

## Combination Service for Time-Variable Gravity Models (COST-G) – current status

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## IUGG General Assembly 2019

Montreal, Canada

8 – 18 July, 2019

# Introduction

## Gravity and geoid metadata

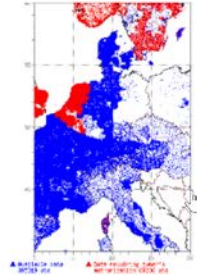
Online applications for the creation of metadata for gravity and geoid data. Service for searching the metadata database.

**g-meta**  
the gravity metadata editor  
(v0.2.6 - beta edition)

**N-meta**  
the geoid metadata editor  
(v0.1.3 - alpha edition)

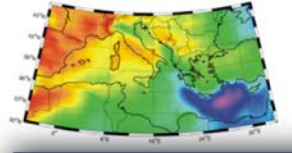
## Gravity data

Land, marine, airborne gravity data as point and gridded values. Absolute and relative gravity data, WGM



## Geoid

Geoid models and geoid determination software, geoid modeling processing methodologies



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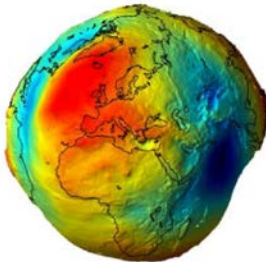
## SG and Earth tide data

Temporal variations of the Earth gravity field through long-term records from ground gravimeters, SG data, Earth tide data.



## Global Earth Models

Collection and archive of all existing global gravity field models, web interface for access to GEMs, model visualization and service.



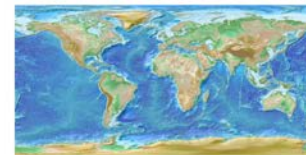
## Time-variable GEMs

Combined gravity field solutions in SH coefficients and spatial grids for hydrological, oceanic and polar ice sheets applications.

**COST-G**  
Combination Service for Time-variable Gravity Models

## DEM data

Digital Elevation Models, relevant software for DEM creation, assessment, manipulation and display, global relief and crustal models and spherical harmonic data sets.



**COST-G is a new product center of the**



<http://igfs.topo.auth.gr/>



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# COST-G Website



Combination Service for Time-variable Gravity Fields

Home

Introduction

Consortium

Service

Products

Documents

Contact

The COST-G Plotter

## Welcome to COST-G

The International **C**ombination **S**ervice for **T**ime-variable **G**ravity Fields (**COST-G**) is a product center of the International Gravity Field Service (IGFS) and is dedicated to the combination of monthly global gravity field models. COST-G steems from the activities of the former H2020 project European Gravity Service for Improved Emergency Management (EGSIEM).

Please use the top menu to visit the various parts of our website!

The service started its work in 2019 and the website is still under construction. More features will be available soon! We apologize for any inconvenience. For any questions, please [contact us](#).

Best regards,  
Your COST-G Team.

<https://cost-g.org/>

### Latest News

July 14th 2019

COST-G is officially launching at the occasion of the IUGG 2019 in Montreal!

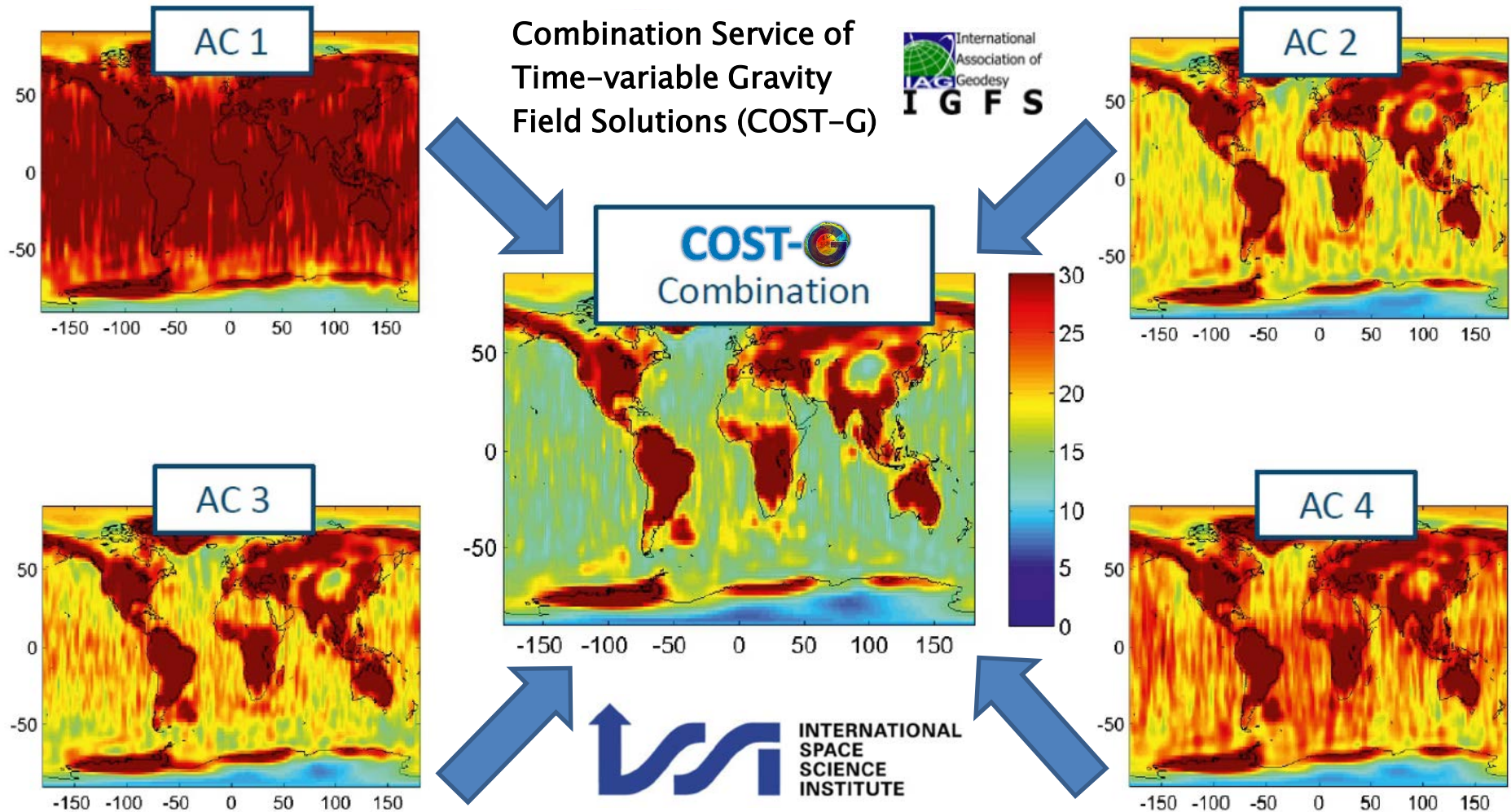


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# Combination of GRACE Gravity Fields



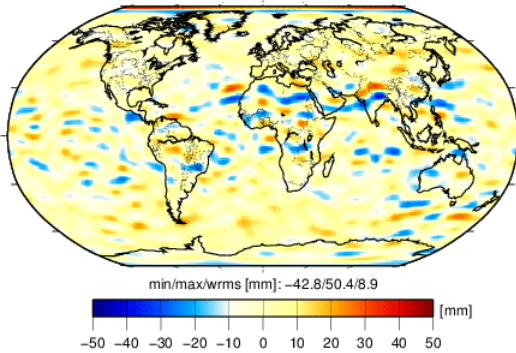
Improved and consolidated product integrating the strengths of all ACs



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# Combination of Swarm Gravity Fields

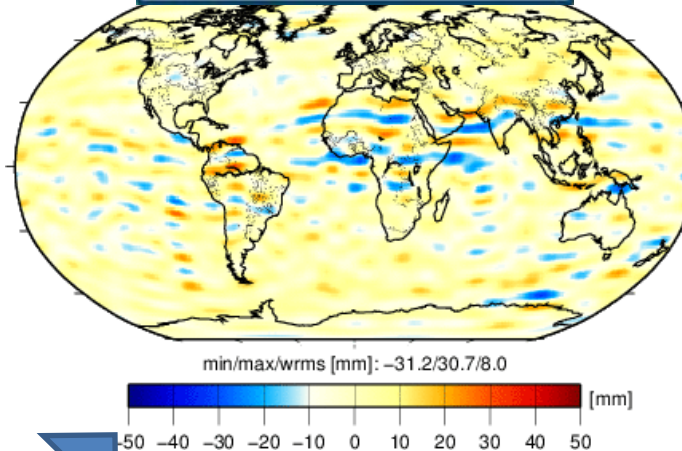
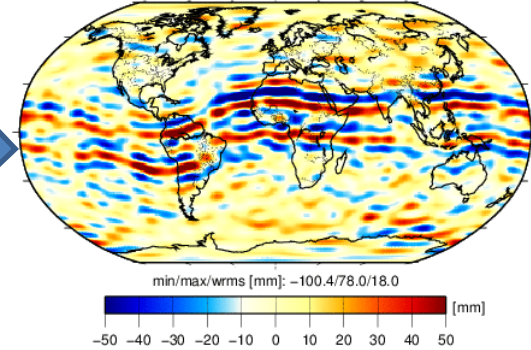
GSWARM\_GF\_SABC\_AIUB\_2015-03\_01\_AIUB



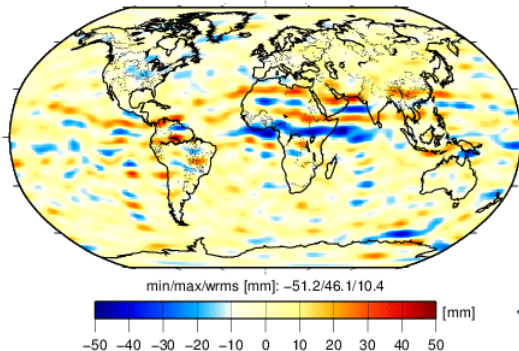
Combination Service of  
Time-variable Gravity  
Field Solutions (COST-G)



GSWARM\_GF\_SABC\_ASU\_2015-03\_01\_TUD



GSWARM\_GF\_SABC\_IFG\_2015-03\_03\_IFG



For Swarm

- Operational continuation is already running
- Will be funded by Swarm/DISC for two more years



funded by contract SD-ITT-1.1,  
part of contract 000109587/13/I-NB



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# Permanent Components of COST-G

