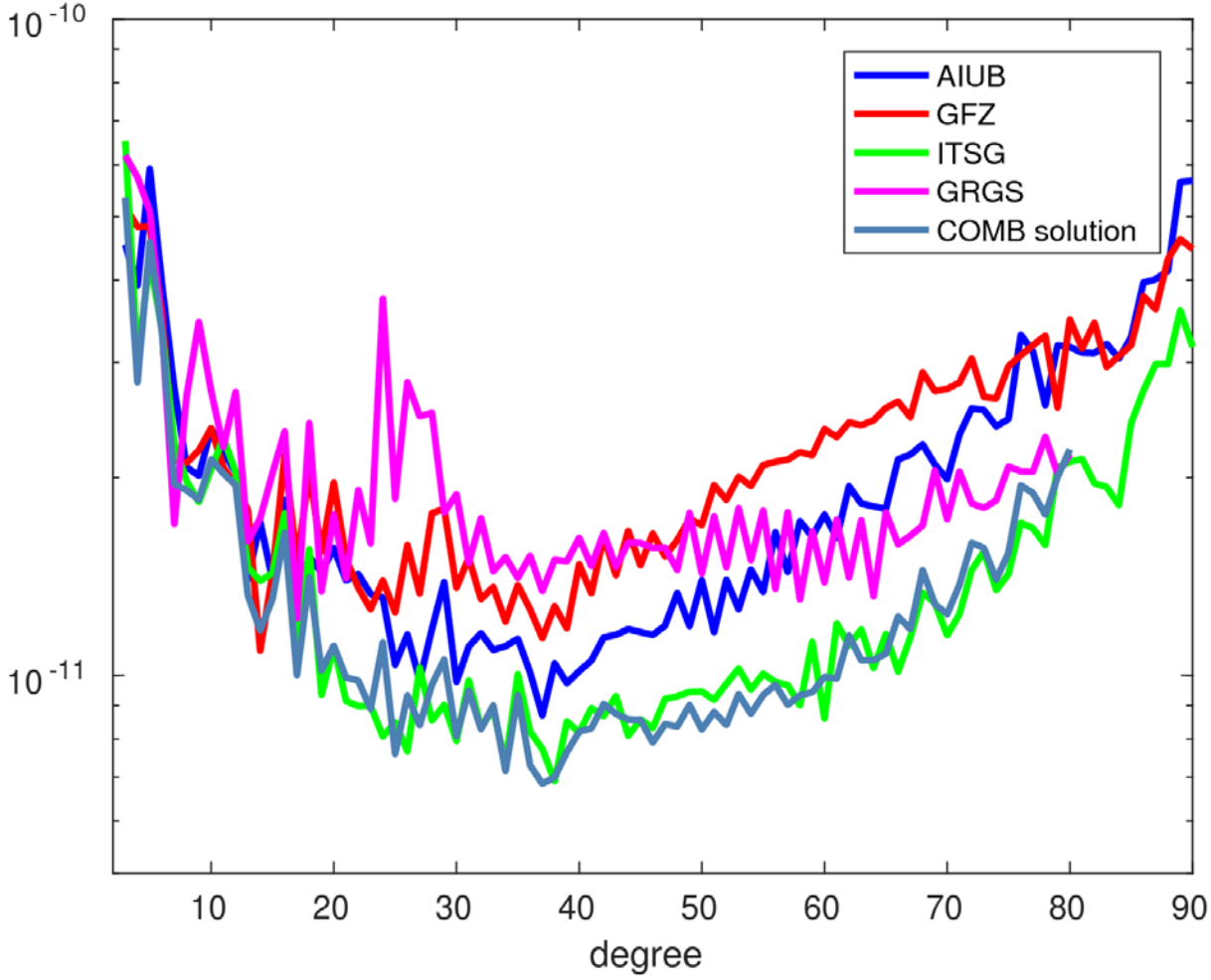
Combination on Normal Equation Level



Empirical rescaling to achieve an equal impact is first needed

equalizing weight	
GRGS	1.60
GFZ	1.00
