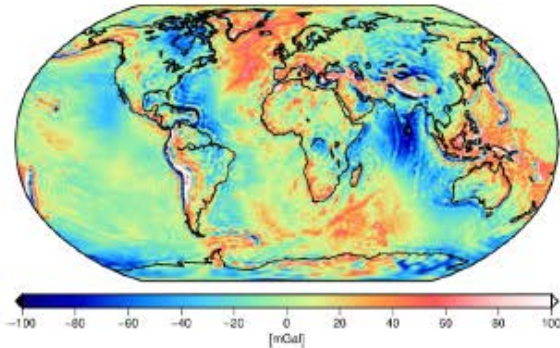
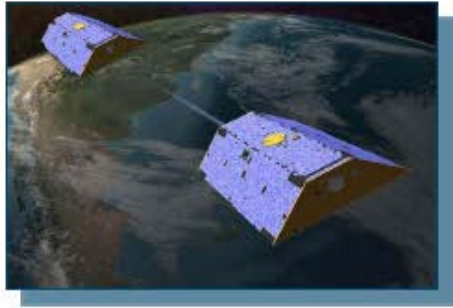


European Gravity Service for Improved Emergency Management – Status and Project Highlights

A. Jäggi, U. Meyer, Y. Jean, A. Susnik, R. Dach, M. Weigelt, T. van Dam, Z. Li, Q. Chen, F. Flechtner, C. Gruber, L. Poropat, A. Güntner, B. Gouweleeuw, T. Mayer-Gürr, A. Kvas, B. Klinger, S. Martinis, H. Zwenzer, S. Bruinsma, J.-M. Lemoine, R. Biancale, J. Flury, T. Bandikova, S. Bourgeois, H. Steffen, J. Teixeira da Encarnação, M. Horwath

GGHS 2016, 19.09. - 23.09., Thessaloniki, Greece

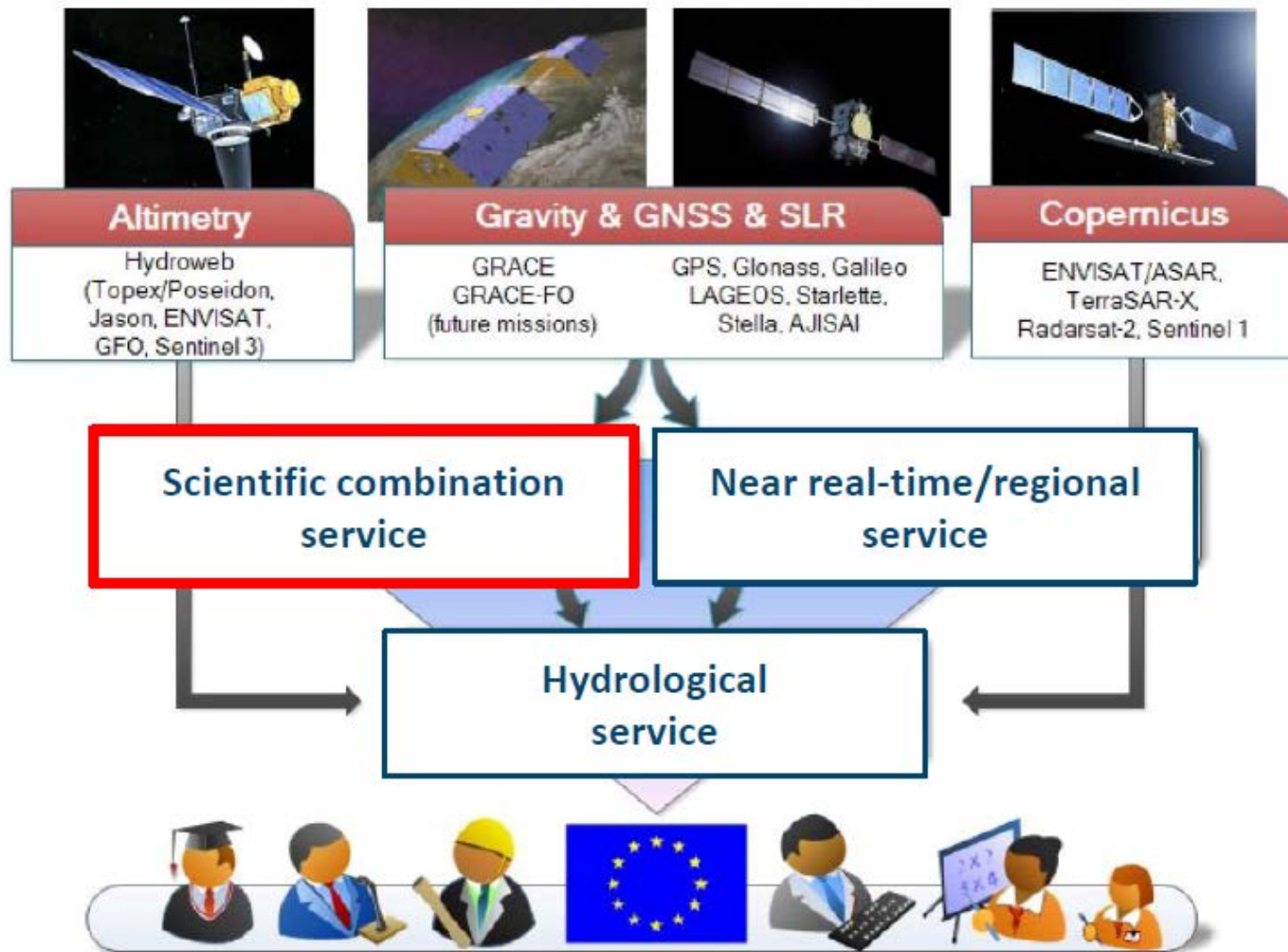
EGSIEM Project



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

EGSIEM Project – Three services shall be established



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

```
%=SNX 2.02  
+FILE/REFERENCE  
+FILE/COMMENT  
+SOLUTION/STATISTICS  
+SOLUTION/NORMAL_EQUATION_VECTOR  
+SOLUTION/NORMAL_EQUATION_MATRIX U  
+SOLUTION/ESTIMATE  
+SOLUTION/APRIORI  
%ENDSNX
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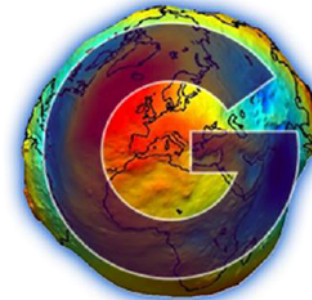


*EO-1-2014: New ideas for Earth-relevant space applications
Research and Innovation Action*