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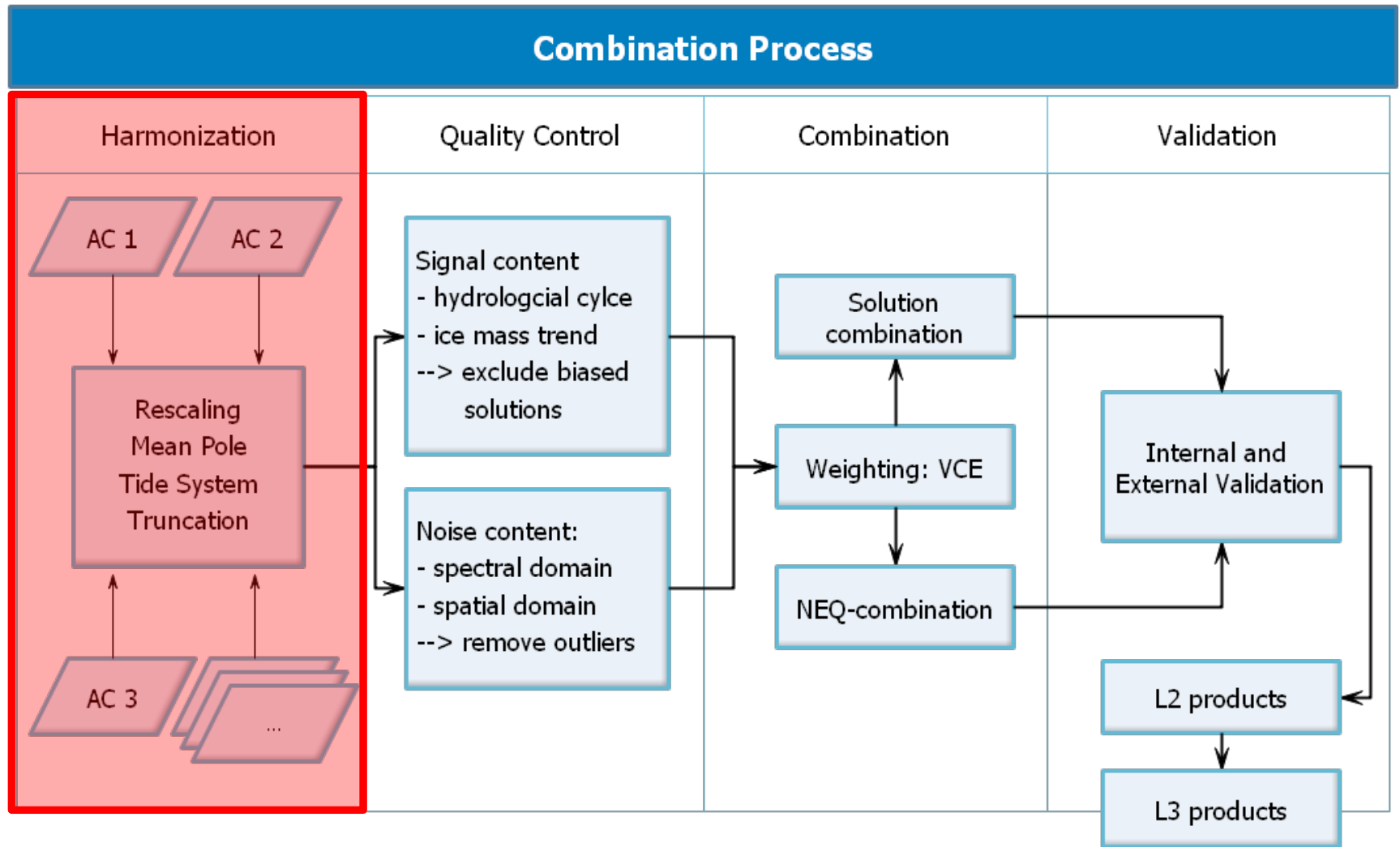
COST-G accomplishes its objectives through the following permanent components and roles:

- **Central Bureau (CB) & Analysis Center Coordinator (ACC)**
  - AIUB
- **Analysis Centers (ACs)**
  - AIUB, CNES, GFZ, TUG
- **Level-3 Center (L3C)**
  - GFZ
- **Validation Centers (VCs)**
  - GRGS, GFZ
- **Product Evaluation Group (PEG)**
  - A. Eicker, A. Groh, L. Longuevergne, B. Meyssignac