AIUB	7.81
ITSG	2.21

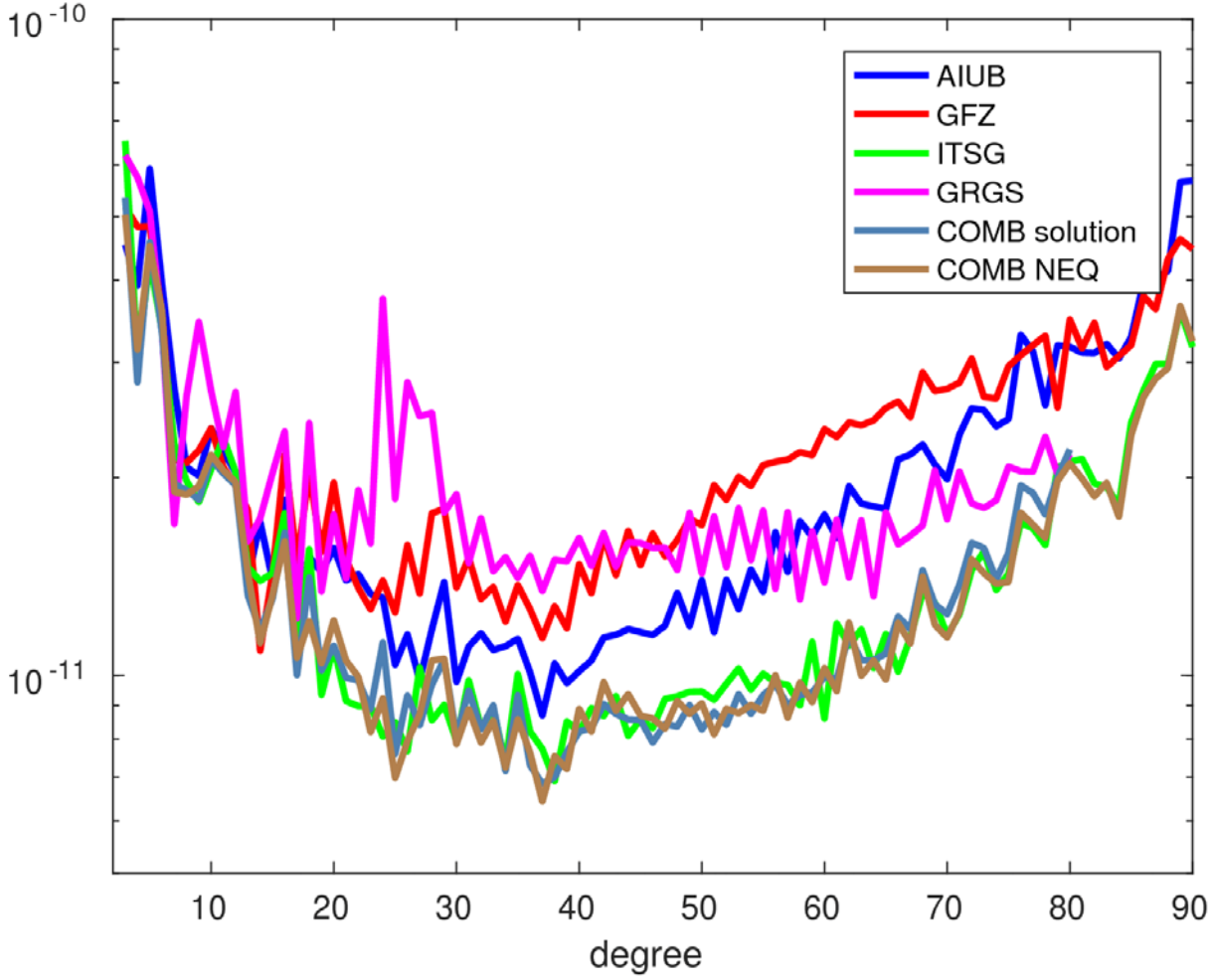
Combination on Normal Equation Level



Currently weights are first derived on the solution level using a VCE scheme:

Solution:	weight
GRGS	0.14
GFZ	0.19
AIUB	0.29
ITSG	0.38

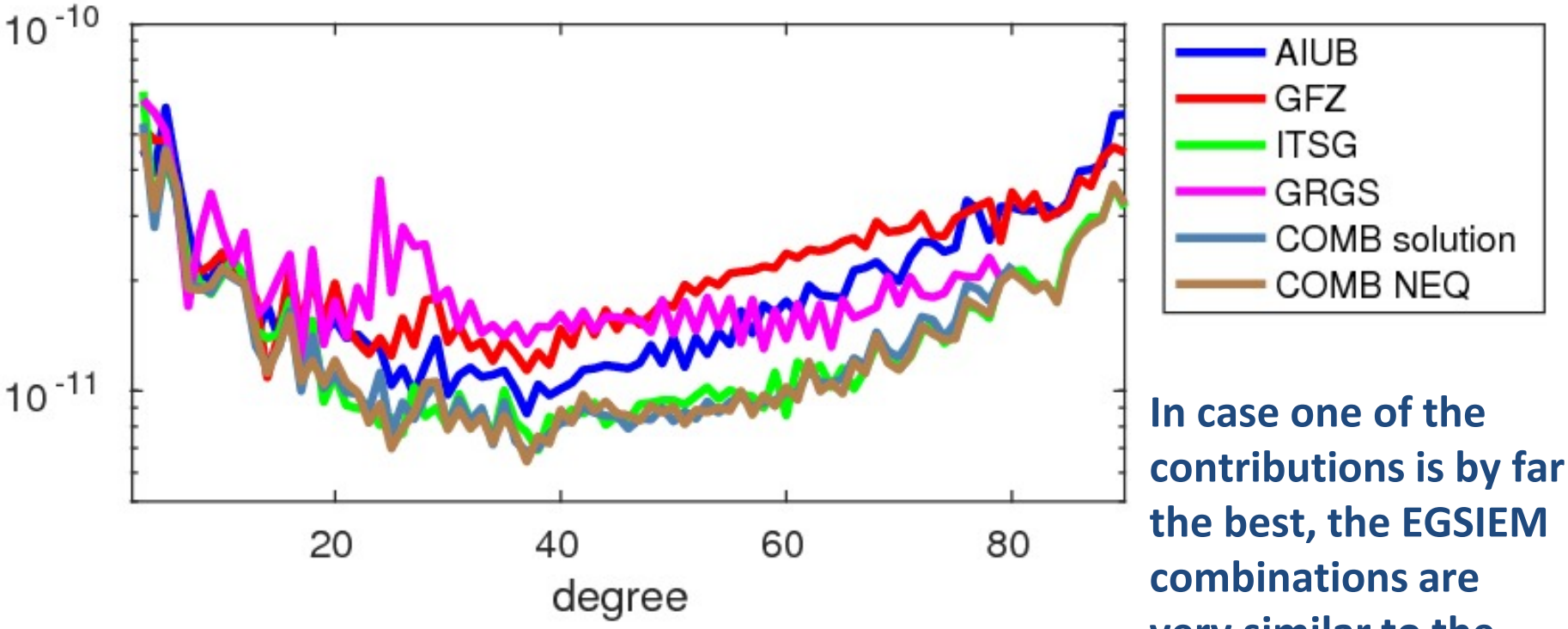
Combination on Normal Equation Level



equalizing weight	
GRGS	1.60
GFZ	1.00
AIUB	7.81
ITSG	2.21

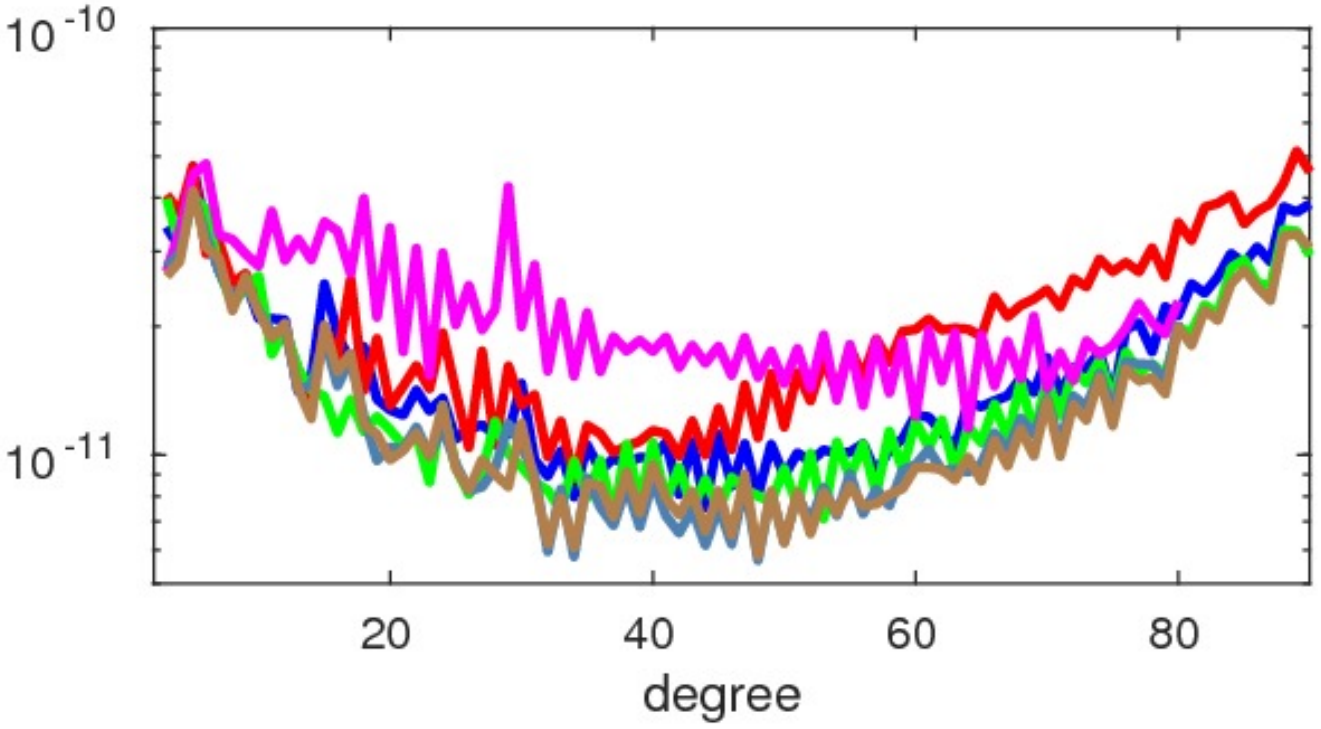
Solution:	weight
GRGS	0.14
GFZ	0.19
AIUB	0.29
ITSG	0.38