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

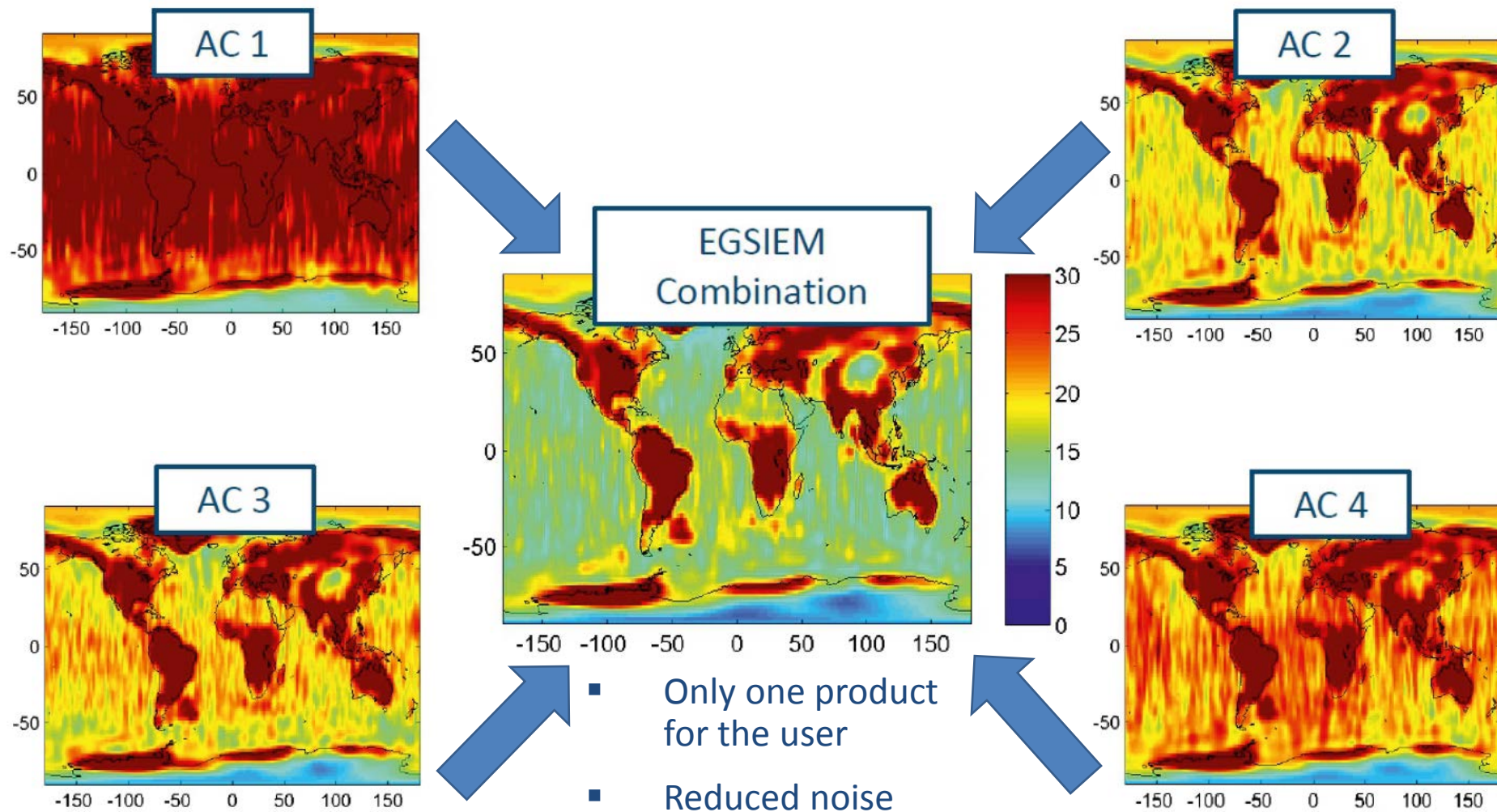
Deliverable 2.1
Processing Standards

Date: 27/02/2015



Prepared by: U. Meyer

Scientific Combination Service



Combination on Solution Level

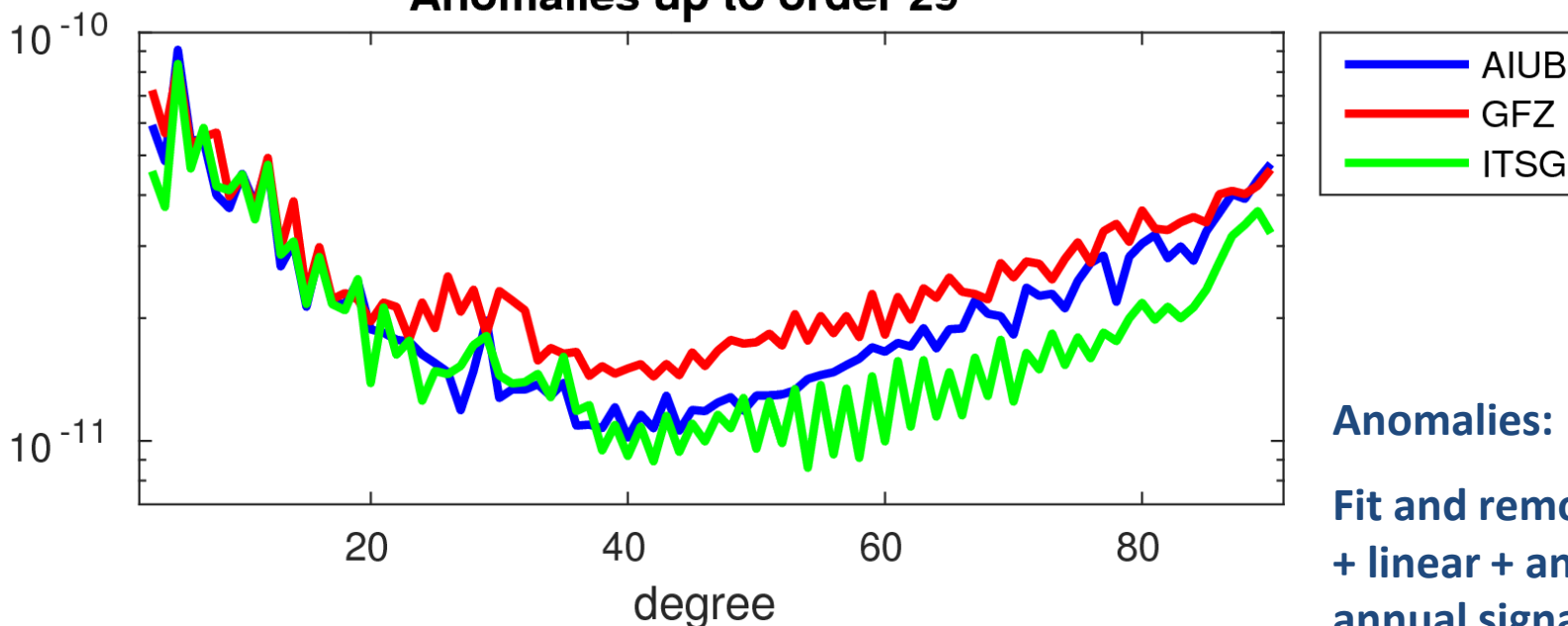
Formulas of Variance Component Estimation (VCE) may be adopted to the resulting (trivial) normal equations when using SH coefficients from individual ACs to compute the combined solution by a simple weighted average. The following explicit formulas result:

$$\begin{array}{ll} \text{Iteration 0} & \hat{\mathbf{x}}_0 = \frac{1}{n} \sum_k \mathbf{x}_k \quad \text{with} \quad w_{k,0} = \frac{1}{n} \quad \forall k, \quad k = 1, \dots, n \\ \\ \text{Iteration } i > 0 & \hat{\mathbf{x}}_i = \frac{1}{\sum_k w_{k,i}} \sum_k w_{k,i} \mathbf{x}_k \quad \text{with} \quad w_{k,i} = \left(1 - \frac{w_{k,i-1}}{\sum_k w_{k,i-1}}\right) / \text{RMS}(\mathbf{d}_{k,i-1})^2 \\ \\ & \mathbf{d}_{k,i-1} = \mathbf{x}_k - \hat{\mathbf{x}}_{i-1} \quad \text{Differences to the combined solution from } \hat{\mathbf{x}}_{i-1} \\ & \quad \text{the previous iteration} \end{array}$$

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.

