COST-G

Combination Service for Time-variable Gravity Models

Combination Service for Time-variable Gravity Fields (COST-G) – operations

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[3]Graz University of Technology, Austria
[4]Centre National d'Etudes Spatiales, France
[5]Stellar Space Studies, France
[6]Leibniz University Hannover, Germany
[7]Technical University of Dresden, German
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G3P

EGU 2020

G2.1 The Global Geodetic Observing System

UNIVERSITÄT BERN

GFZ Helmholtz Centre Potsdam

TU Graz Graz University of Technology

cnes

Leibniz Universität Hannover

TECHNISCHE UNIVERSITÄT DRESDEN

STELLAR SPACE STUDIES

HCU HafenCity Universität Hamburg

LEGOS

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- Introduction to COST-G
- Products of COST-G
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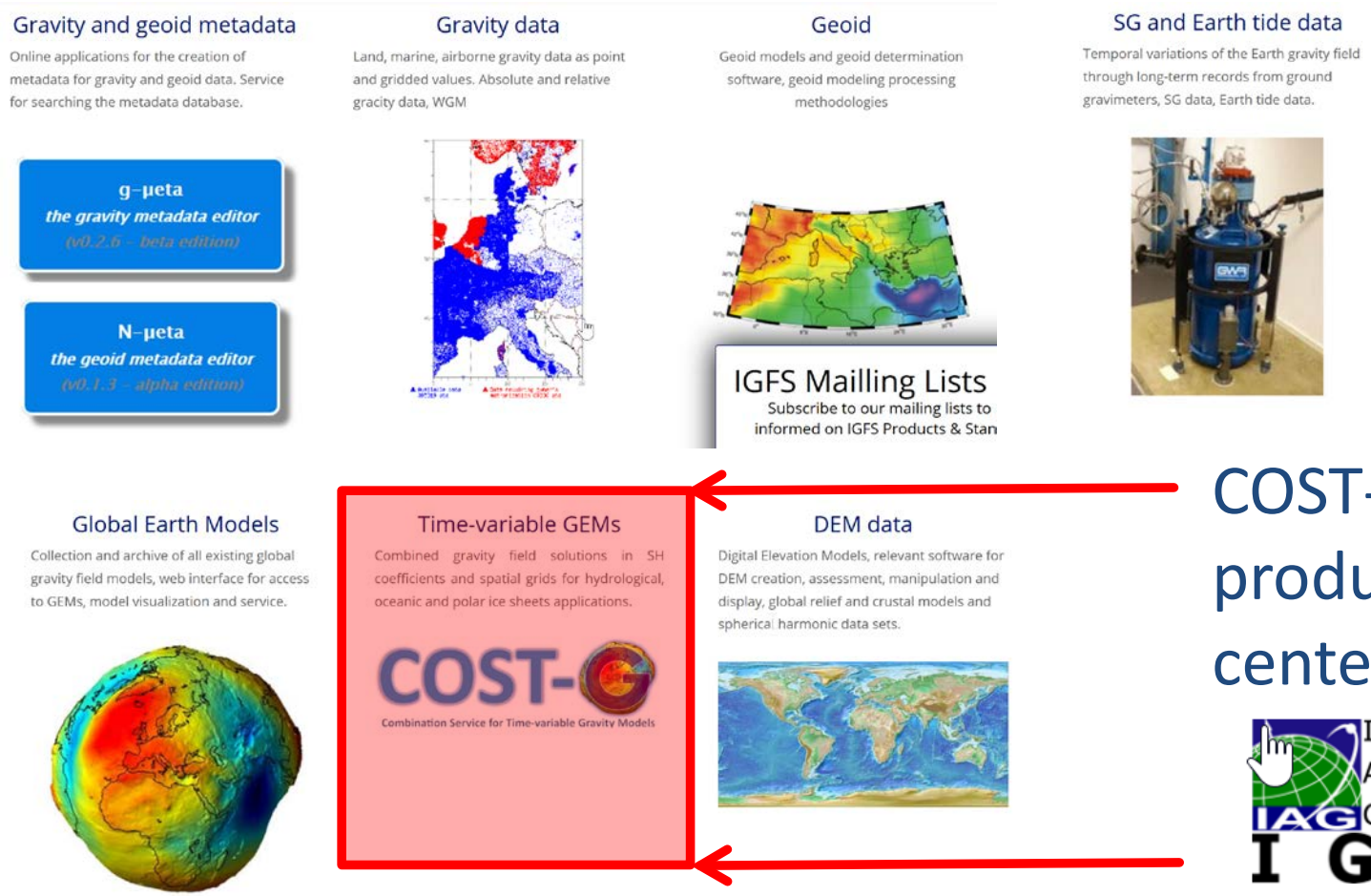
  - Combined Swarm gravity fields
- Components of COST-G
- COST-G workflow, exemplified by a prototype GRACE-FO combination:
  - Quality control (Noise/Signal content)
  - Combination applying variance component estimation
- External validation (COST-G GRACE RL01)

Introduction



COST-G is a product center of the International Association of Geodesy IAG IGFS

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

COST-G Website

Welcome to COST-G

The **I**nternational **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 activitities 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

March 18th 2020

COST-G standards and RL01 release notes are now available here!

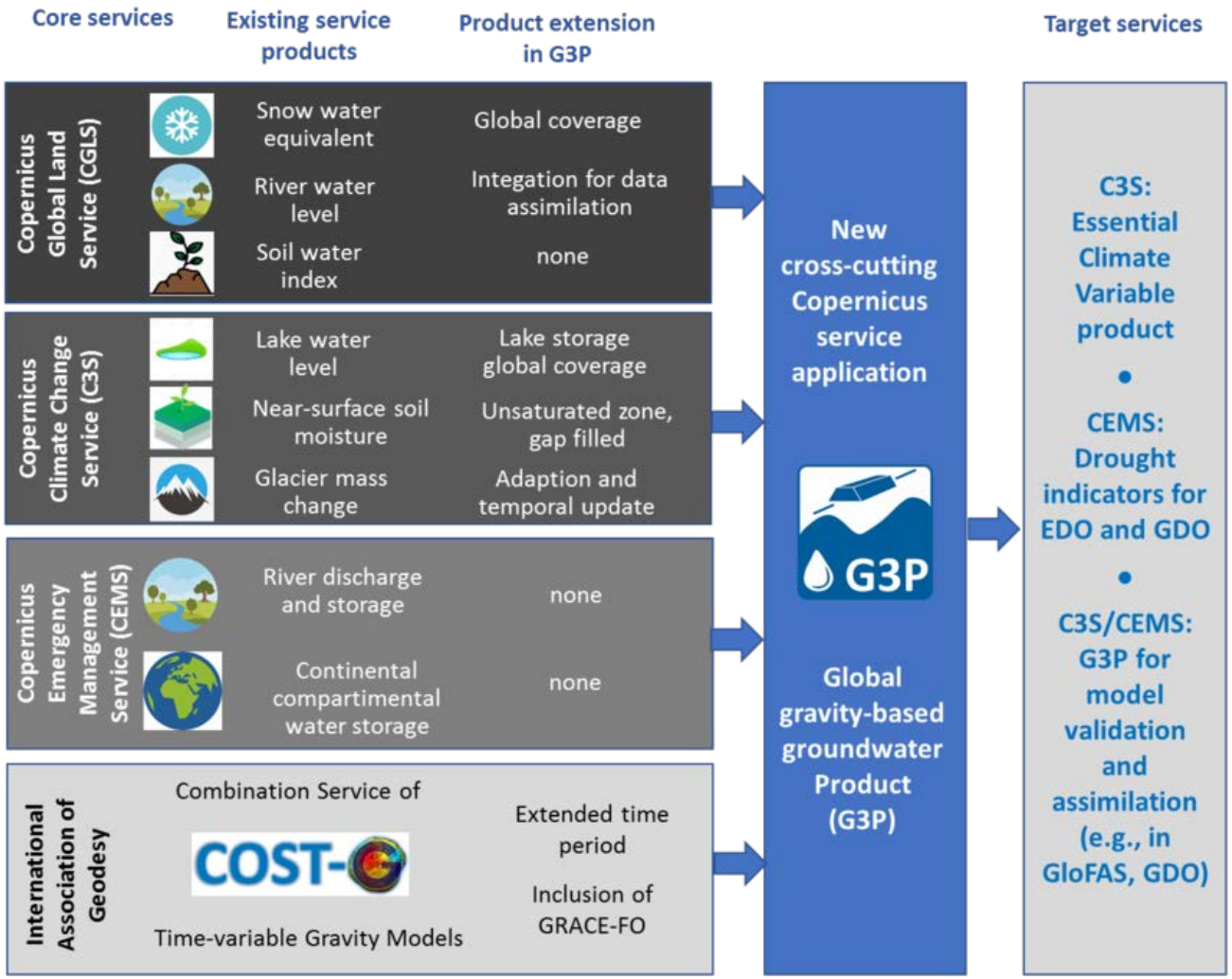
January 19th 2020

COST-G had its second ISSI team meeting in Bern, January 13-17. The Terms of References are available here.