Scientific Combination Service – Examples



In case one of the contributions is by far the best, the EGSIEM combinations are very similar to the best solution.

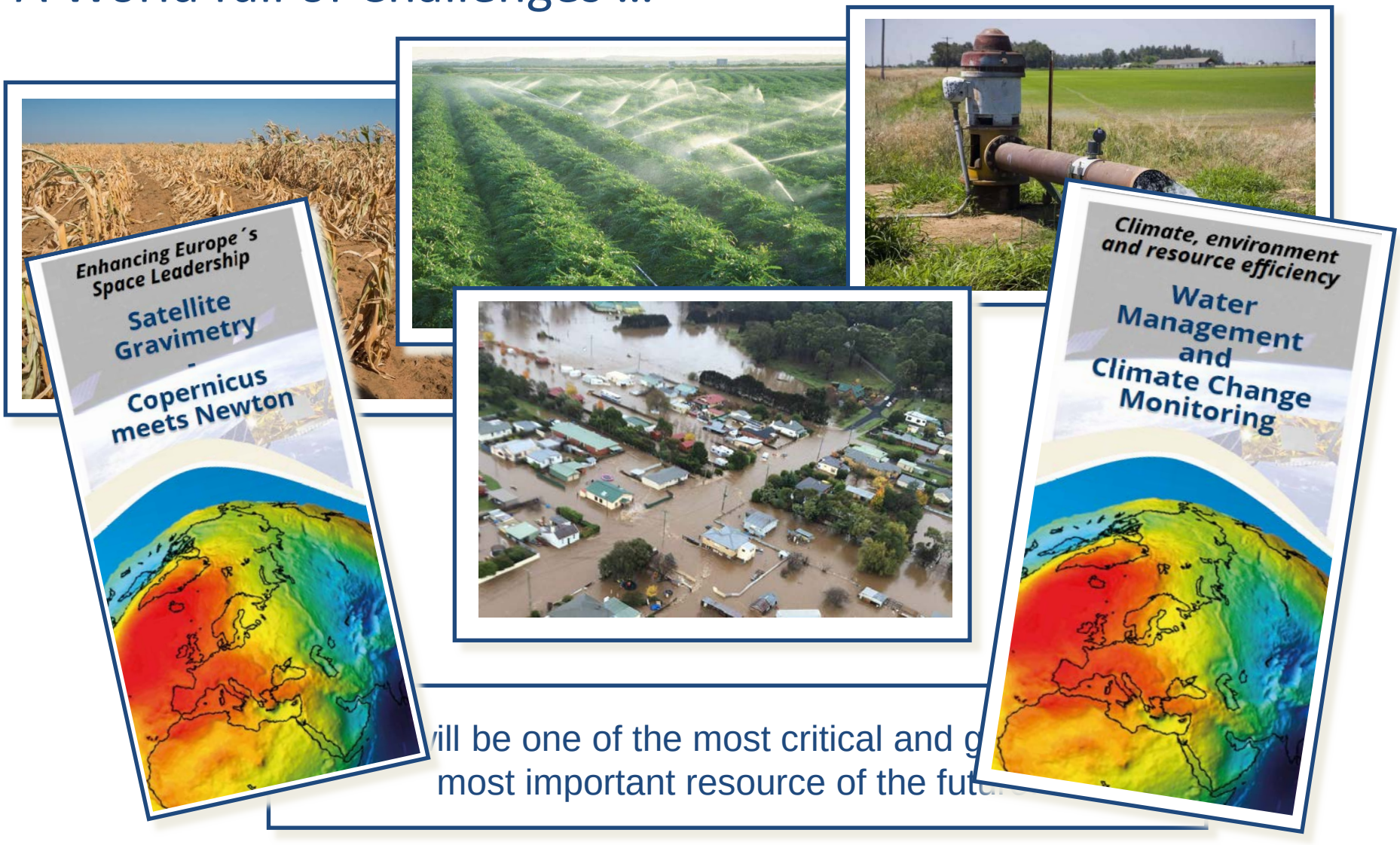
Scientific Combination Service – Examples