Scientific Combination Service

Anomalies up to order 29



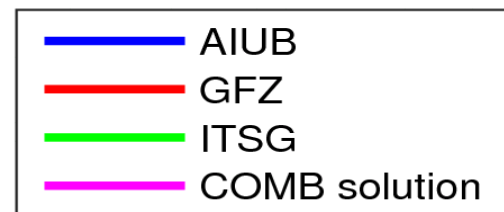
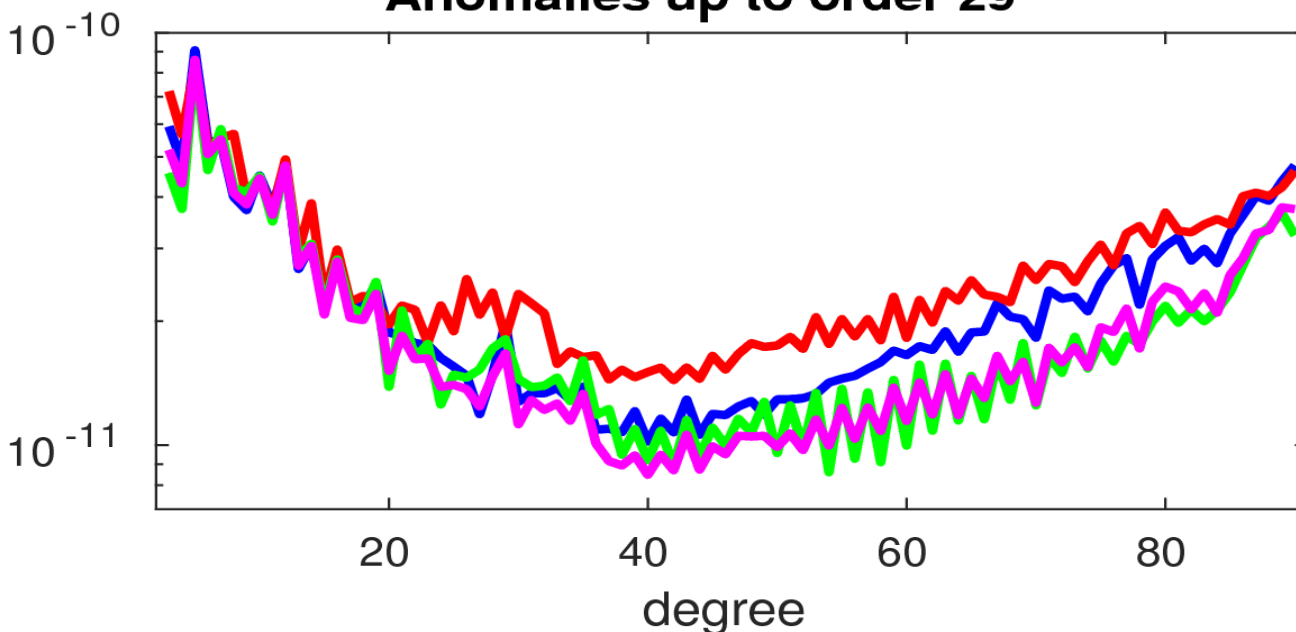
Anomalies:

**Fit and remove constant
+ linear + annual + semi-
annual signal parts per
coefficient.**

	AIUB	GFZ	ITSG	COMB sol	COMB NEQ	COMB w*NEQ
weight	0.52	0.09	0.39			
wSTD	8.2 mm	14.4 mm	5.5 mm			

Scientific Combination Service

Anomalies up to order 29



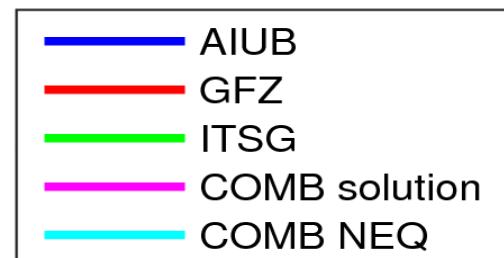
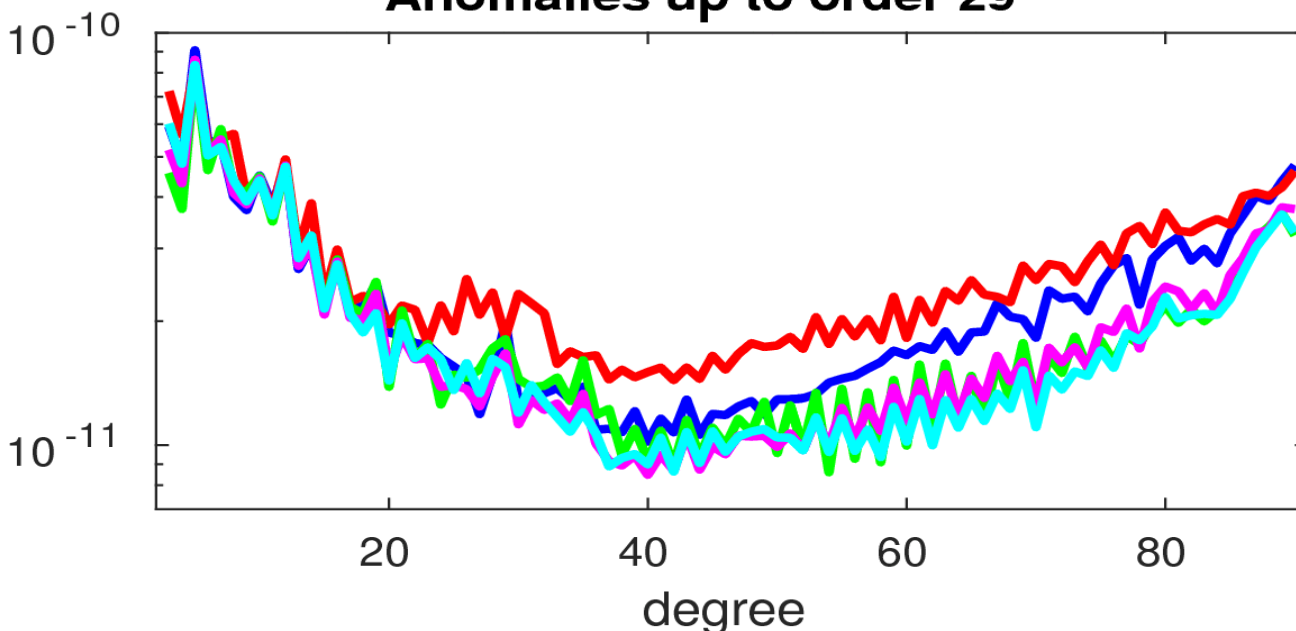
Anomalies:

Fit and remove constant + linear + annual + semi-annual signal parts per coefficient.