July 14th 2019

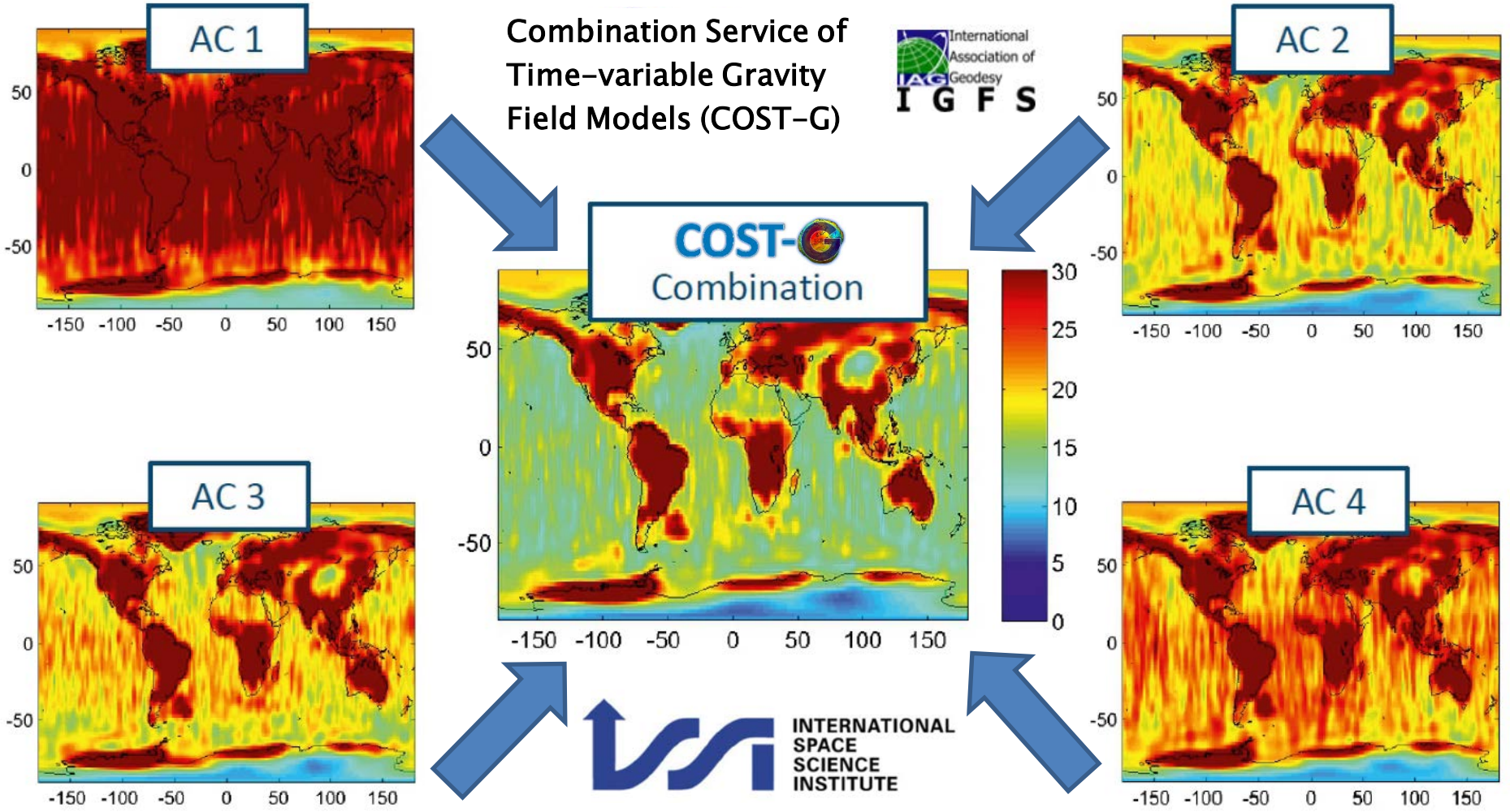
COST-G is officially launching at the occasion of the IUGG 2019 in Montreal!

COST-G and the H2020 G3P-project



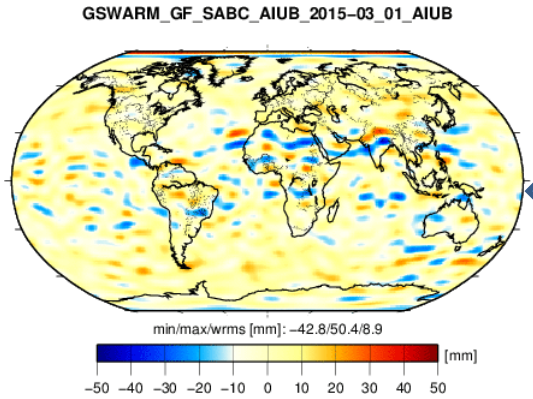
COST-G is further developed within the frame of the Horizon 2020 project: G3P - Global Gravity - based Groundwater Product

Products: Combined GRACE/GRACE-FO Gravity Fields



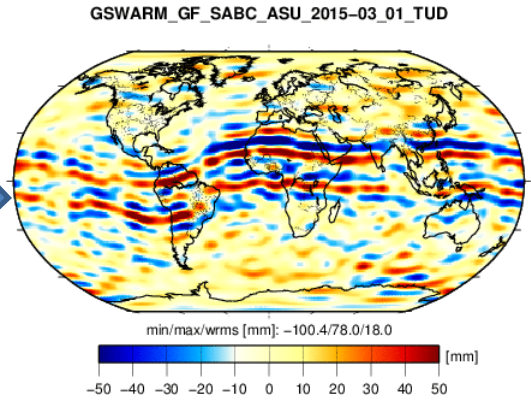
Improved and consolidated product integrating the strengths of all ACs

Products: Combined Swarm Gravity Fields

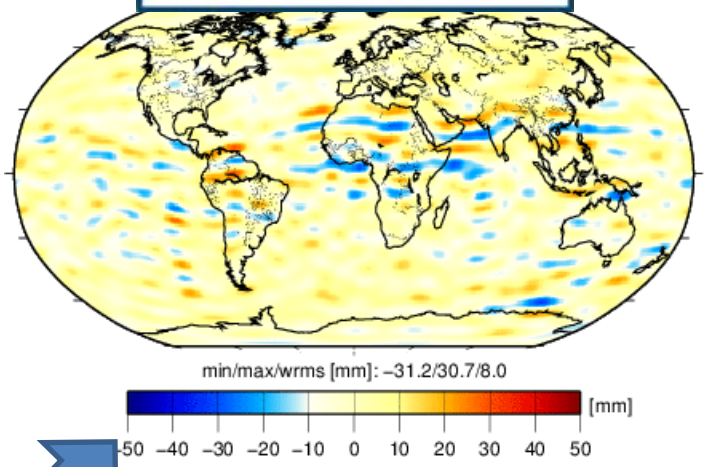


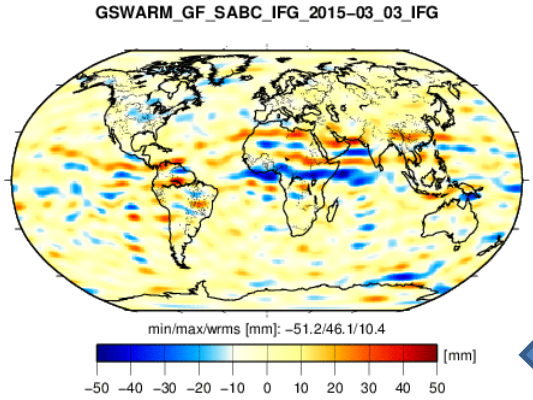
Combination Service of Time-variable Gravity Field Solutions (COST-G)