**COST-G is very open for additional contributors**

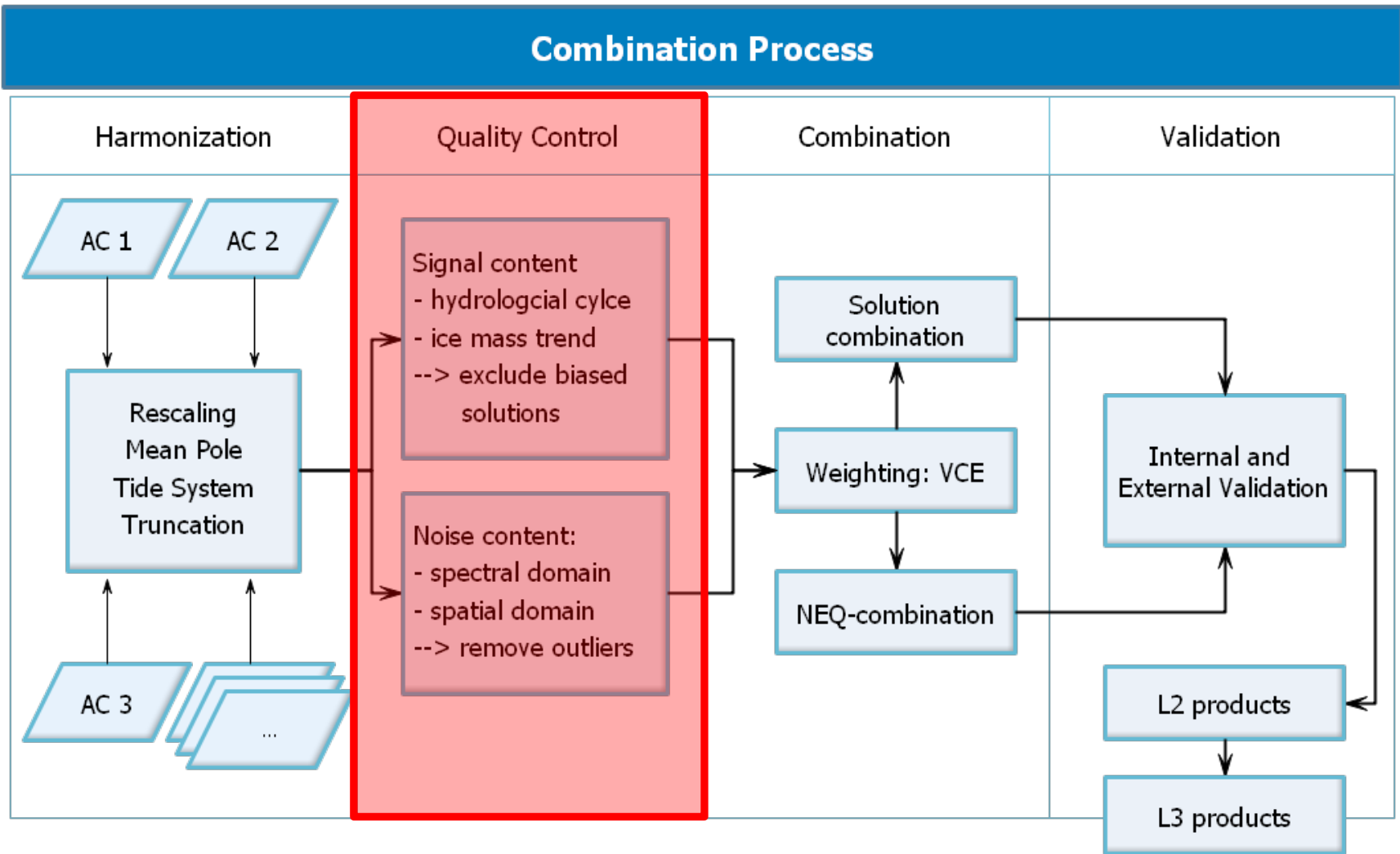


# COST-G Workflow





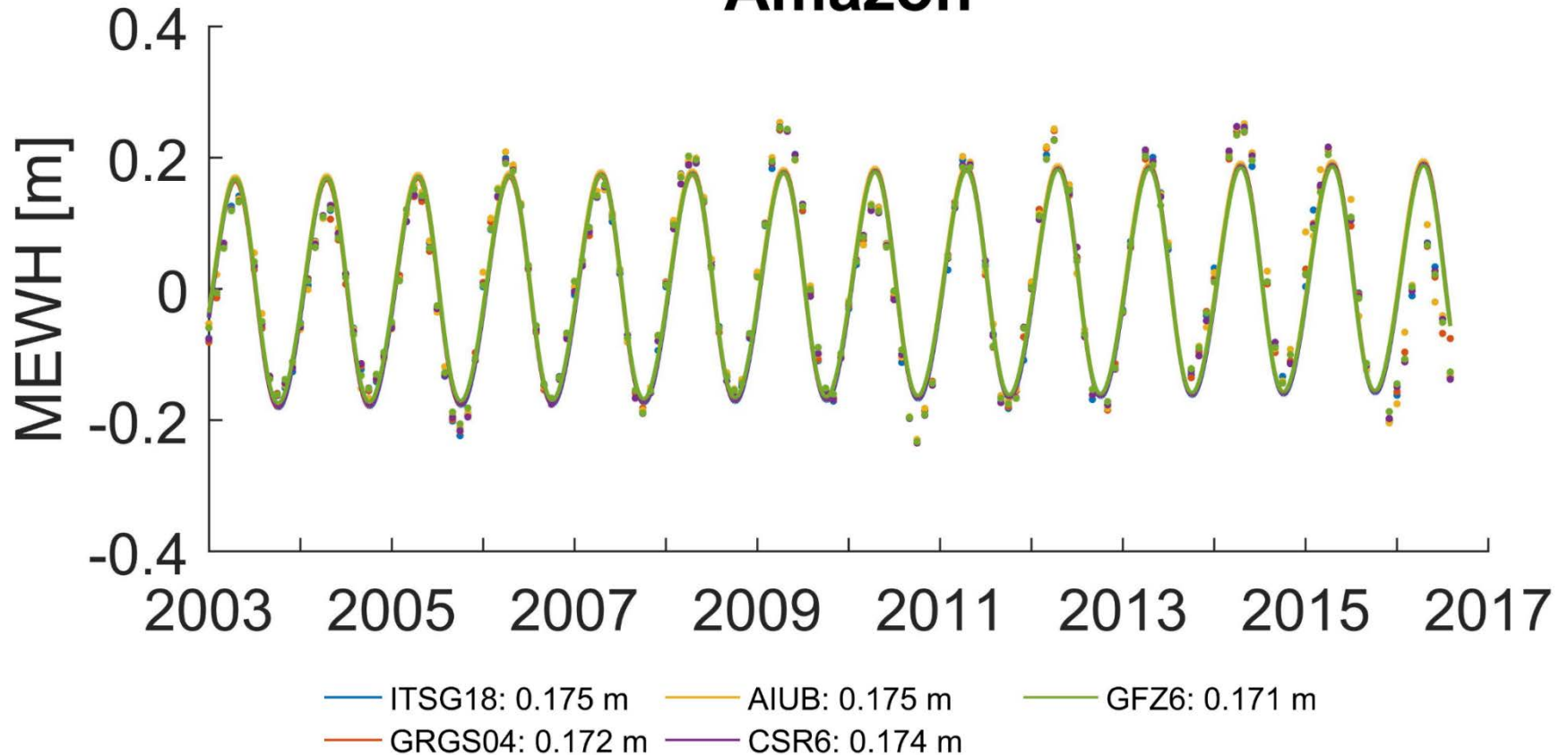
# Quality Control





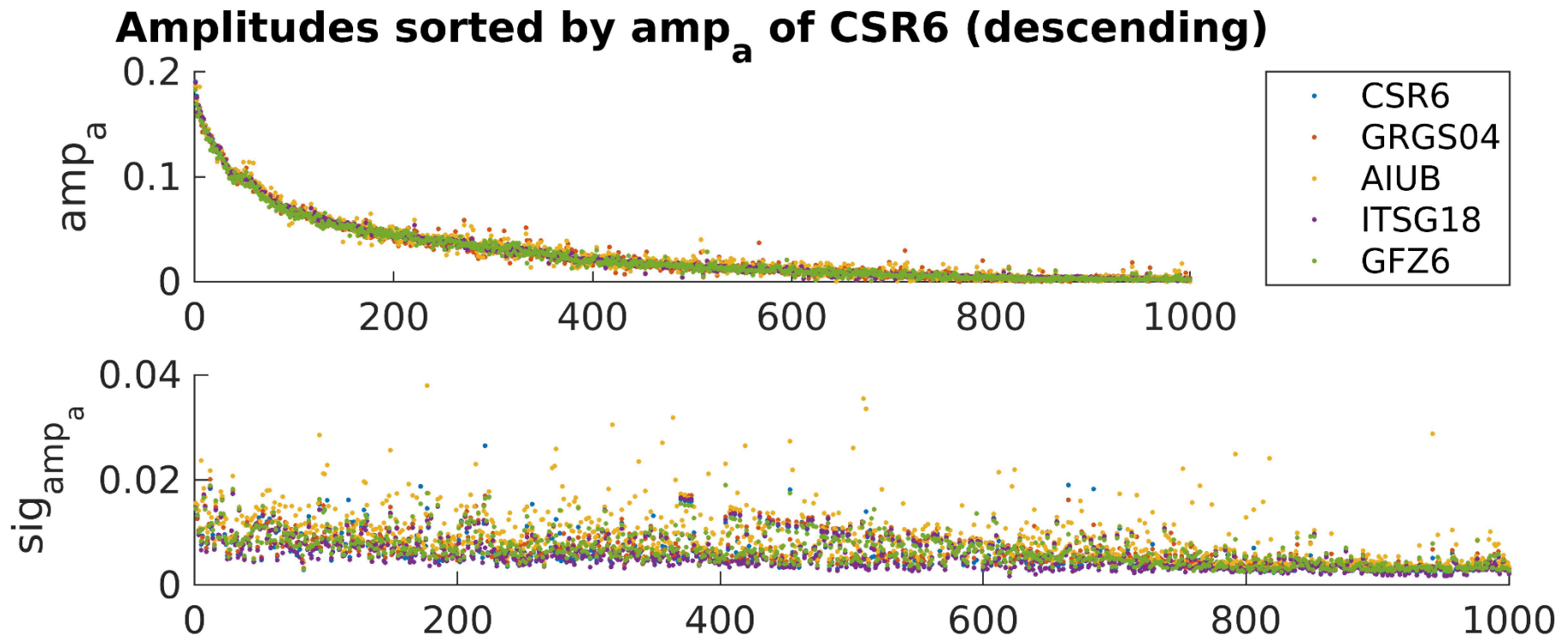
# Quality Control – Signal Content (Hydrology)

## Amazon



**Example: amplitude of seasonal variations in Amazon river basin.**

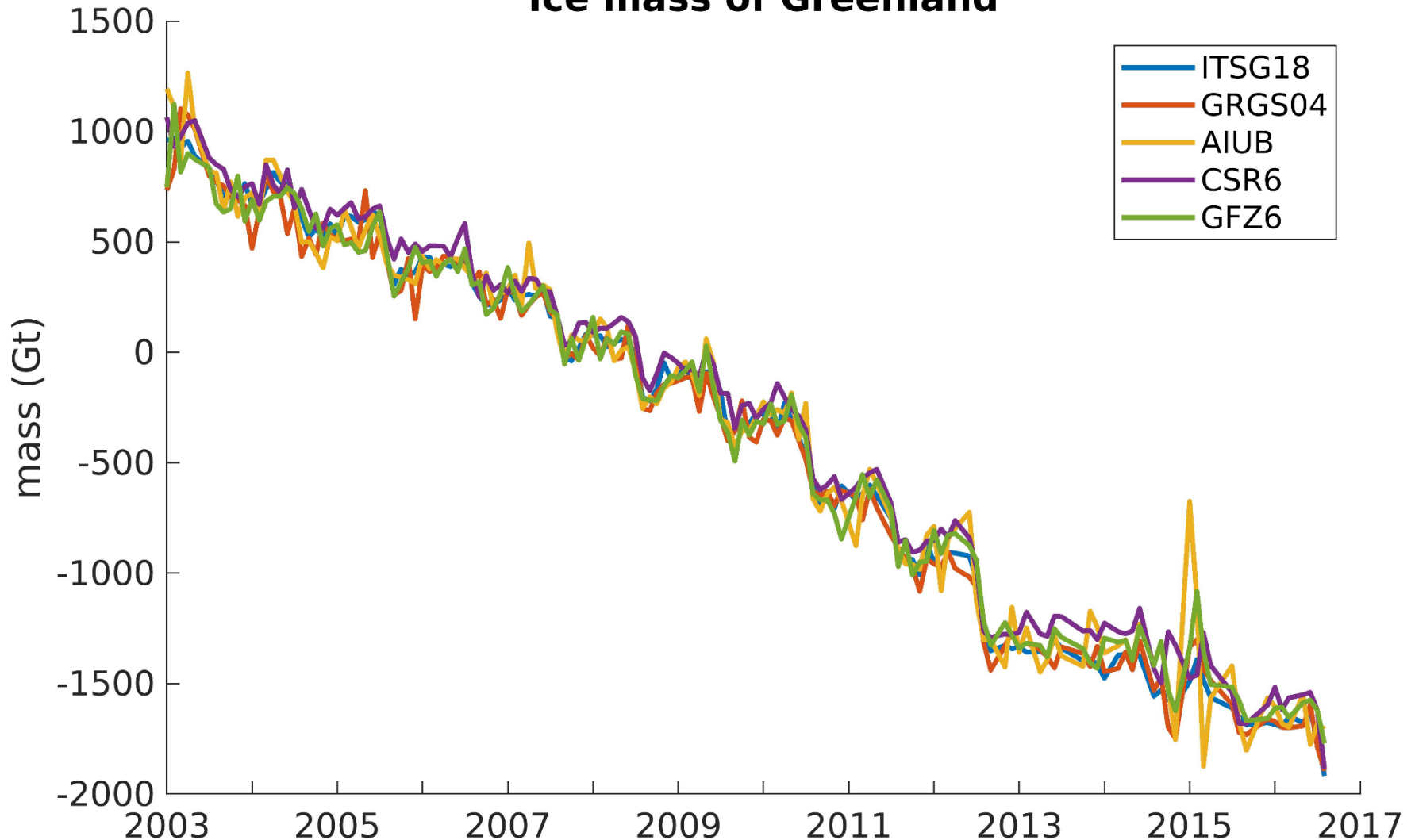
# Quality Control – Signal Content (Hydrology)



Amplitude of seasonal variations and formal errors of amplitudes in major river basins. No systematic signal attenuation in any of the contributing gravity field time-series can be observed.

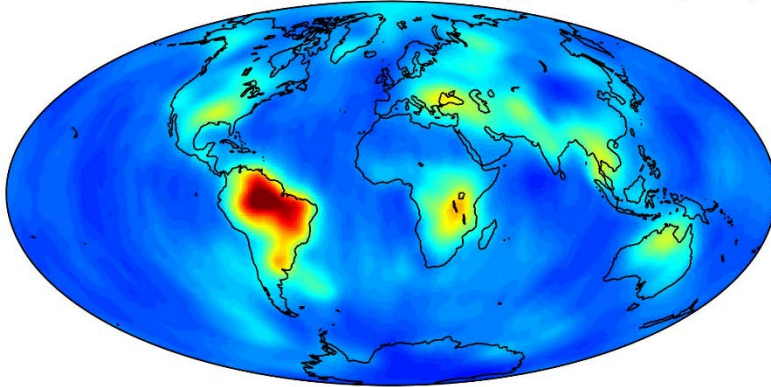
# Quality Control – Signal Content (Ice Mass Loss)

**Ice mass of Greenland**

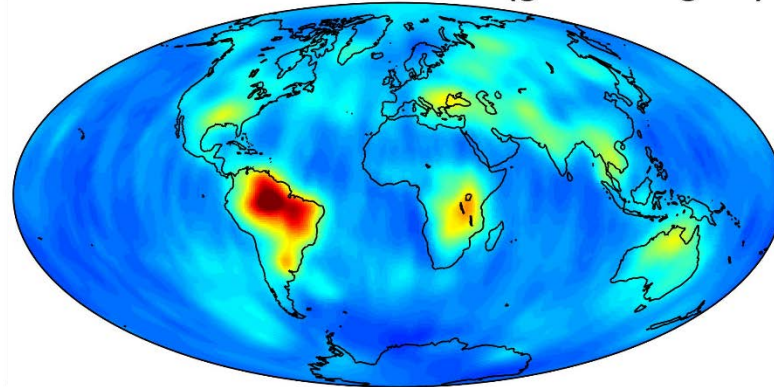


# Quality Control – Noise Levels

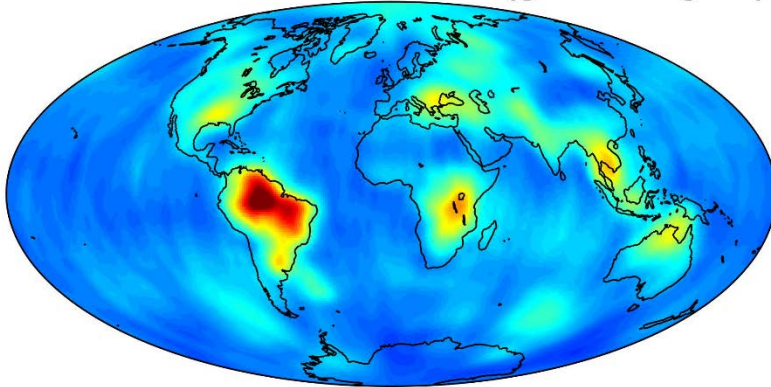
RMS of anomalies of CSR6 (geoid heights)



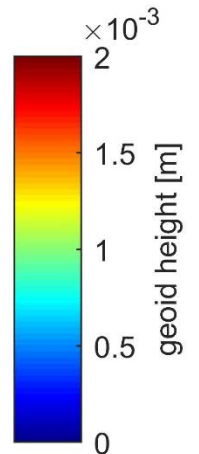
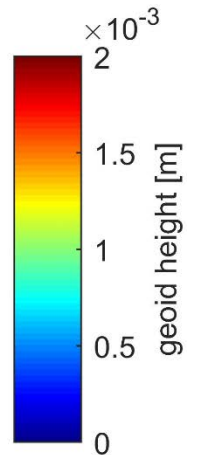
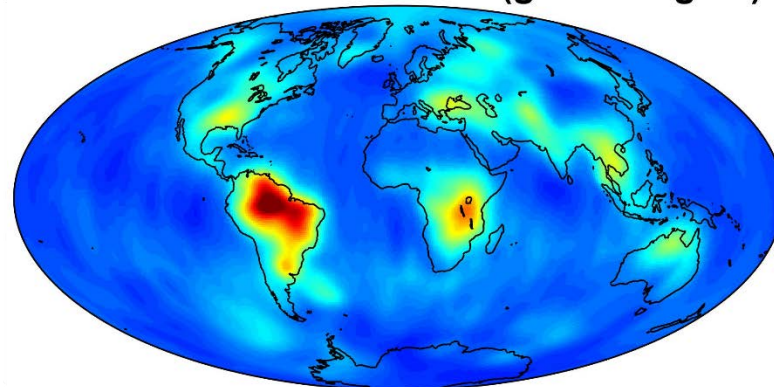
RMS of anomalies of GFZ6 (geoid heights)