	AIUB	GFZ	ITSG	COMB sol	COMB NEQ	COMB w*NEQ
weight	0.52	0.09	0.39			
wSTD	8.2 mm	14.4 mm	5.5 mm	6.3 mm		

Scientific Combination Service

Anomalies up to order 29



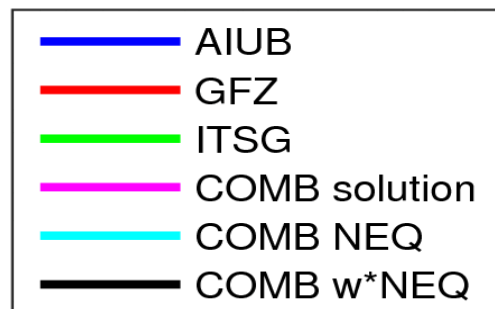
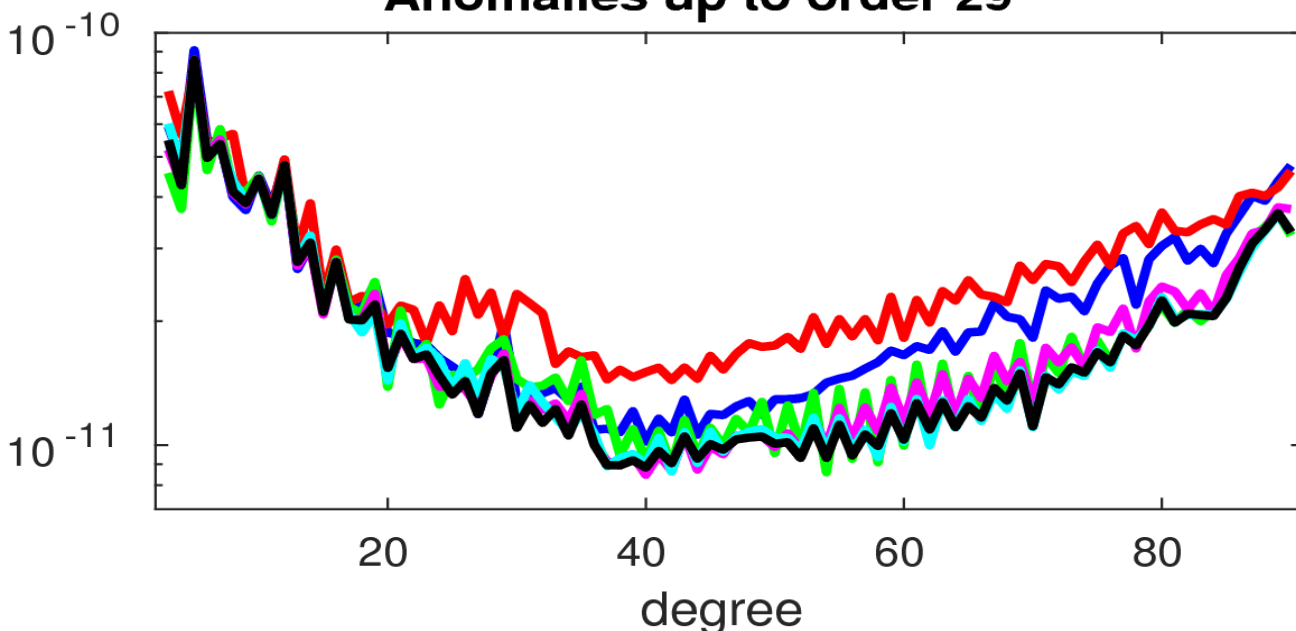
Anomalies:

**Fit and remove constant
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annual signal parts per
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	AIUB	GFZ	ITSG	COMB sol	COMB NEQ	COMB w*NEQ
weight	0.52	0.09	0.39			
wSTD	8.2 mm	14.4 mm	5.5 mm	6.3 mm	7.5 mm	

Scientific Combination Service

Anomalies up to order 29

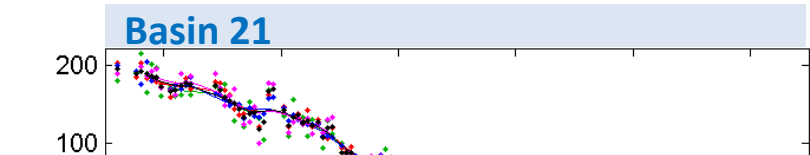
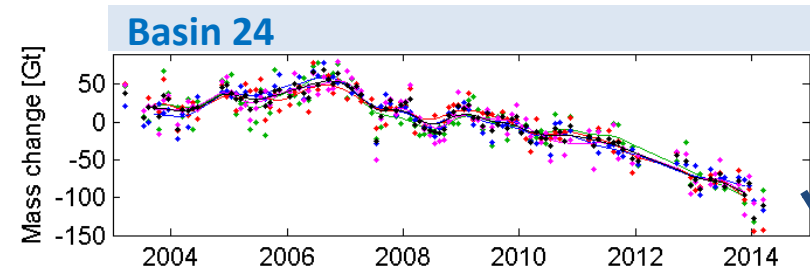


Anomalies:

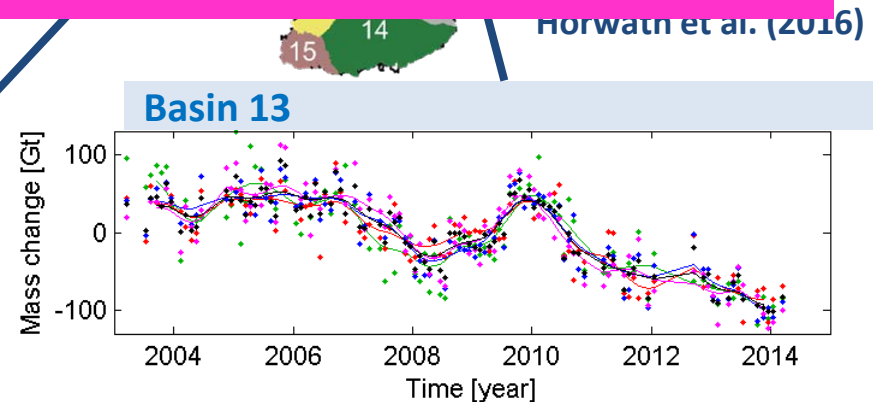
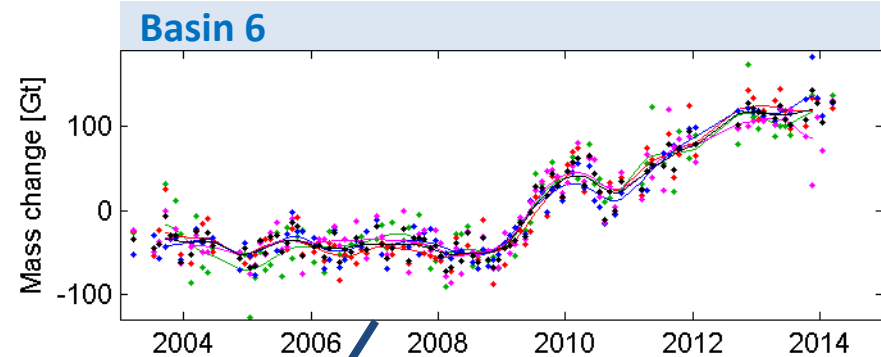
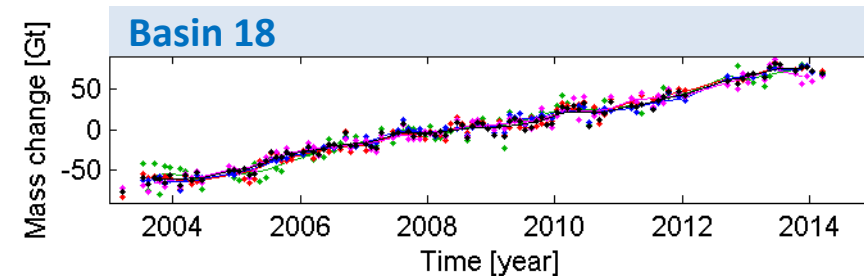
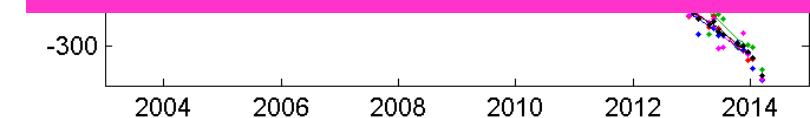
Fit and remove constant + linear + annual + semi-annual signal parts per coefficient.