International Association of Geodesy
IAG
I G F S



COST-G Combination





esa SWARM DISC

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

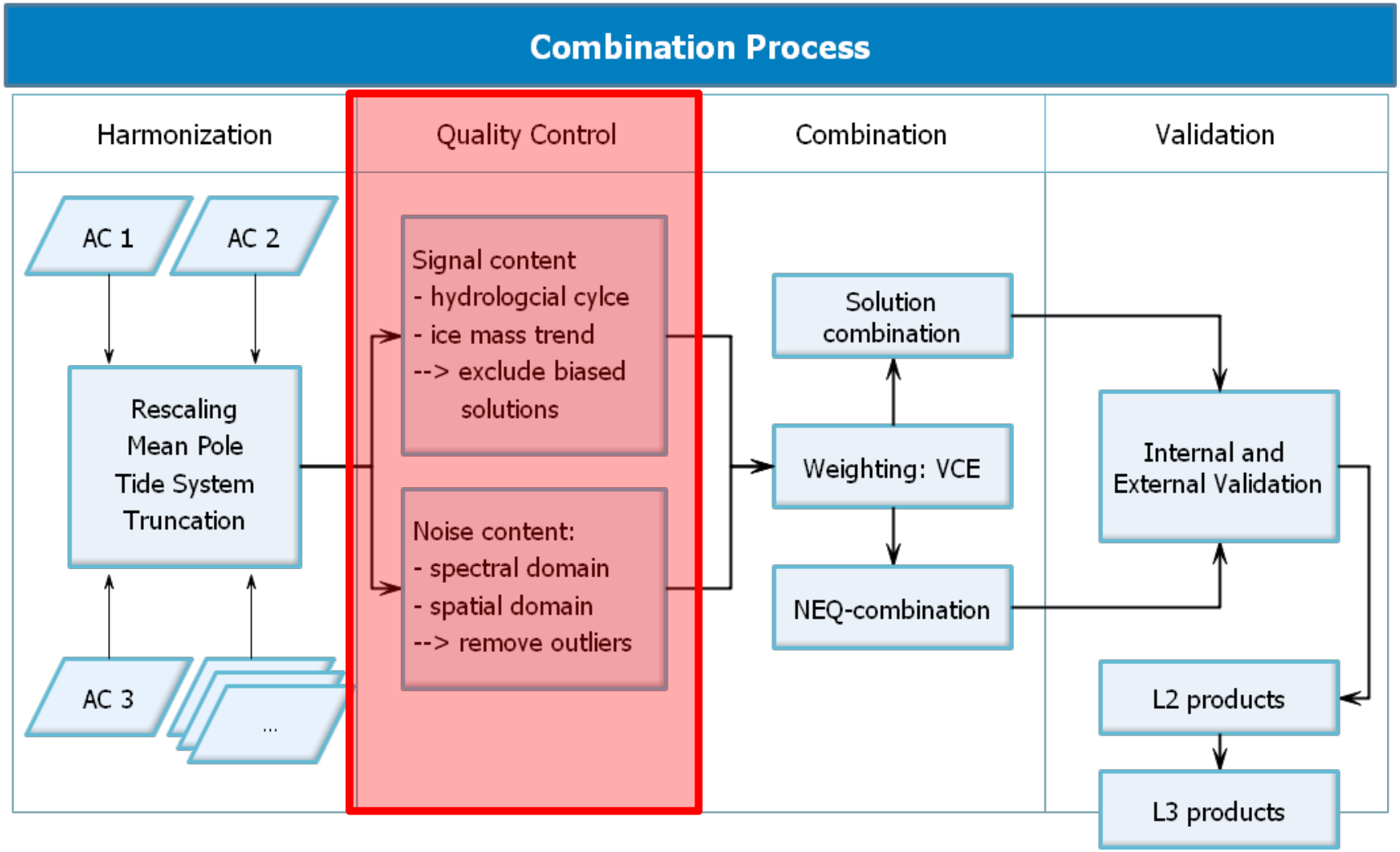
Permanent Components of COST-G

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

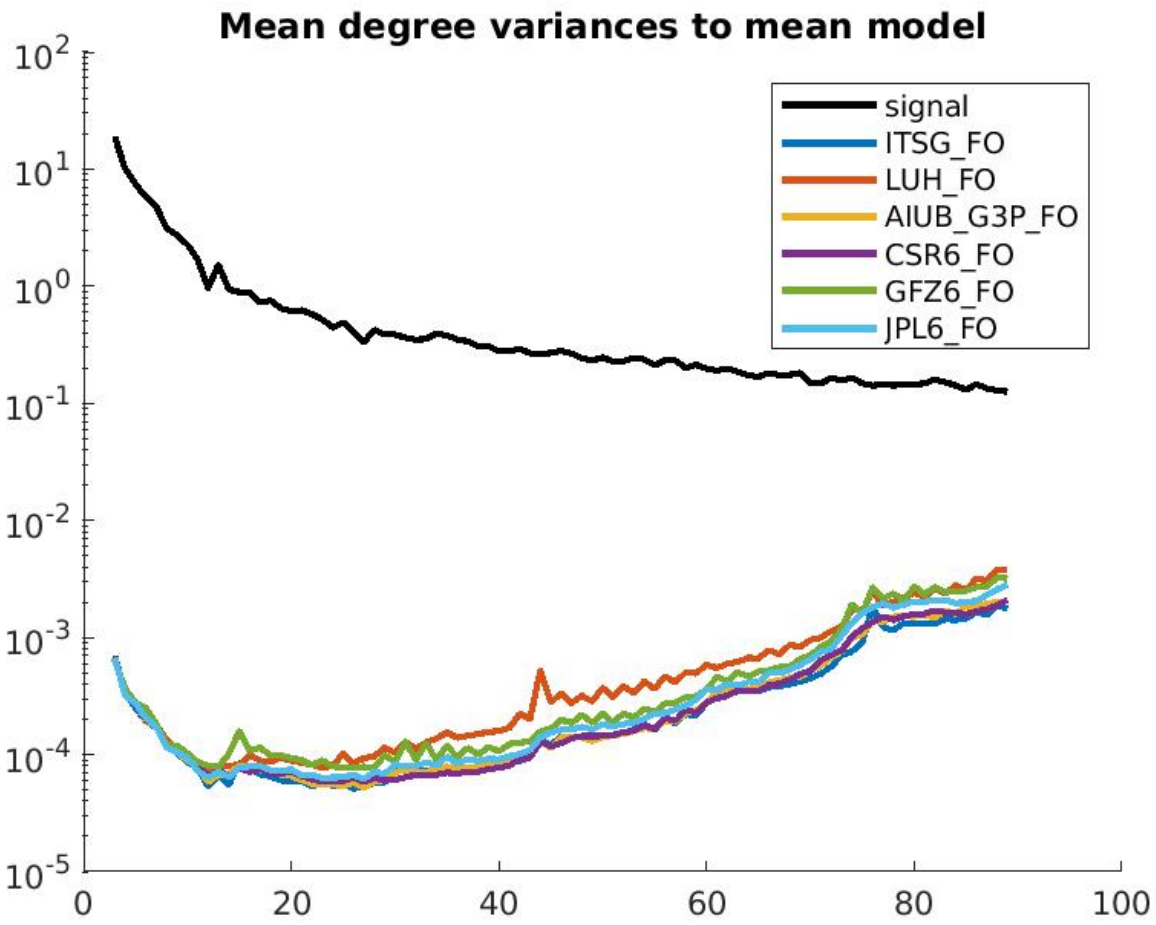
- **Central Bureau (CB) & Analysis Center Coordinator (ACC)**
  - AIUB
- **Analysis Centers (ACs)**
  - AIUB, CNES, GFZ, TUG
- **Level-3 Center (L3C)**
  - GFZ
- **Validation Centers (VCs)**
  - GRGS, GFZ
- **Product Evaluation Group (PEG)**
  - A. Eicker, A. Groh, B. Meyssignac
- **Candidate ACs:**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

GRACE/GRACE-FO SDS (CSR, JPL) contribute as partner ACs to COST-G combinations.