RMS of anomalies of GRGS (geoid heights)



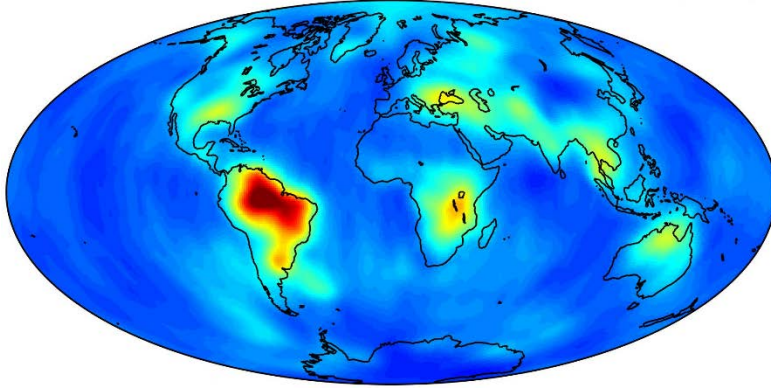
RMS of anomalies of ITSG (geoid heights)



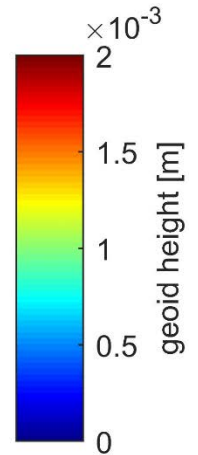
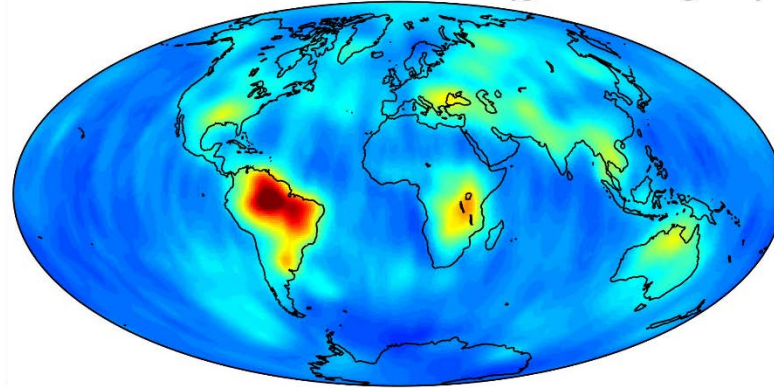


# Quality Control – Noise Levels

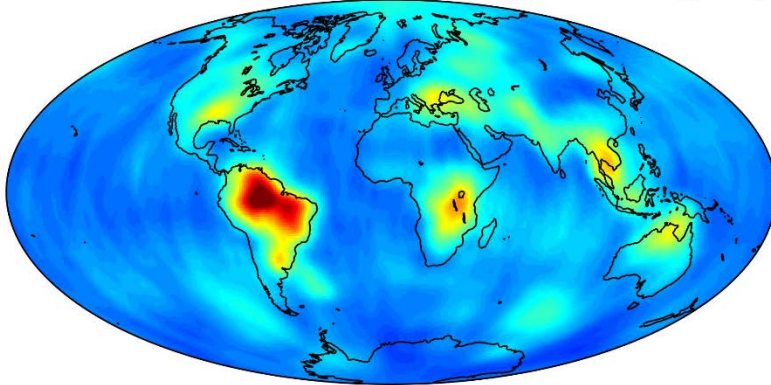
RMS of anomalies of CSR6 (geoid heights)



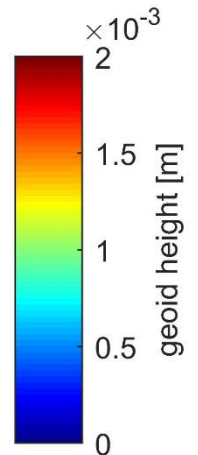
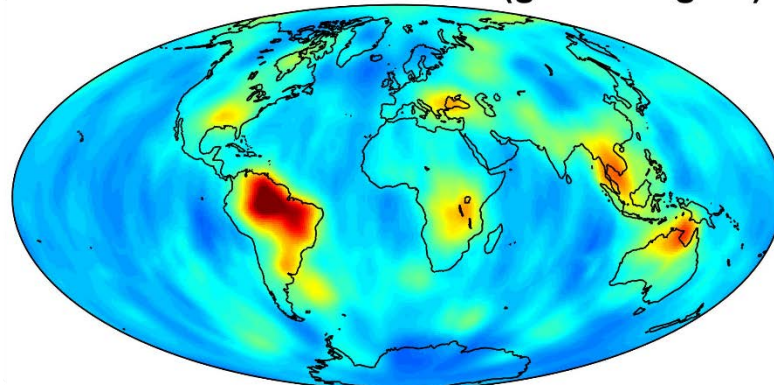
RMS of anomalies of GFZ6 (geoid heights)



RMS of anomalies of GRGS (geoid heights)

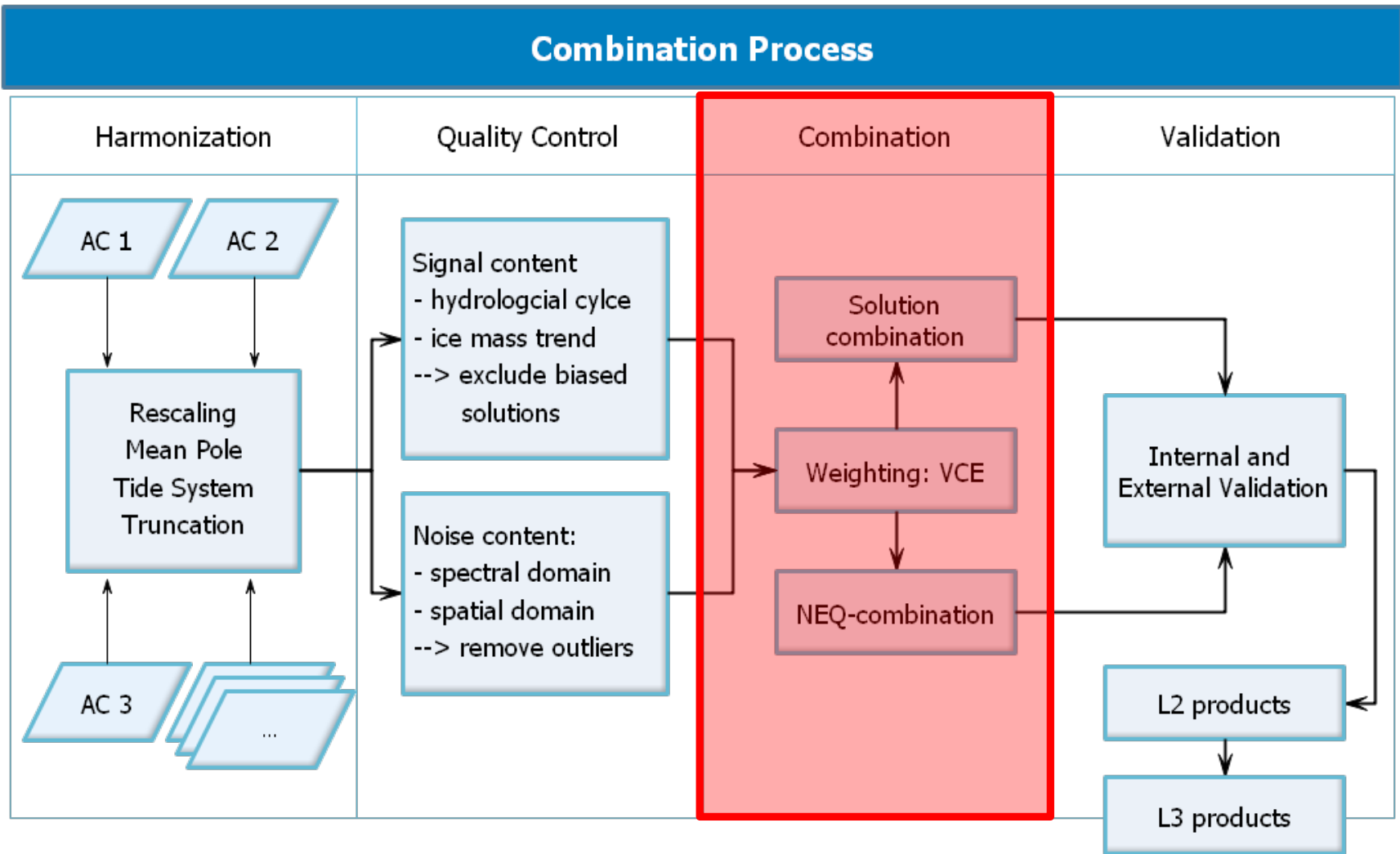


RMS of anomalies of AIUB (geoid heights)