	AIUB	GFZ	ITSG	COMB sol	COMB NEQ	COMB w*NEQ
weight	0.52	0.09	0.39			
wSTD	8.2 mm	14.4 mm	5.5 mm	6.3 mm	7.5 mm	5.9 mm

Validation of Solutions

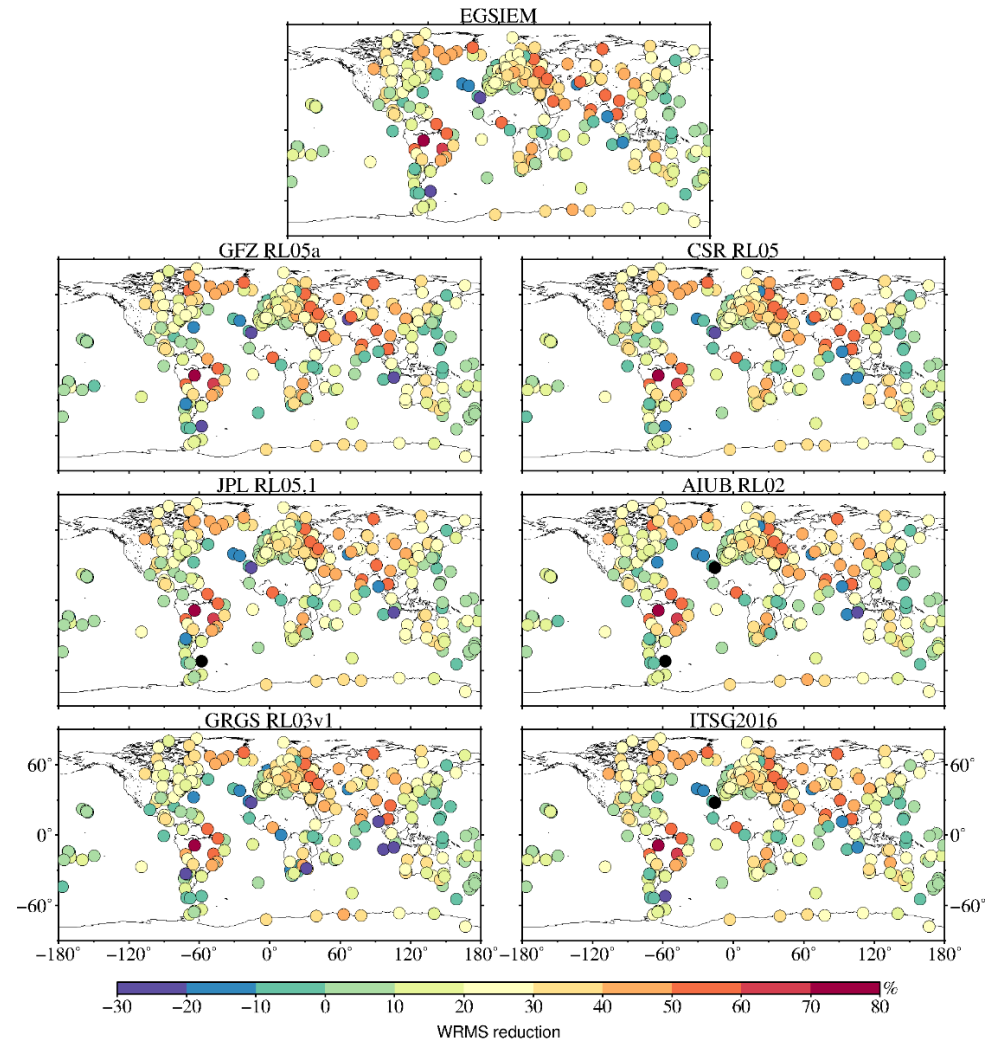


- Differences in noise STD between the individual series are currently in the order of 10% to 50%
- Combined time series show lowest noise in most cases

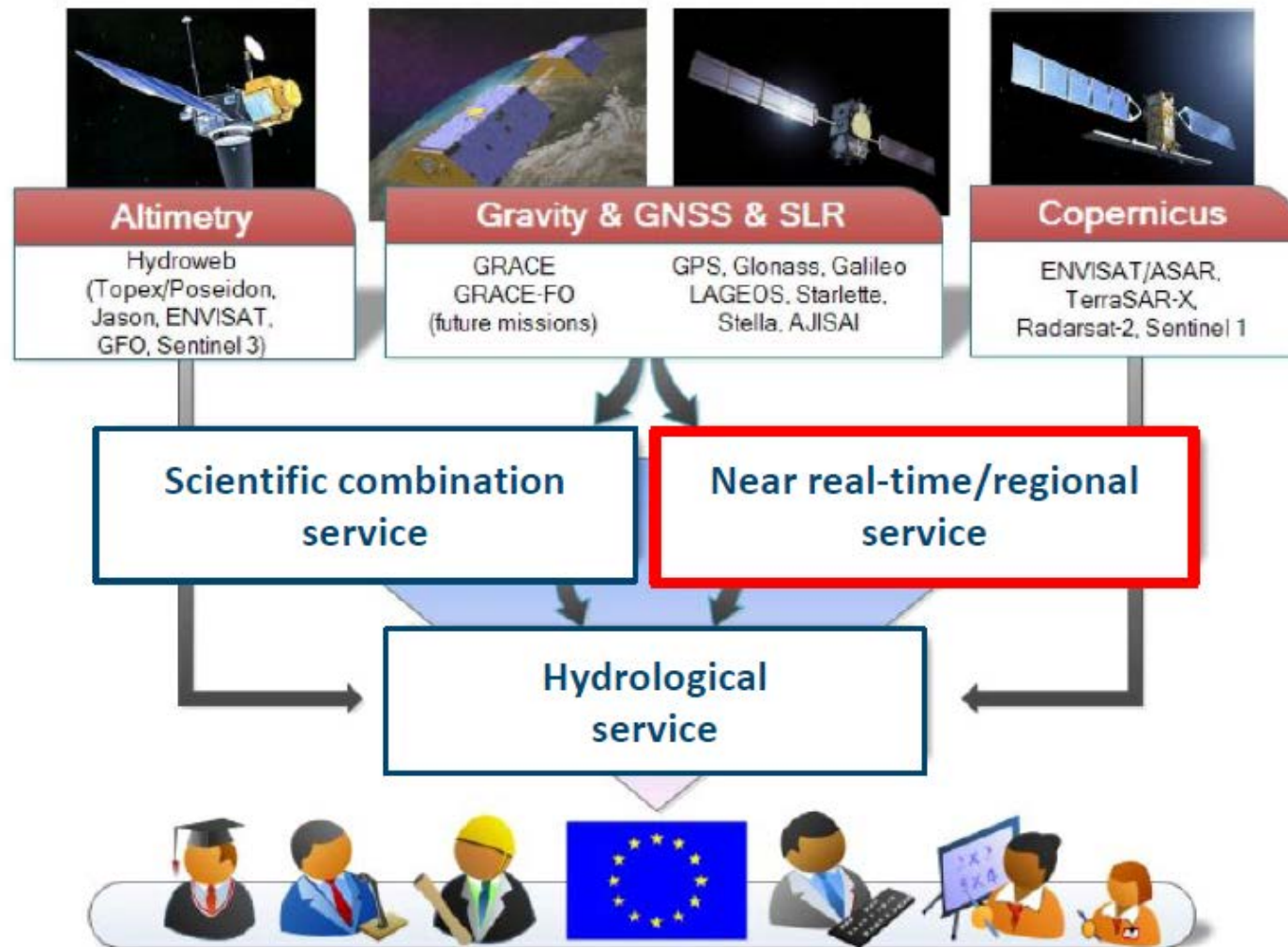


Validation with GNSS

- Comparison to 394 common GNSS stations from JPL, SOPAC and ITRF2014 time series shows WRMS reduction
- The figure shows one example of GRACE comparing to ITRF2014 time series.