COST-G Workflow



Quality Control – Noise Levels (spectral domain)



GRACE-FO time-series:

COST-G ACs:

- AIUB
  - continuation of RL02
  - G3P project
- GFZ
- GRGS (delayed)
- ITSG

COST-G candidate AC:

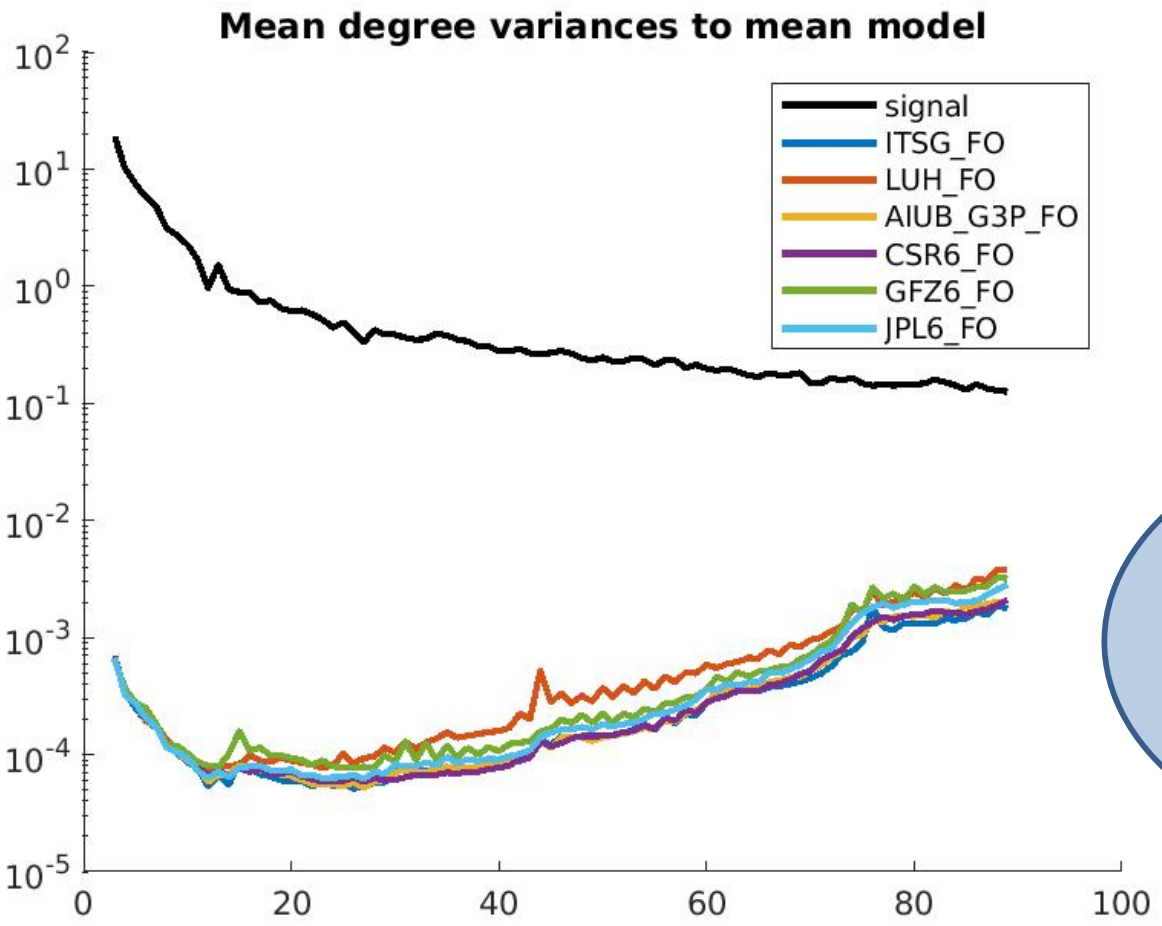
- LUH

COST-G partner ACs:

- CSR-RL06
- JPL-RL06

Degree-wise comparison of spherical harmonic coefficients to a deterministic signal model derived from the monthly means of all time-series (GRACE-FO).

Quality Control – Noise Levels (spectral domain)



GRACE-FO time-series:

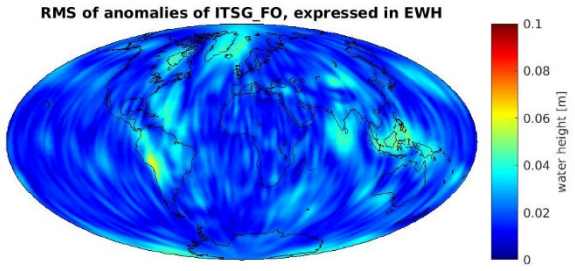
COST-G ACs:

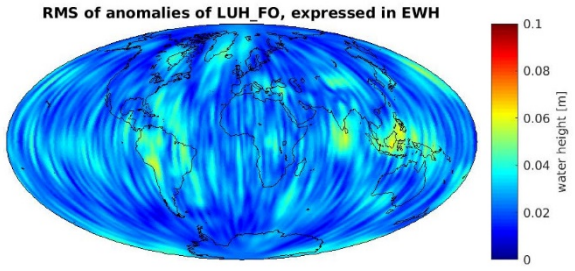
- AIUB
  - continuation of RL02
  - G3P project
- GFZ
- [illegible]
- [illegible]

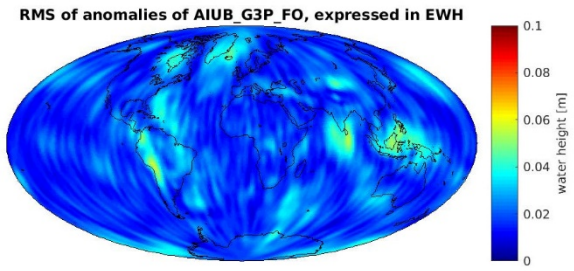
If not labeled differently, the AIUB time-series derived from alternative ACC transplant products in the frame of the G3P project is shown.

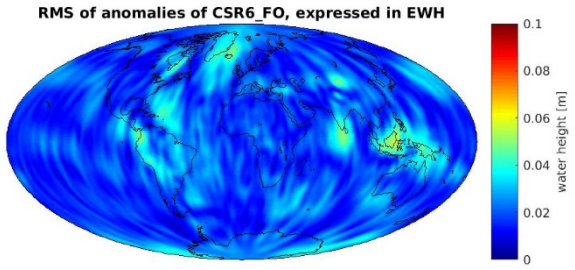
Degree-wise comparison of spherical harmonic coefficients to a deterministic signal model derived from the monthly means of all time-series (GRACE-FO).

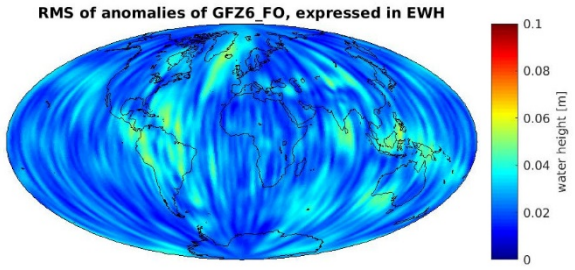
Quality Control – Noise Levels (spatial domain)