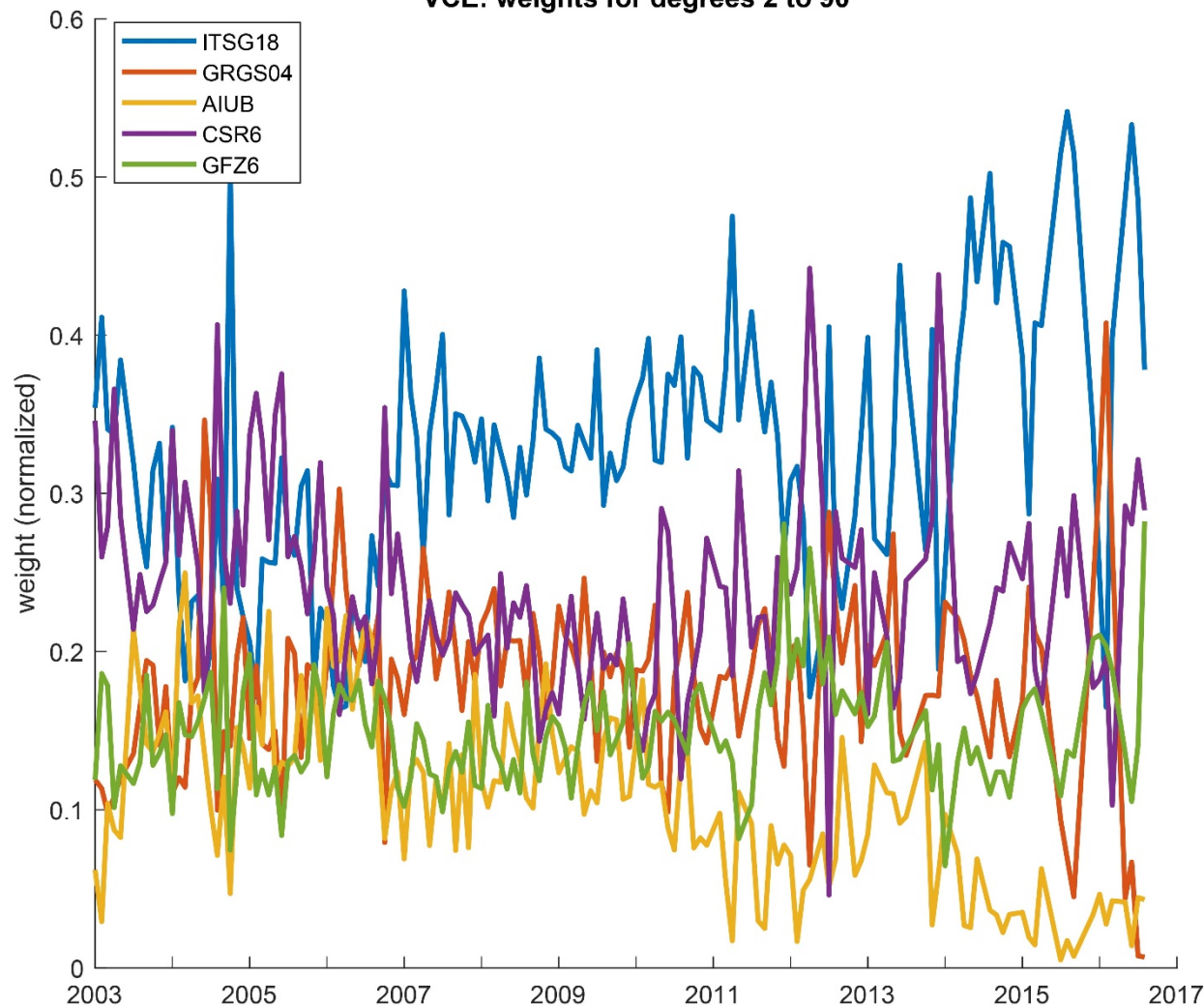
AIUB contribution is still based on L1B-RL02 and AOD1B-RL05.

# COST-G – Combination



# Combination

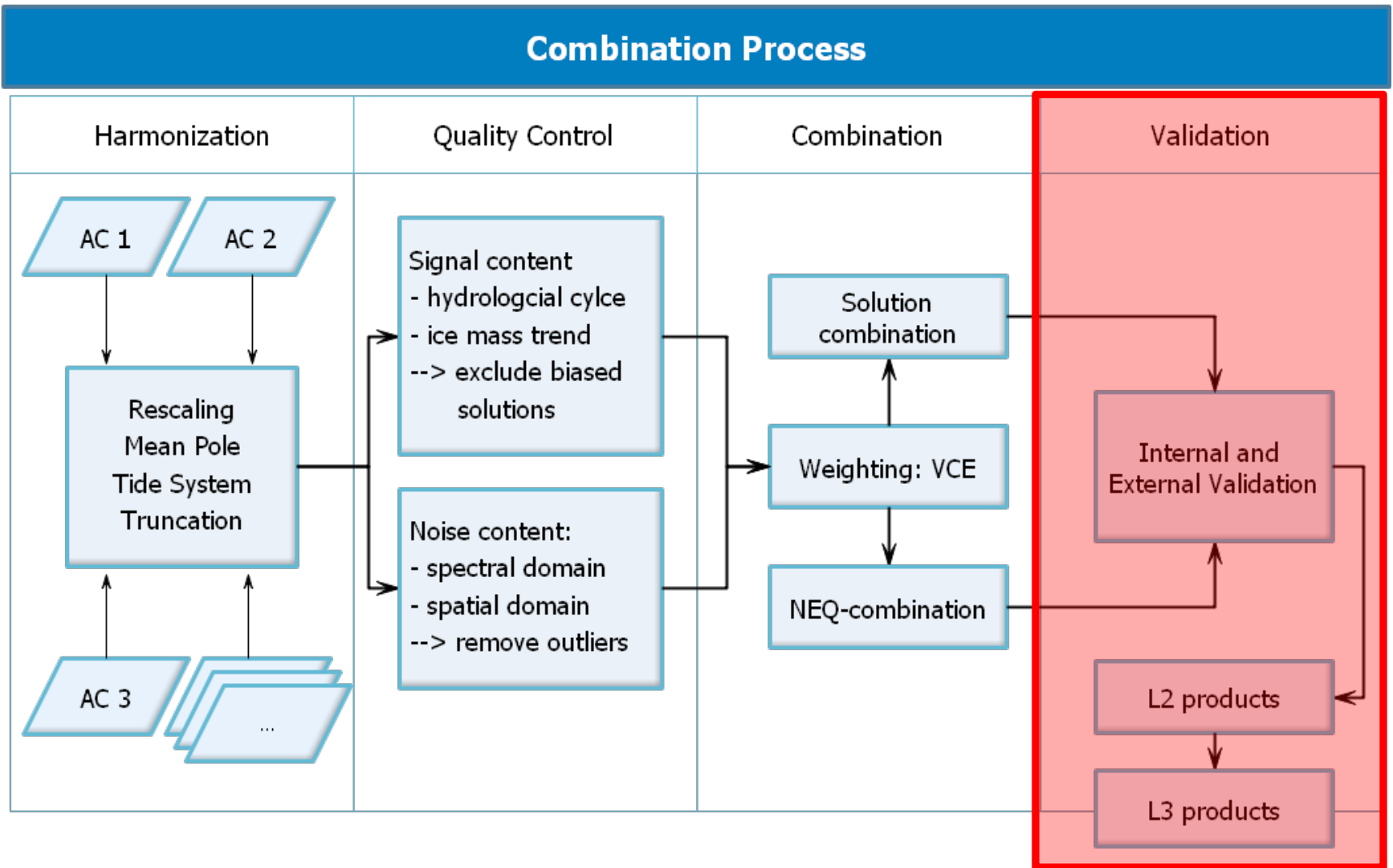
VCE: weights for degrees 2 to 90



**COST-G RL01 has been combined on the solution level iteratively applying variance component estimation.**

**The relative weights determined by VCE can directly be interpreted as quality indicators, they are inversely proportional to the noise levels of the individual contributions.**