- Up to 75% of WRMS reduction at POVE station (Porto Velho, Brazil)
- Different GRACE solutions show similar patterns

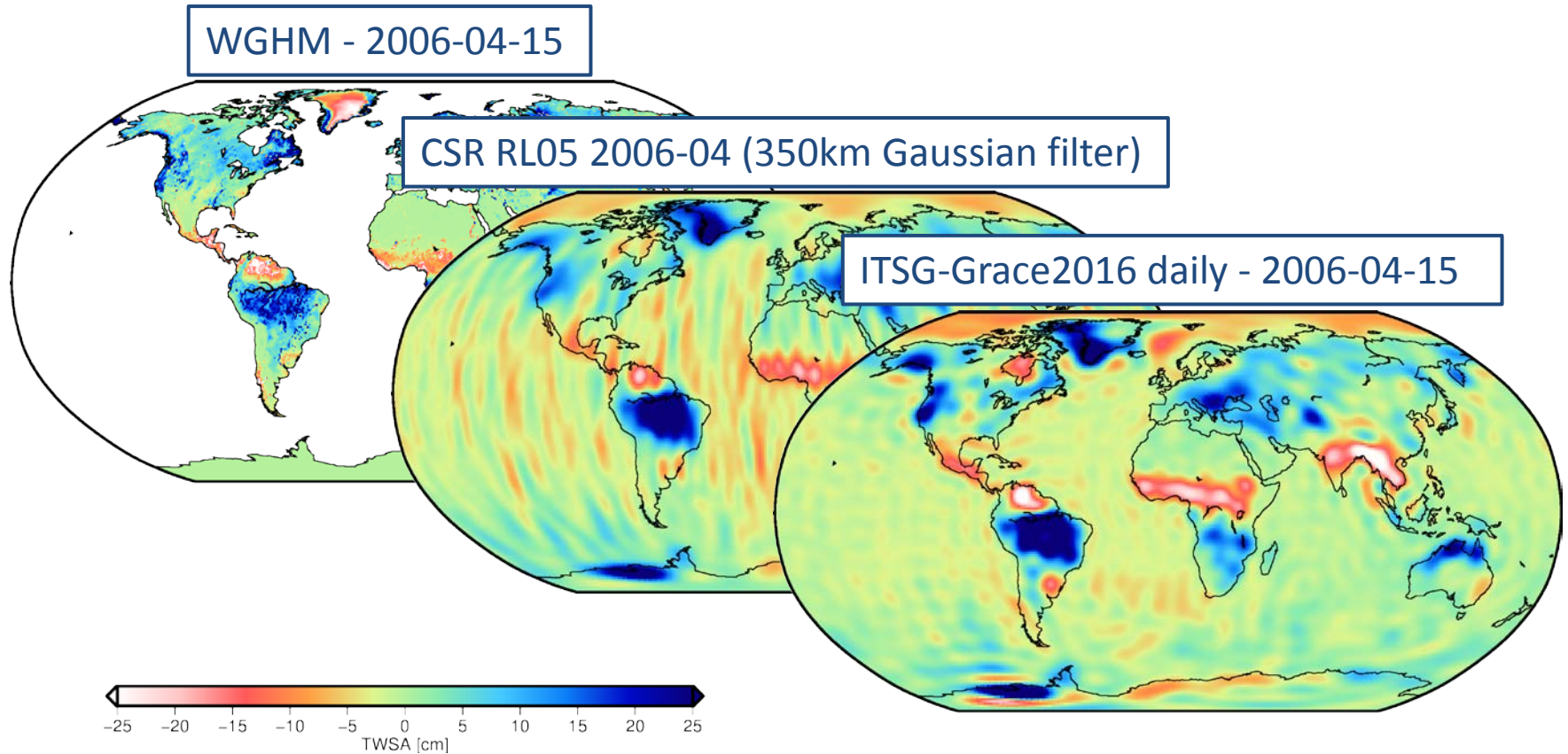


EGSIEM Services

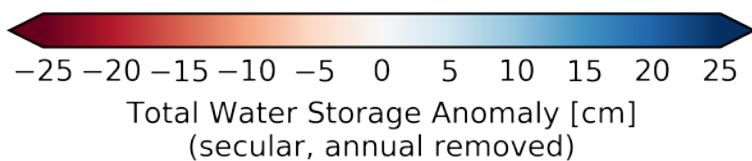
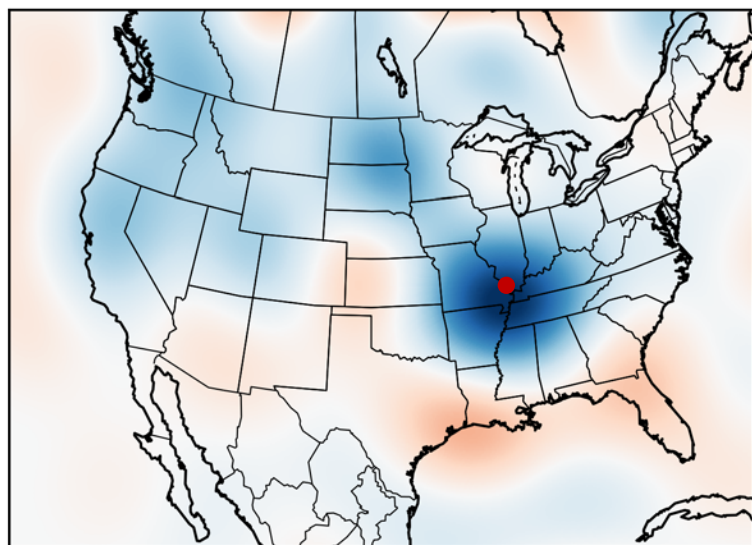


Improved Daily Gravity Field Solutions – ITSG-Grace2016

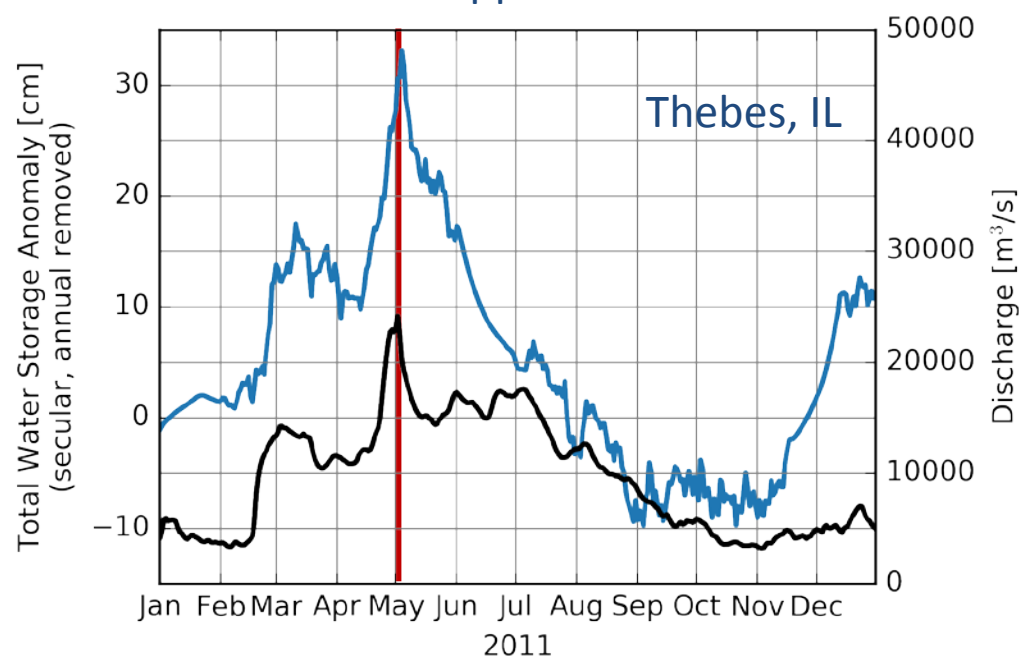
- Daily Kalman smoothed gravity field solutions up to d/o 40
- Full GRACE time series starting from 2002 processed and continually updated