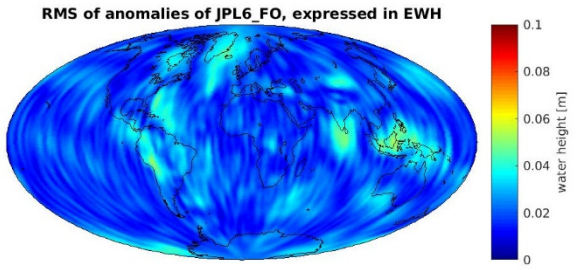






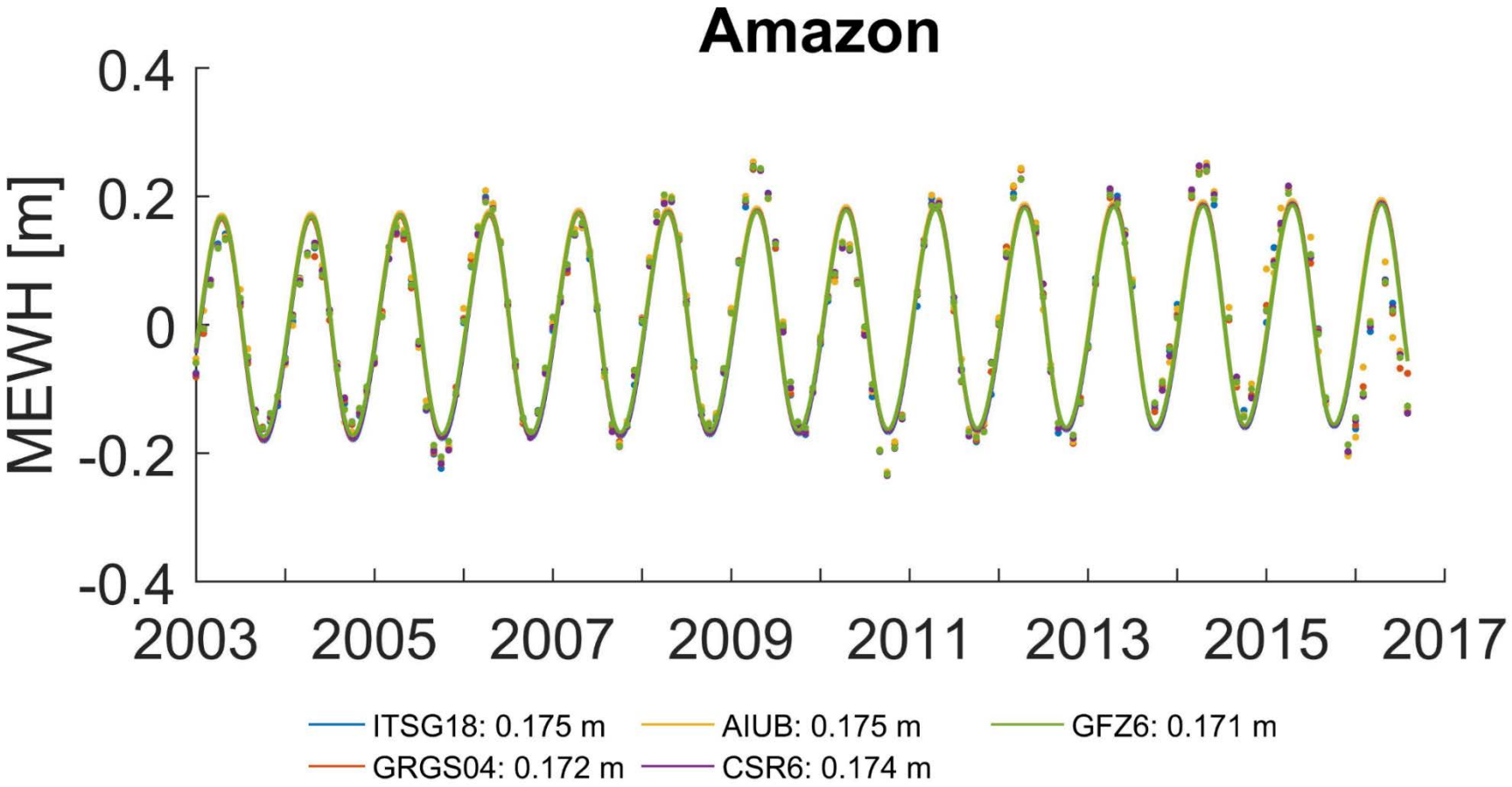






Comparison of monthly grids to a deterministic signal model derived from the monthly means of all time-series (GRACE-FO). Shown are the RMS-values per grid cell over a common subset of monthly solutions per time-series.

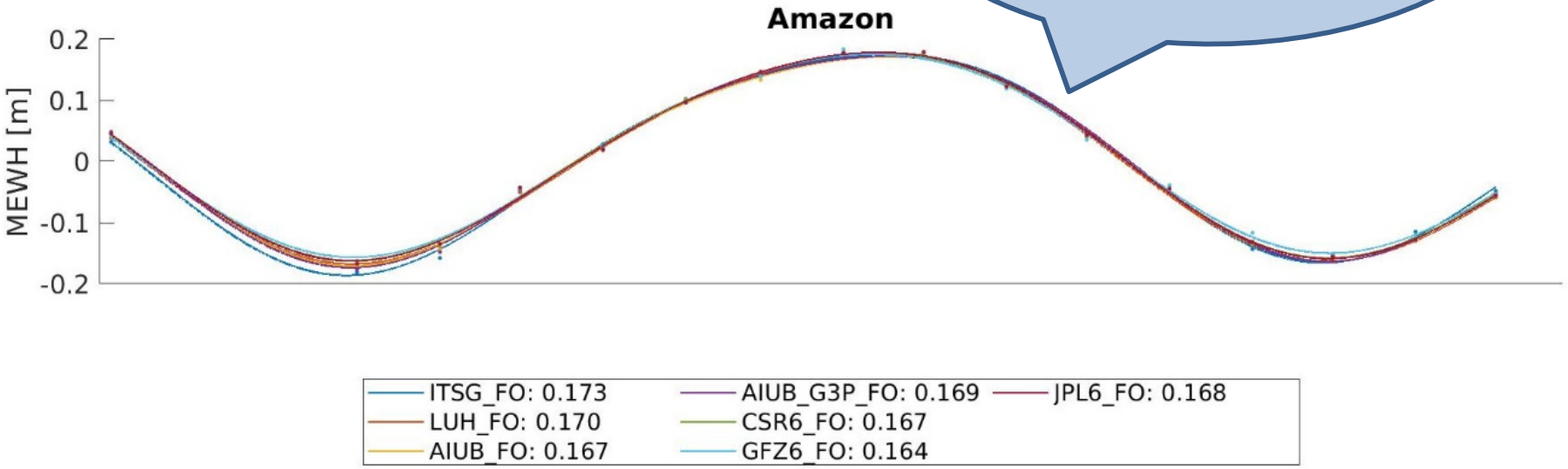
Quality Control – Signal Content (Hydrology)



Example: amplitude of seasonal variations in Amazon river basin (GRACE).

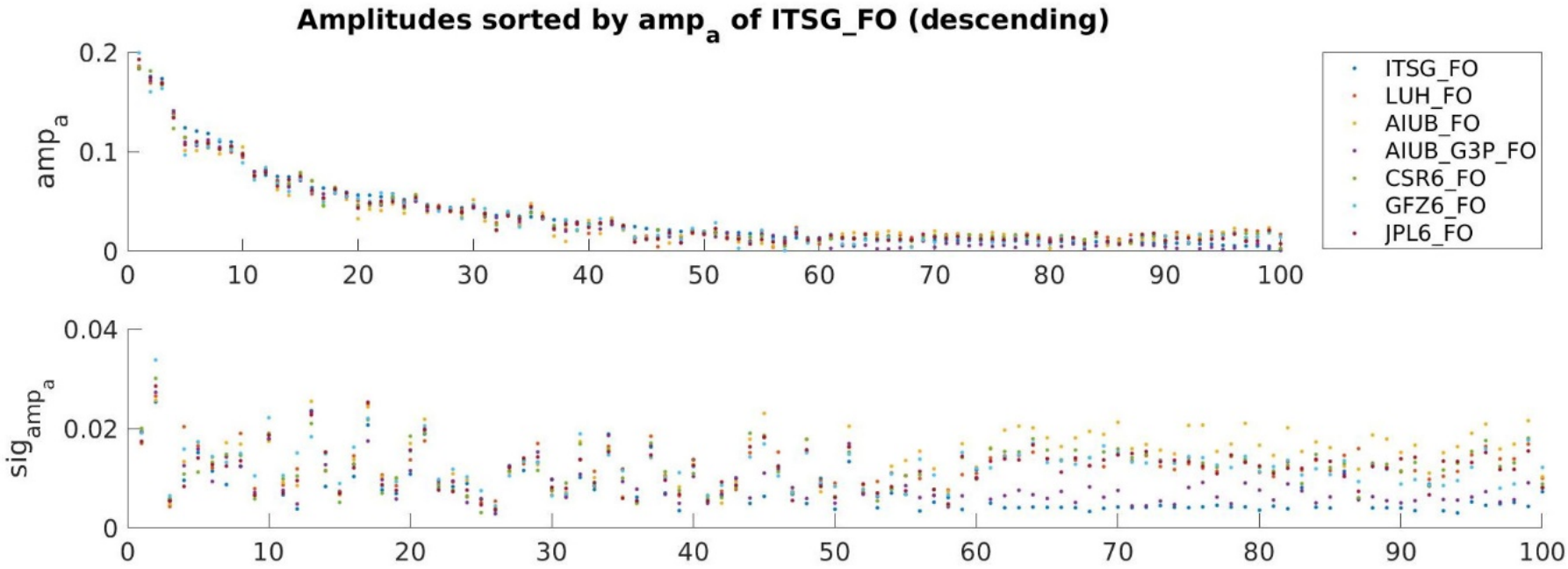
Quality Control – Signal Content (Hydrology)

Due to the short time span of the GRACE-FO time-series the quality control by comparison of signal amplitudes is still somewhat limited.