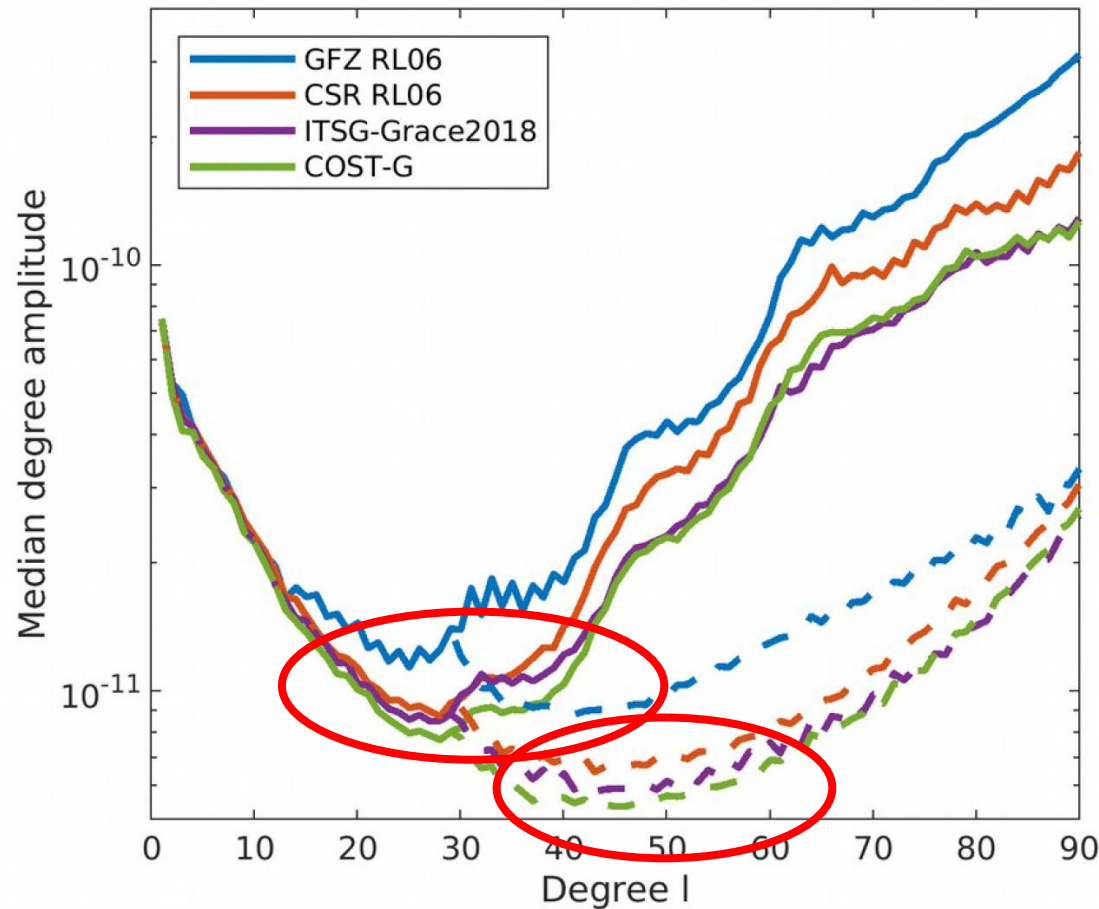
# COST-G – Validation





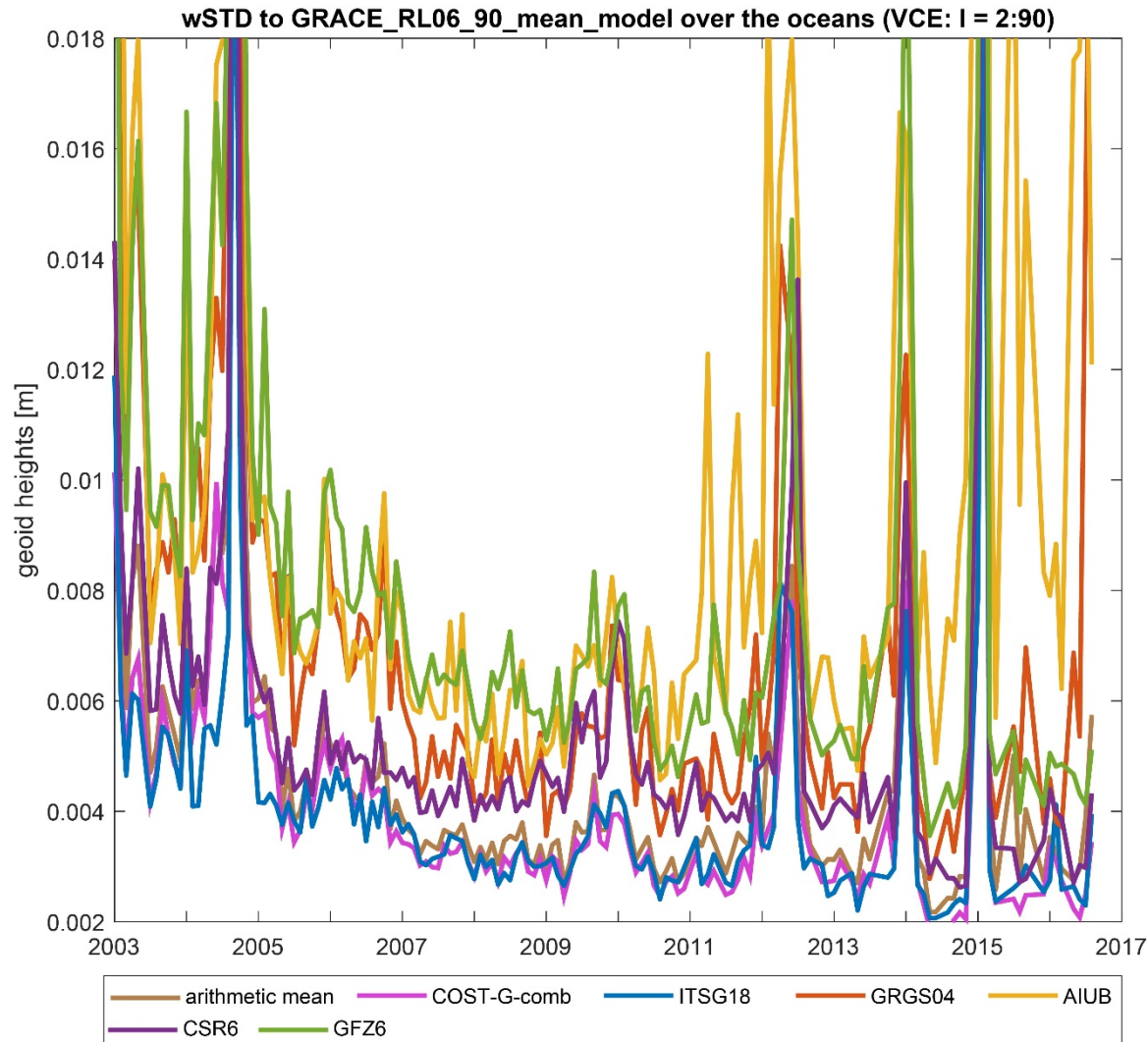
# Internal Validation: spherical harmonics domain

- Median degree amplitudes of anomalies wrt a linear and seasonal model (no filtering applied)



The main gain of the combination is in the range of degrees 15-45.

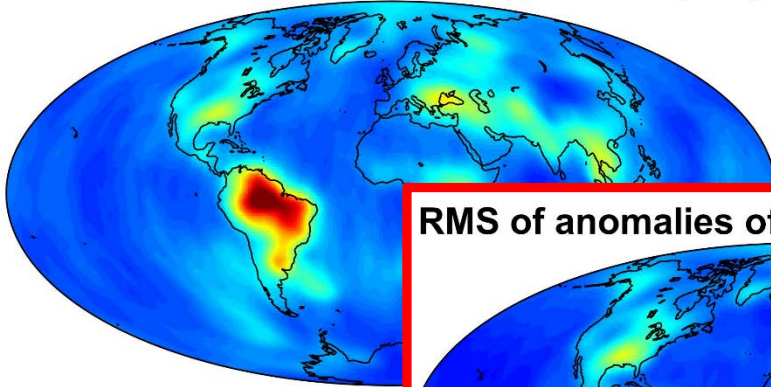
# Internal Validation: spatial domain



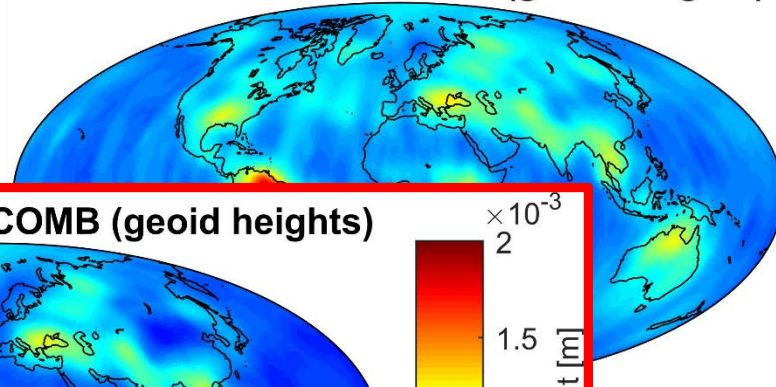
For internal validation the noise content of the individual and the combined gravity fields is assessed by their non-secular, non-seasonal variability over the oceans.

# Internal Validation: spatial domain

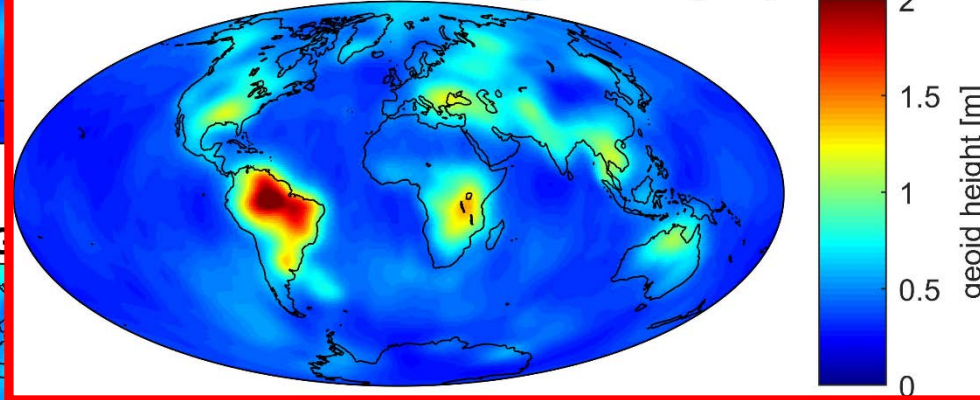
RMS of anomalies of CSR6 (geoid heights)



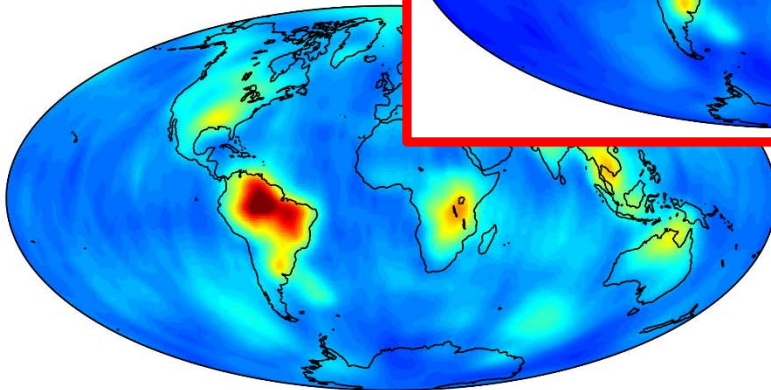
RMS of anomalies of GFZ6 (geoid heights)



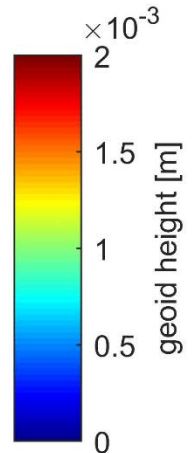
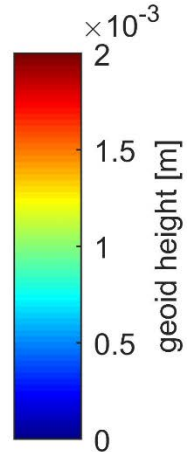
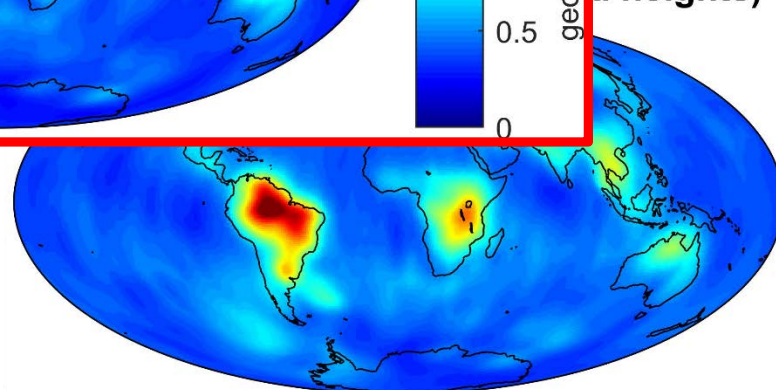
RMS of anomalies of COMB (geoid heights)



RMS of anomalies of COMB (geoid heights)



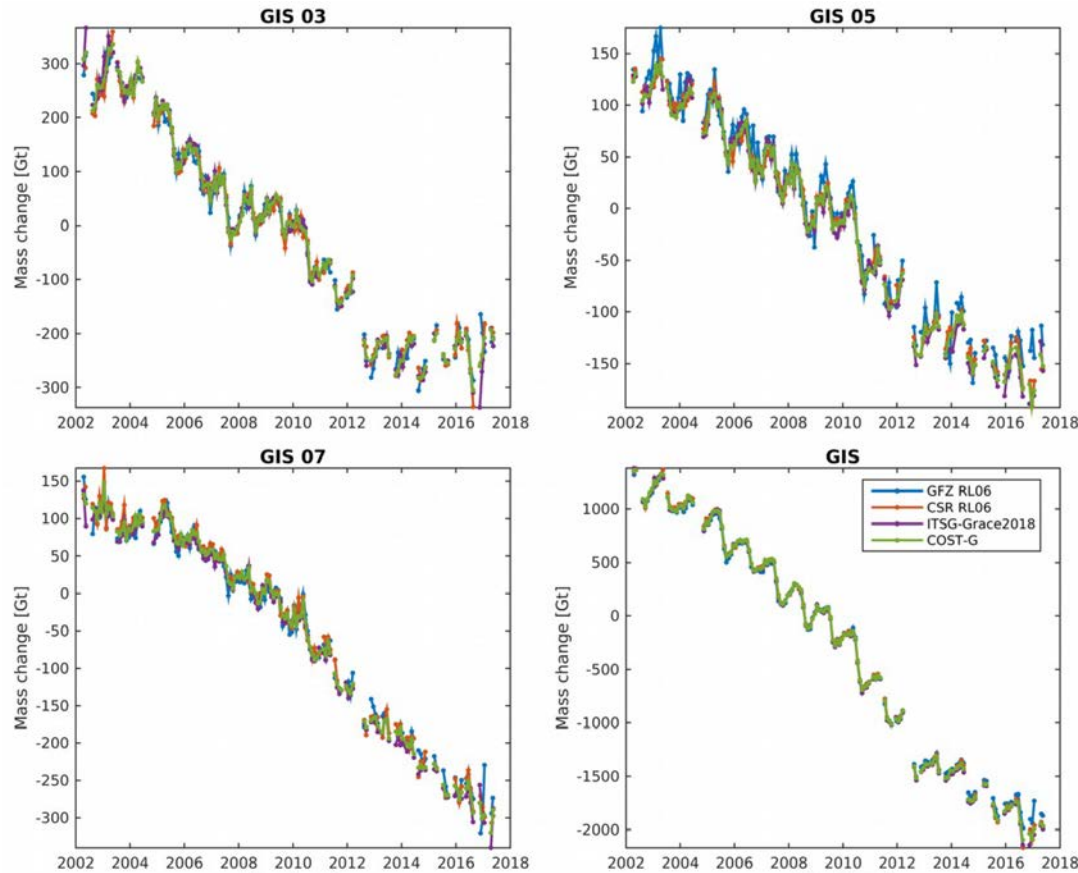
RMS of anomalies of COMB (geoid heights)