Improved Daily Gravity Field Solutions – ITSG-Grace2016



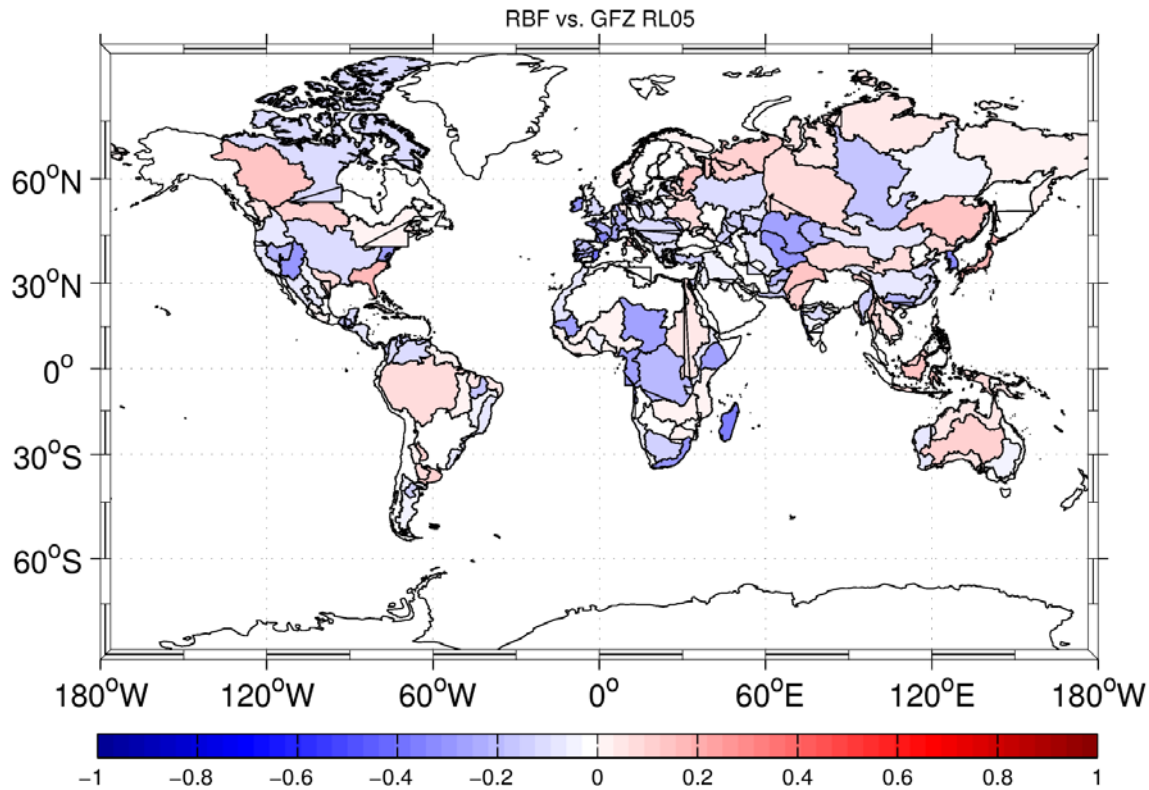
Great Mississippi Flood of 2011



- Daily updated solution will be generated in near real-time (max. 5 days delay)

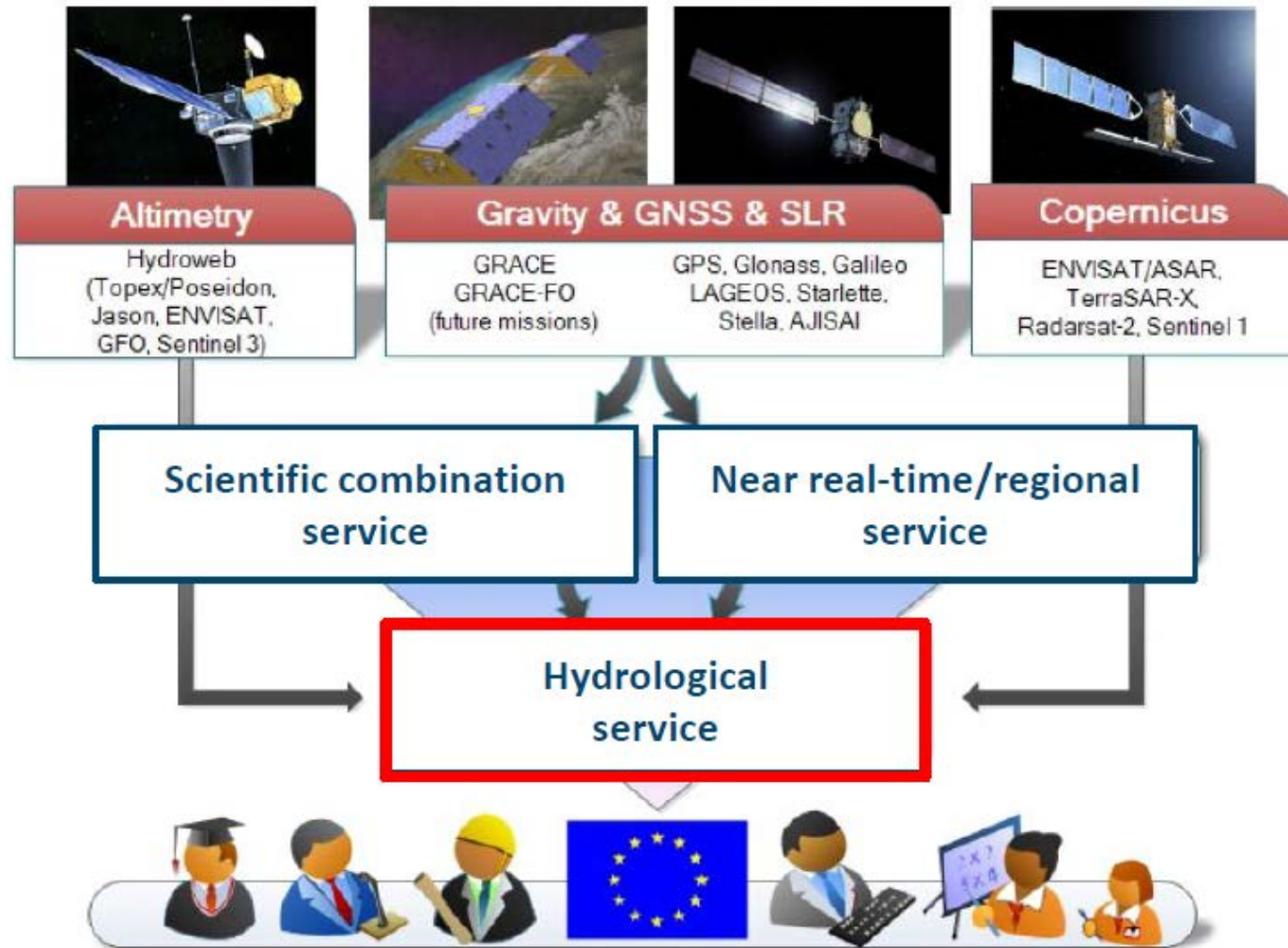
Daily Gravity Field Solutions from GFZ

- GFZ daily 2°x2° grids based on radial basis functions (RBF)
- Full GRACE time series starting from 2002 processed and continually updated
- Comparison of de-seasoned RBF and GFZ RL05a signals per basin with WGHM.