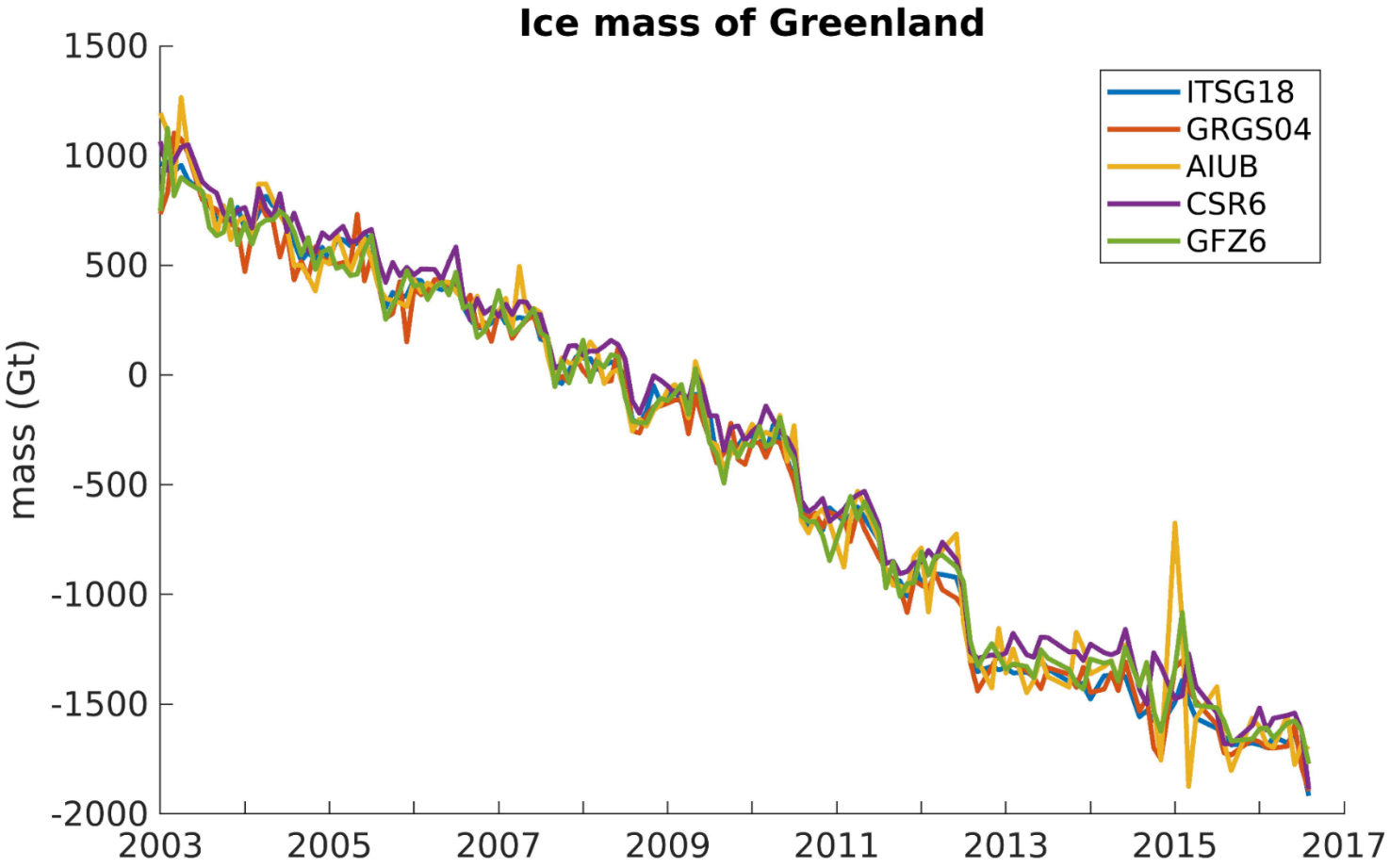
Example: amplitude of seasonal variations in Amazon river basin (GRACE-FO).

Quality Control – Signal Content (Hydrology)



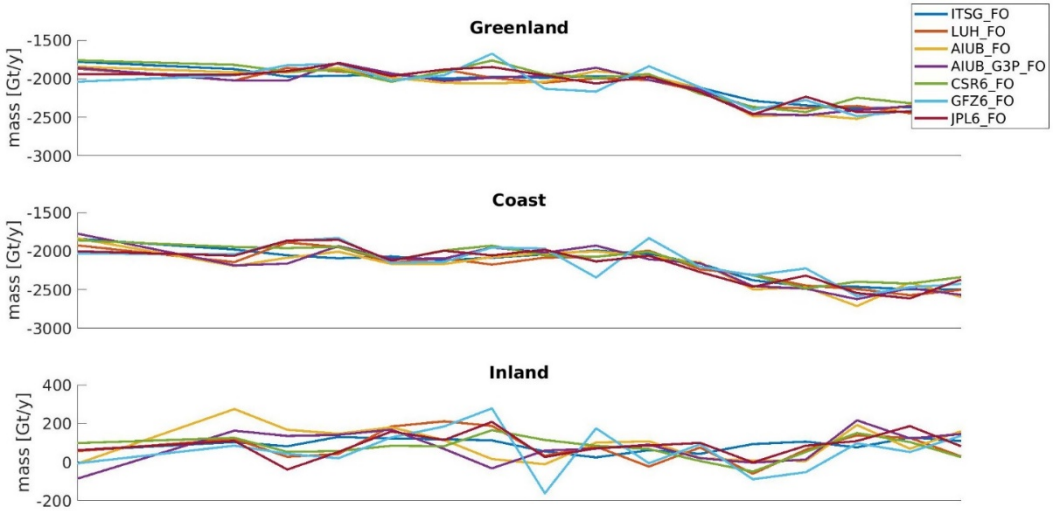
Comparison of amplitudes **amp$_a$** of seasonal mass variations and their formal errors **sig$_{amp}$** in 100 major river basins.

Quality Control – Signal Content (Ice Mass Loss)



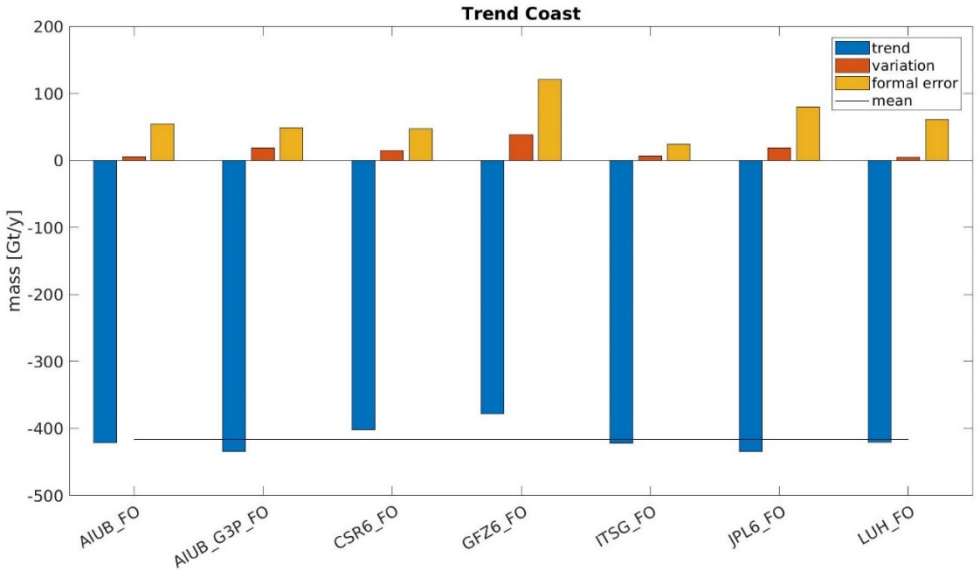
Example: ice mass loss in Greenland (GRACE), compared to static reference field GOCO05S.