In case several contributions are comparably good, the EGSIEM combinations are better.

A first set of products will be released at EGU 2017

A World full of Challenges …



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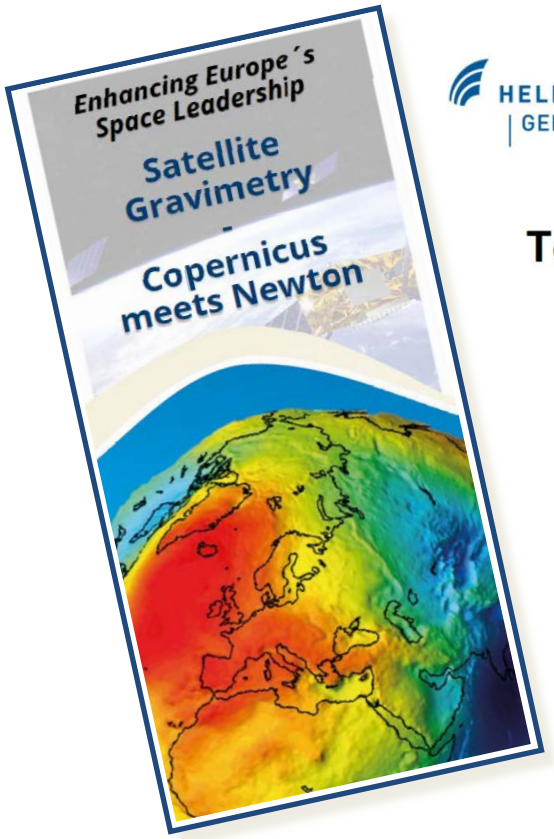
most important resource of the fut…

Lobby Events for Satellite Gravimetry



HELMHOLTZ GEMEINSCHAFT

GFZ Helmholtz Centre POTSDAM

SwissCore
Contact Office for European Research Innovation and Education

Tea Time Event on March 2nd, 2017

at

Helmholtz Brussels Office,

6th Floor, 98 Rue du Trone, 1000 Brussels

14.00 – 15.30

Lobby Events for Satellite Gravimetry

- A first lobby event was organized in Brussels with support of the Helmholtz Office in Brussels, the GFZ EU Project Office, and SwissCore to further promote satellite gravimetry in view of the upcoming GRACE-FO mission and future calls of H2020, FP9, …

- Info material (short talks, flyers, position papers) were prepared to inform program coordinators, project officers, national delegates of the program committees about the activities of EGSIEM and the satellite gravimetry community at large.

- Further events will follow, e.g. on 31th May in the European Parliament

Lobby Events for Satellite Gravimetry

- EGSIEM was funded to demonstrate the value of satellite gravimetry for new applications, e.g. in view of the current Earth Observation Programme Copernicus of the European Commission

- EGSIEM did first steps to establish links between satellite gravimetry and Copernicus.

- More work is needed, also beyond EGSIEM, to improve the visibility towards Copernicus. This is a joint effort, every institution has to contribute to the “lobbying”.

Summary and Outlook

- EGSIEM is running for three years (2015-2017)

- Three different prototype services are being established:
  - a scientific combination service
  - a near real-time (NRT) / regional service
  - a hydrological/early warning service

- Future integration into the services of the International Association of Geodesy (IAG) under the umbrella of the International Gravity Field Service (IGFS)

Thanks a lot for your attention!