# Basin-Averaged GIS Mass Changes

- Basin-integrated AIS/GIS mass changes based on the sensitivity kernel approach by TU Dresden

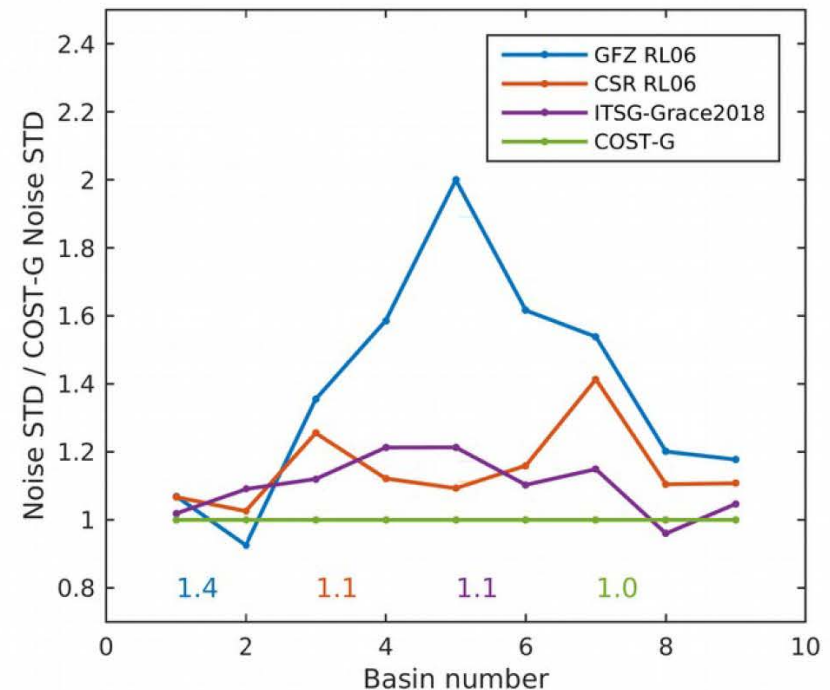
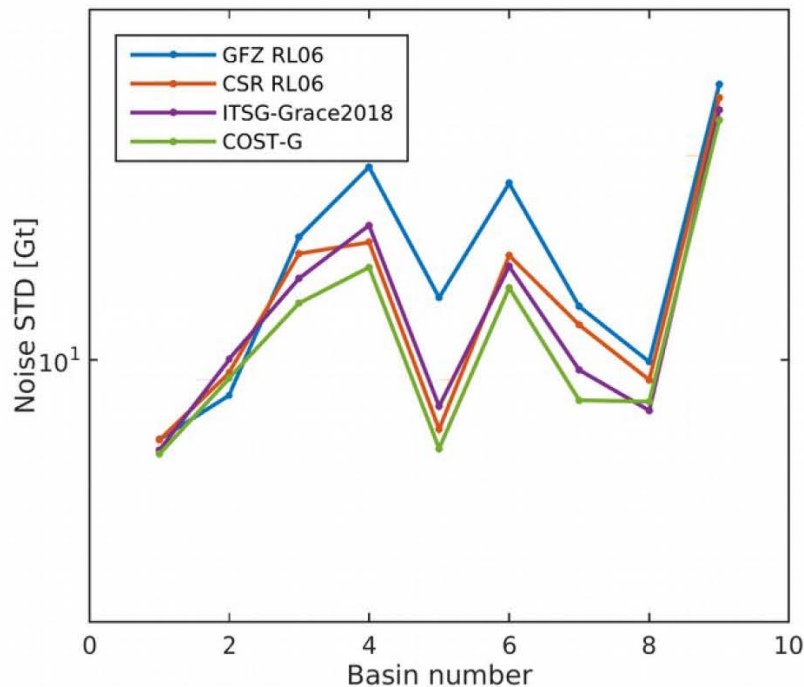


**Trends agree  
fairly well for  
the Greenland  
Ice Sheet**

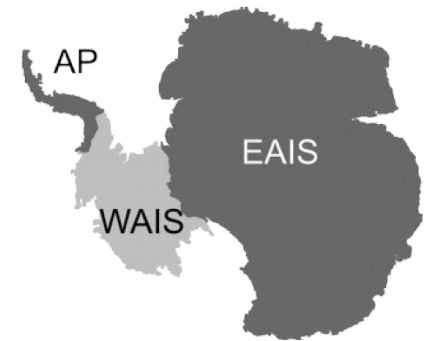
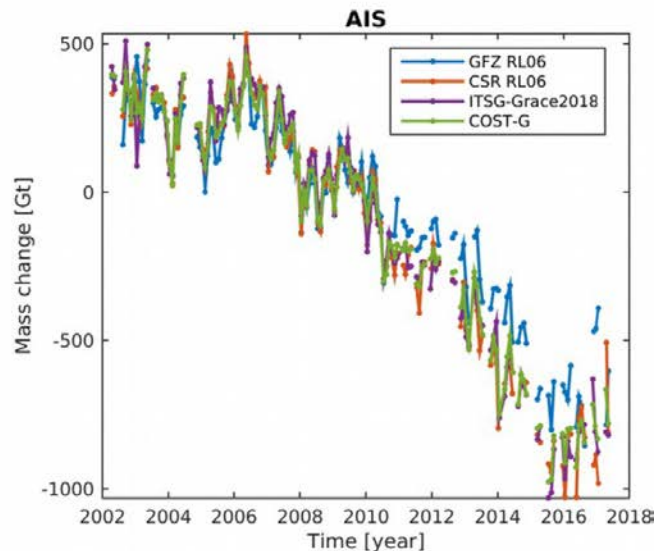
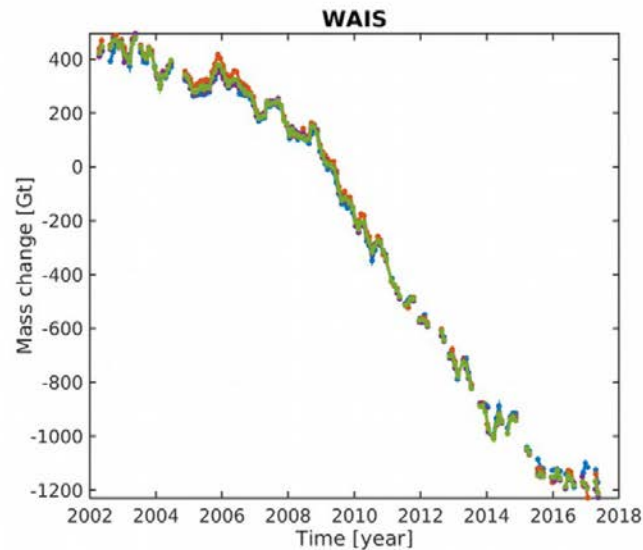
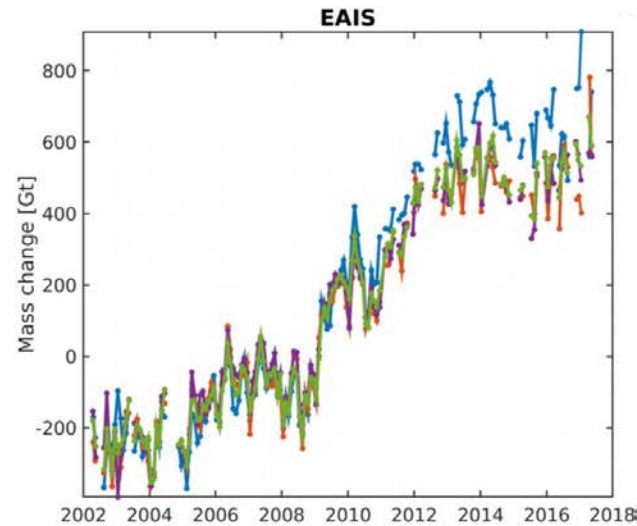
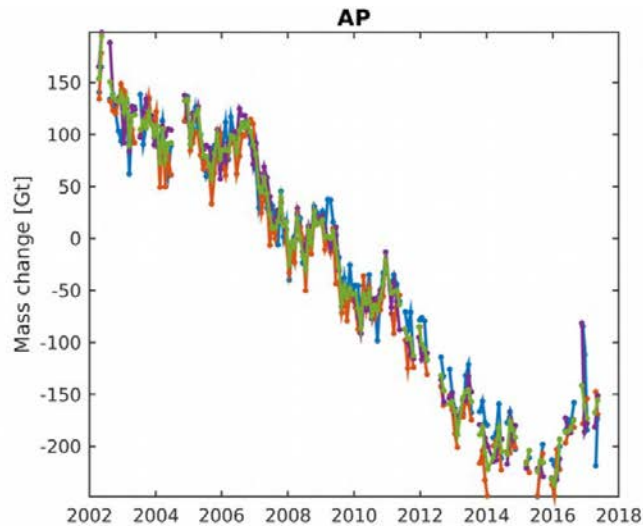


# Basin-Averaged GIS Mass Changes

- Noise measure for each basin time series and ratio to the noise measure of the COST-G time series (numbers indicate the median of all basin ratios). Basin 9 denotes the entire GIS.