Quality Control – Signal Content (Ice Mass Loss)

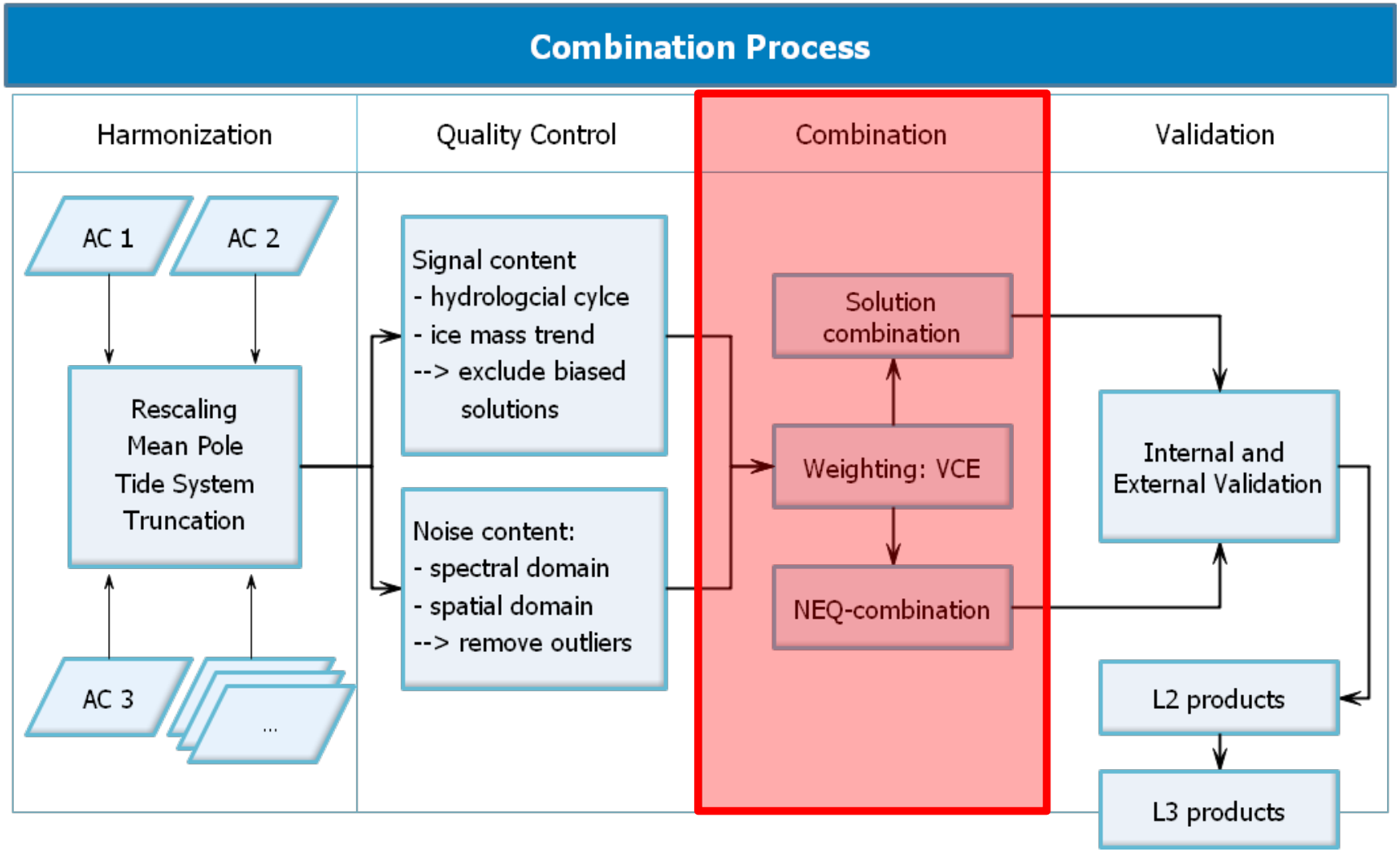


Example: ice mass loss in Greenland (GRACE-FO) with respect to GOCO05S.

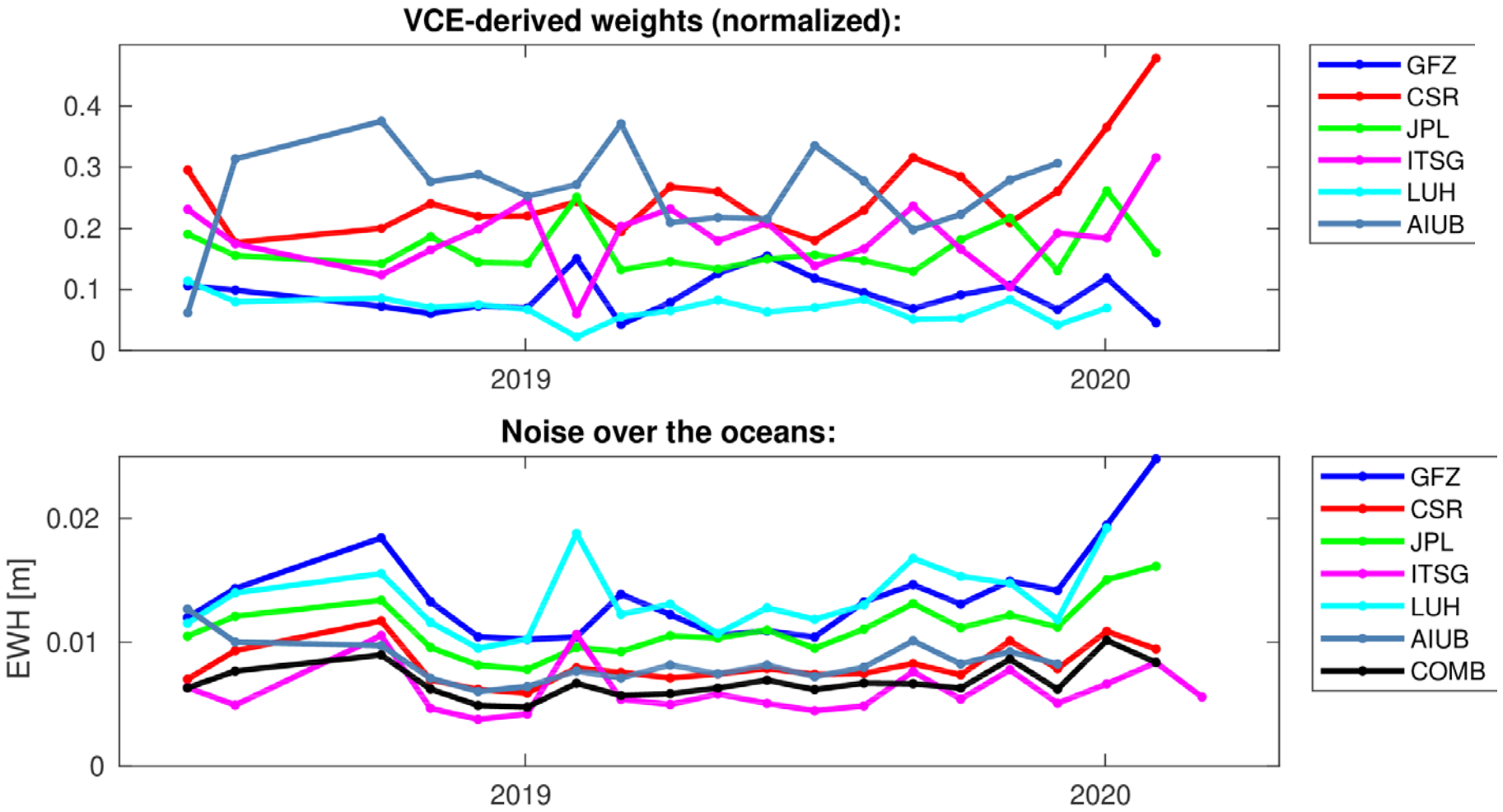
Despite the short time span of the GRACE-FO time-series the mass loss trends in Greenland agree well, no signal attenuation in any of the time-series could be detected.