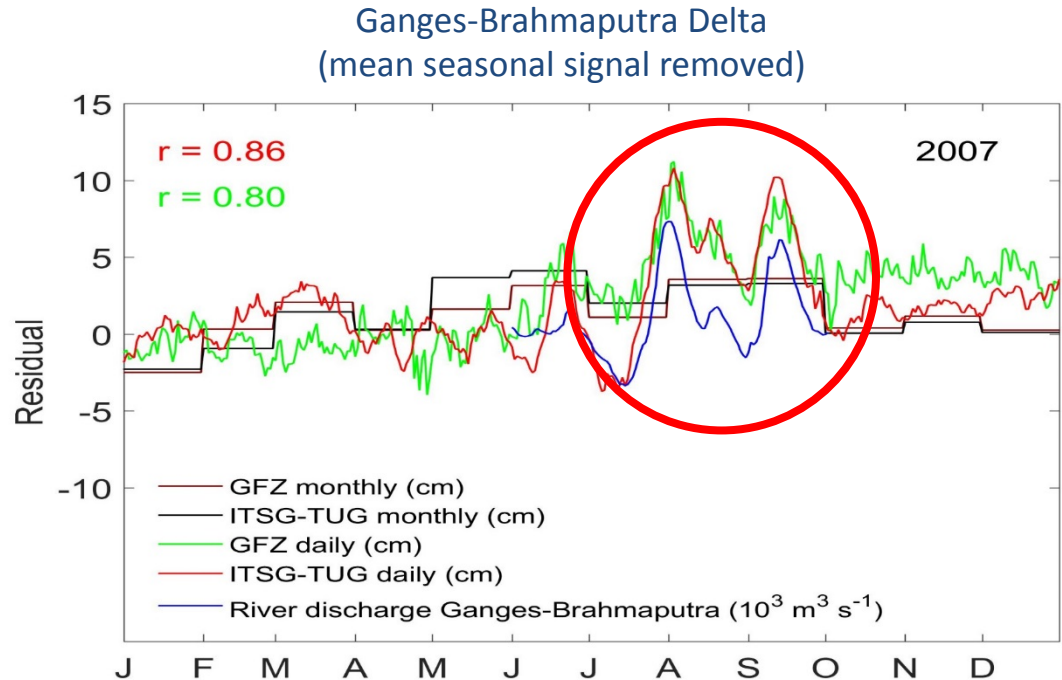
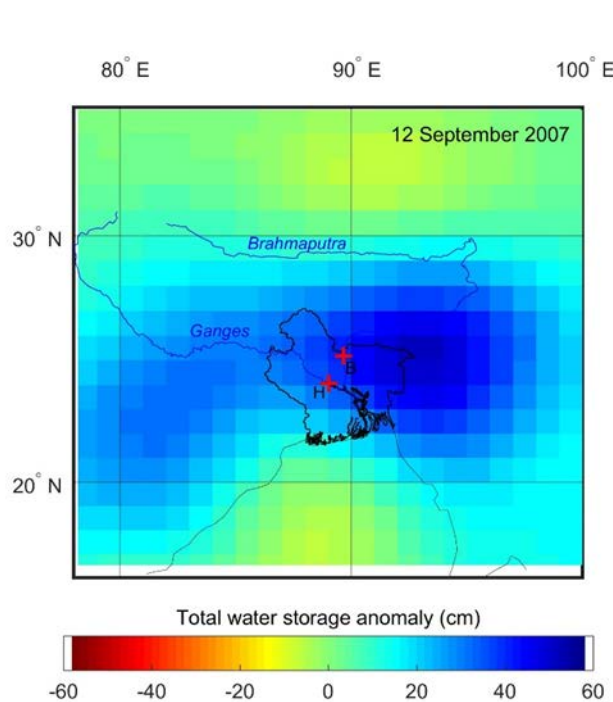
Blue color means higher correlation for (RBF) and red marks higher coherence with the standard model (GFZ RL05).

EGSIEM Services



Daily Solutions track major flood events

- Gravity-based flood and drought indicators shall serve as descriptors of the integral wetness status of river basins
→ early warning for hydrological extreme events

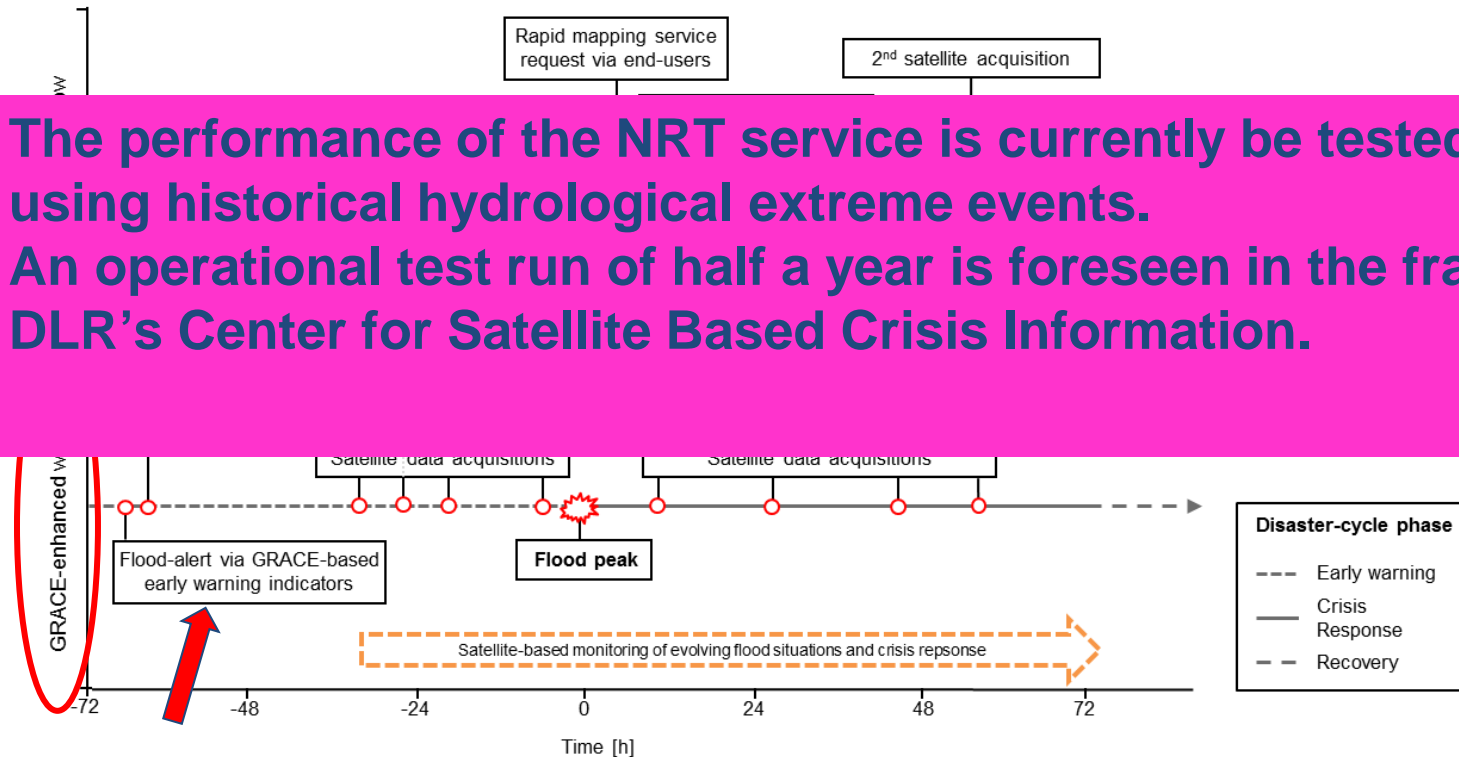


- Added value of gravity-based indicators shall be tested at different lead times (several months to near real time)

Rapid mapping

- Improved rapid mapping by on-demand programming of satellite acquisitions.
- Integration into automatic flood emergency management services.

- The performance of the NRT service is currently be tested using historical hydrological extreme events.
- An operational test run of half a year is foreseen in the frame of DLR's Center for Satellite Based Crisis Information.



Keep in touch

European-wide student competition

THE EGSIM CHALLENGE

Registration opens on
October 1, 2016
www.challenge.egsiem.eu

Droughts Floods
Geodesy Hydrology
Geoid Gravity
Emergency Management

News and updates will be regularly published on various media, e.g., by the quarterly EGSIM Newsletter. Issues can be accessed at www.egsiem.eu

EGSIM is also present on social media:

- <https://twitter.com/EGSIM>
- www.facebook.com/egsiem
- <https://egsiem.wordpress.com>

Summary and Outlook

- EGSiem will run for three years (2015-2017)
- Three different services shall be 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), e.g., under the umbrella of the International Gravity Field Service (IGFS), and into the Copernicus emergency service is envisaged
- EGSiem is open for collaborations with further partners.
- Thanks a lot for your attention!