# Basin-Averaged AIS Mass Changes

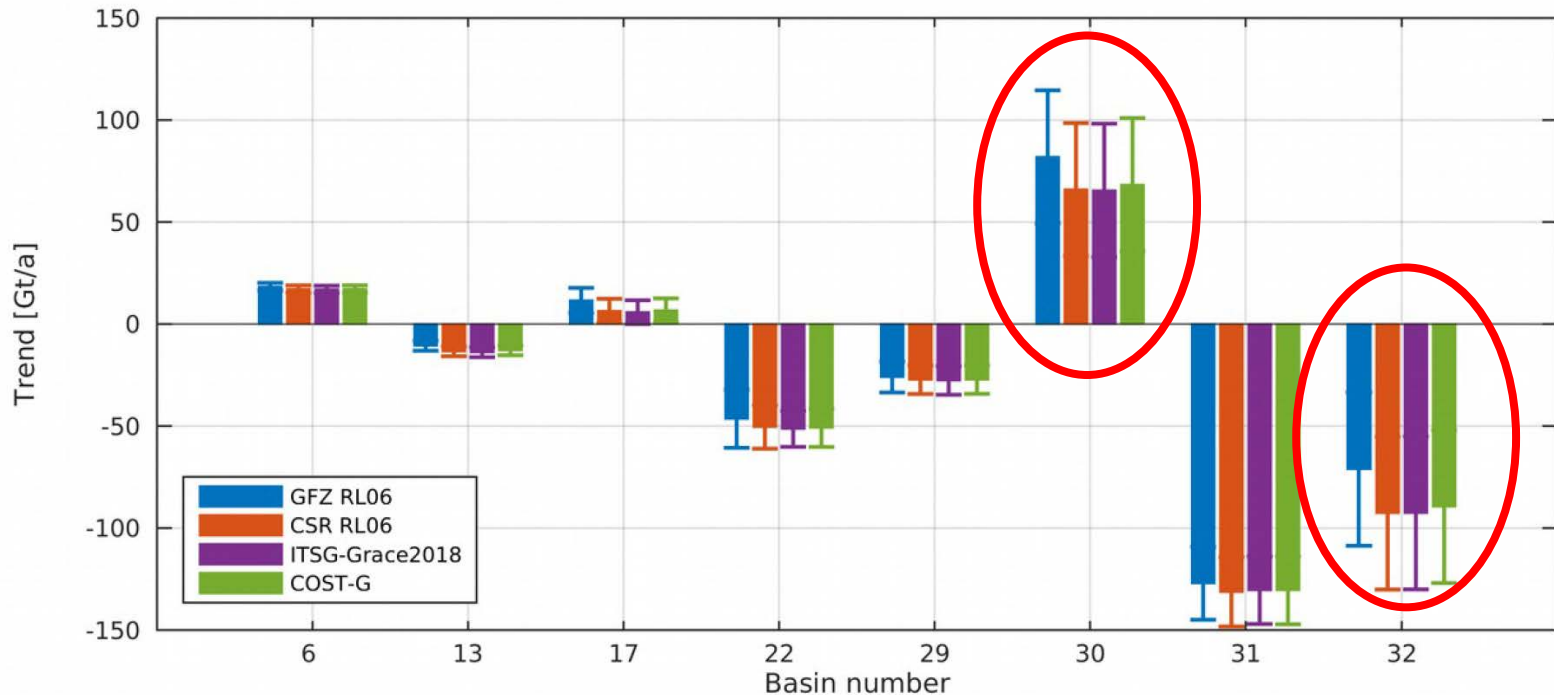
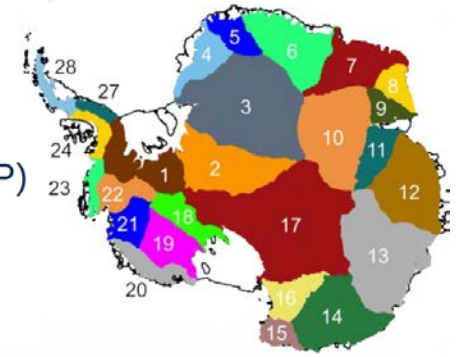


**Larger trend  
differences for  
Antarctic Ice Sheet**

# Basin-Averaged AIS Mass Changes

- Trends from GFZ seem to be different for East Antarctica. Influence on COST-G products may be seen.

Basin numbers:  
29: Ant. Peninsula (AP)  
30: East Ant. (EAIS)  
31: West Ant. (WAIS)  
32: AIS



# Comparison to Altimetry

**SIGNAL ASSESSMENT** → Comparison to Altimetry. Presently, two test areas for the signal assessment have been selected: **the Caspian sea and the Black sea**. Correlation coefficient with altimetry over the Caspian Sea: the COST-G solution presents a slight improvement over the TUGRAZ and CSR solutions.

Correlation w. ALT	COST-G	TUGRAZ ITSG18	CSR RL06
DDK5 filter	97.2 %	97.0 %	96.9 %
DDK6 filter	96.6 %	96.5 %	96.3 %

**Method:** *The time series of the TVG solutions are compared with the time series of altimetric heights (from Hydroweb for the Caspian Sea or AVISO+ for the Black Sea). One bias (irrelevant) and one scale factor are adjusted. The criteria are the **scale factor** and **correlation coefficients**. Both should be as close as possible to 1.*



# Orbit Tests with GOCE

- GRACE solutions up to d/o 90 filled up with DIR-6 up to d/o 240:
  - Table shows RMS of orbit fits (cm) for the different test cases (3D residuals, mean values from the 30 individual arcs in question)

Gravity model	Month			
	2009/11	2009/12	2010/10	2010/11
GFZ_RL06	<b>7,38</b>	<b>6,84</b>	<b>6,23</b>	<b>6,18</b>
AIUB_RL02	<b>8,69</b>	<b>8,56</b>	<b>7,39</b>	<b>7,21</b>
CSR_RL06	<b>6,88</b>	<b>9,09</b>	<b>6,65</b>	<b>6,20</b>
GRGS_RL04f	<b>5,88</b>	<b>7,30</b>	<b>5,47</b>	<b>5,83</b>
ITSG_2018_tide_free	<b>5,51</b>	<b>5,12</b>	<b>4,19</b>	<b>4,54</b>
COSTG_RL01	<b>5,03</b>	<b>5,54</b>	<b>4,52</b>	<b>4,72</b>

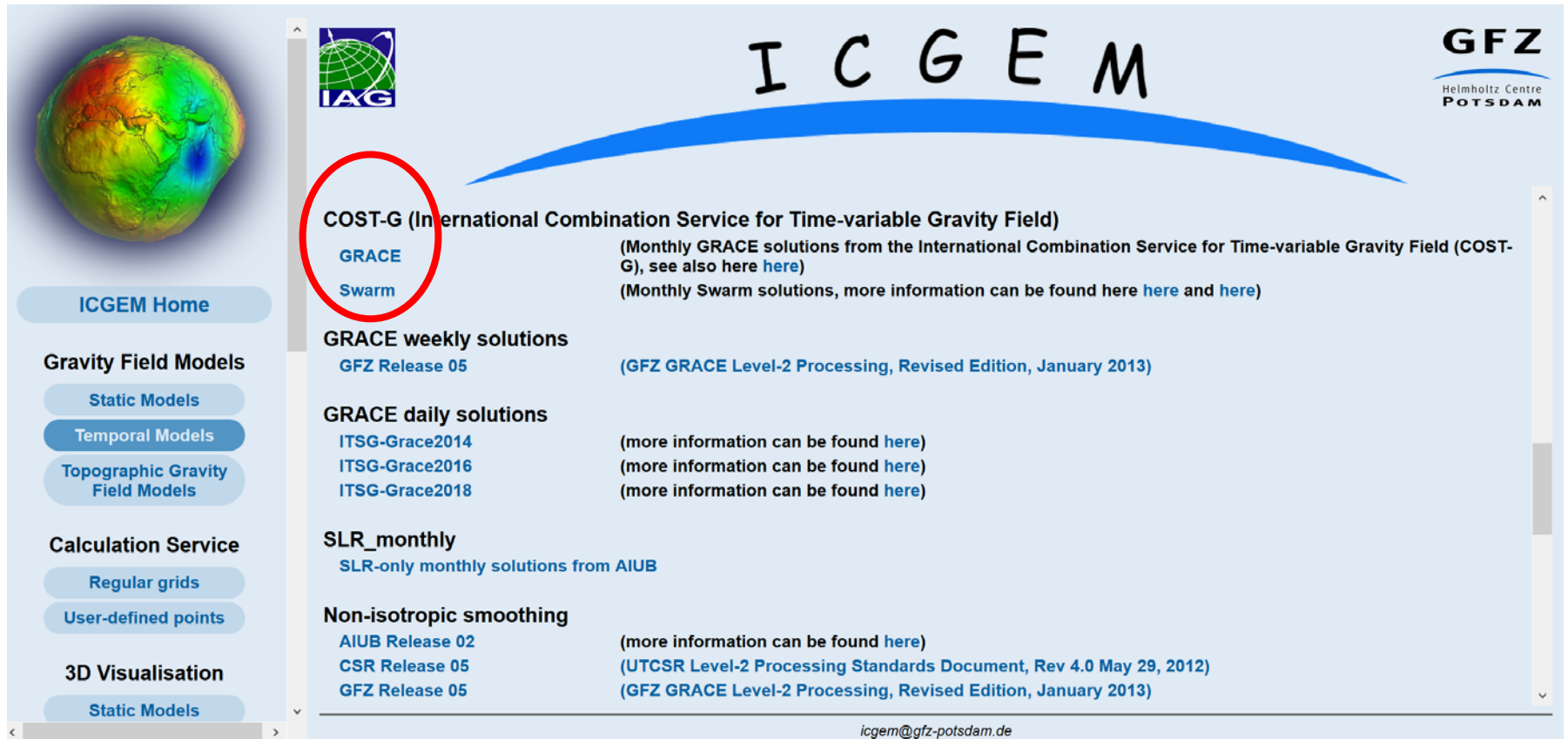
- Good quality for COST-G, but not yet best for all months.

# Product Availability

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- **Monthly combined GRACE gravity field models:**
  - from Apr. 2002 to Jun. 2017 available at ICGEM
  - [http://icgem.gfz-potsdam.de/series/03\\_COST-G/GRACE](http://icgem.gfz-potsdam.de/series/03_COST-G/GRACE)
- **Monthly combined Swarm gravity field models:**
  - from Dec. 2013 to Mar. 2019 available at ICGEM
  - [http://icgem.gfz-potsdam.de/series/03\\_COST-G/Swarm](http://icgem.gfz-potsdam.de/series/03_COST-G/Swarm)

# Product Availability



The screenshot displays the ICGEM (International Combination Service for Time-variable Gravity Field) website. The header features the IAG logo, the ICGEM acronym in large letters, and the GFZ Helmholtz Centre Potsdam logo. A sidebar on the left contains navigation links: ICGEM Home, Gravity Field Models (Static Models, Temporal Models, Topographic Gravity Field Models), Calculation Service (Regular grids, User-defined points), and 3D Visualisation (Static Models). The main content area lists various products and services:

- COST-G (International Combination Service for Time-variable Gravity Field)**
  - GRACE** (Monthly GRACE solutions from the International Combination Service for Time-variable Gravity Field (COST-G), see also here [here](#))
  - Swarm** (Monthly Swarm solutions, more information can be found here [here](#) and [here](#))
- GRACE weekly solutions**
  - GFZ Release 05 ([GFZ GRACE Level-2 Processing, Revised Edition, January 2013](#))
- GRACE daily solutions**
  - ITSG-Grace2014 (more information can be found [here](#))
  - ITSG-Grace2016 (more information can be found [here](#))
  - ITSG-Grace2018 (more information can be found [here](#))
- SLR\_monthly**
  - SLR-only monthly solutions from AIUB
- Non-isotropic smoothing**
  - AIUB Release 02 (more information can be found [here](#))
  - CSR Release 05 ([UTCSR Level-2 Processing Standards Document, Rev 4.0 May 29, 2012](#))
  - GFZ Release 05 ([GFZ GRACE Level-2 Processing, Revised Edition, January 2013](#))

The email address [icgem@gfz-potsdam.de](mailto:icgem@gfz-potsdam.de) is visible at the bottom right of the page.



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# Summary and Outlook

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- **COST-G RL01 Level-2 products for GRACE and Swarm are available on ICGEM**
- **COST-G RL01 Level-3 products for GRACE will be made available soon on ISDC, GravIS**
- **Status of CSR and JPL in COST-G**
- **Inclusion of new candidate Analysis Centers**
- **Definition of further GRACE releases and timeline for operational GRACE-FO combinations**
- **Next COST-G ISSI Team Meeting: 13 – 17 January 2020**





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**Thanks a lot for your attention!**

**Visit us on <https://cost-g.org/>**



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