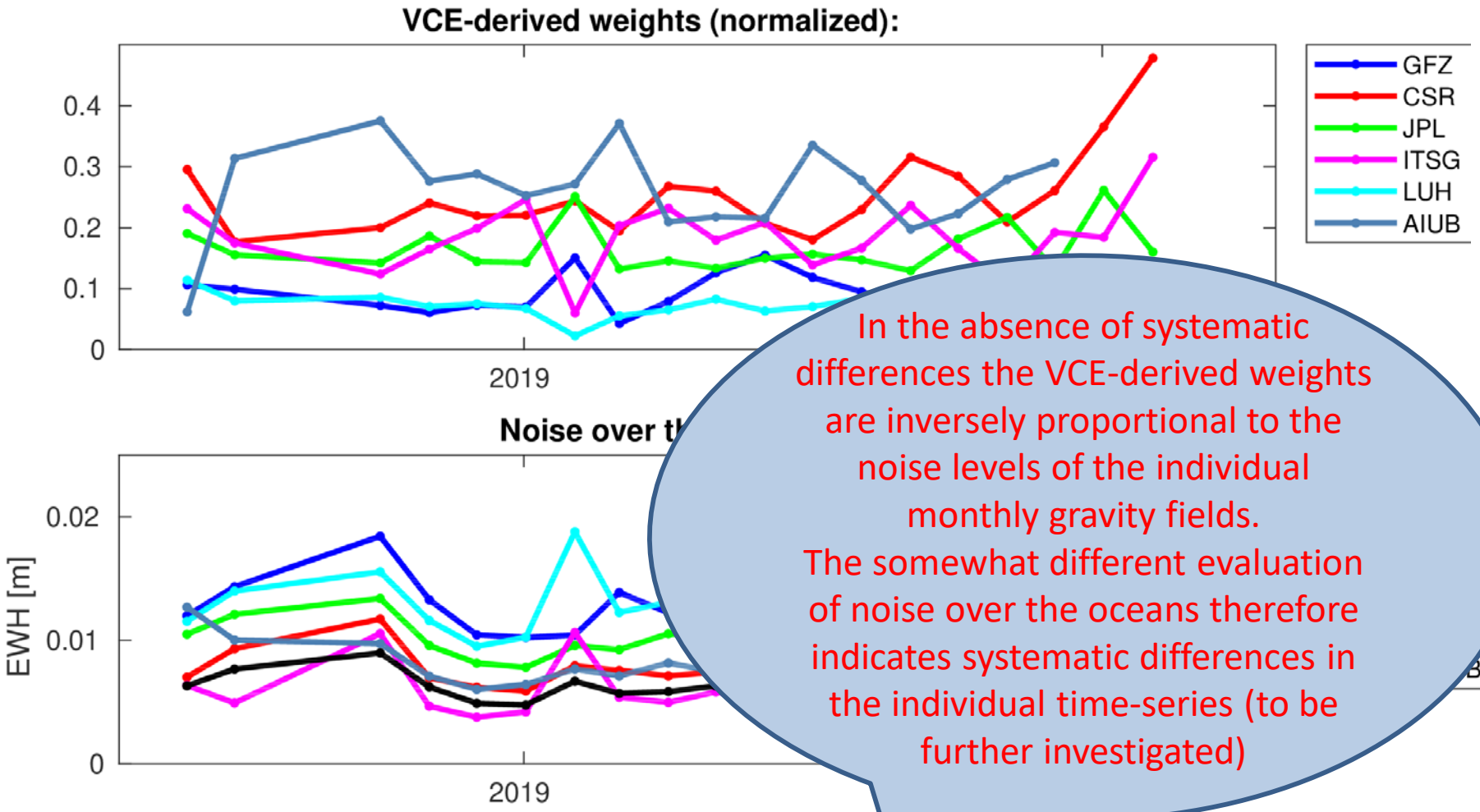
COST-G – Combination



Combination applying Variance Component Estimation

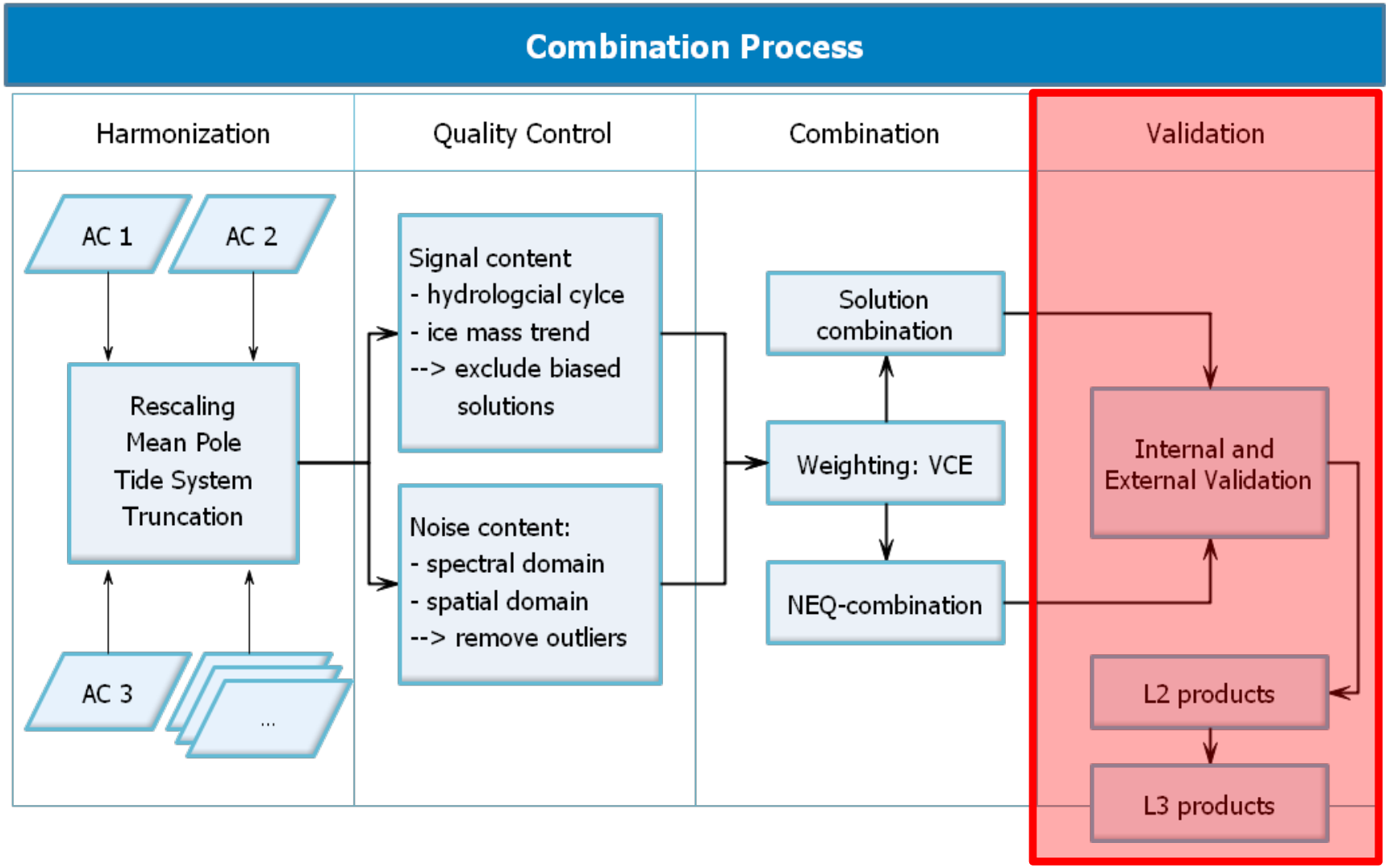


Combination applying Variance Component Estimation



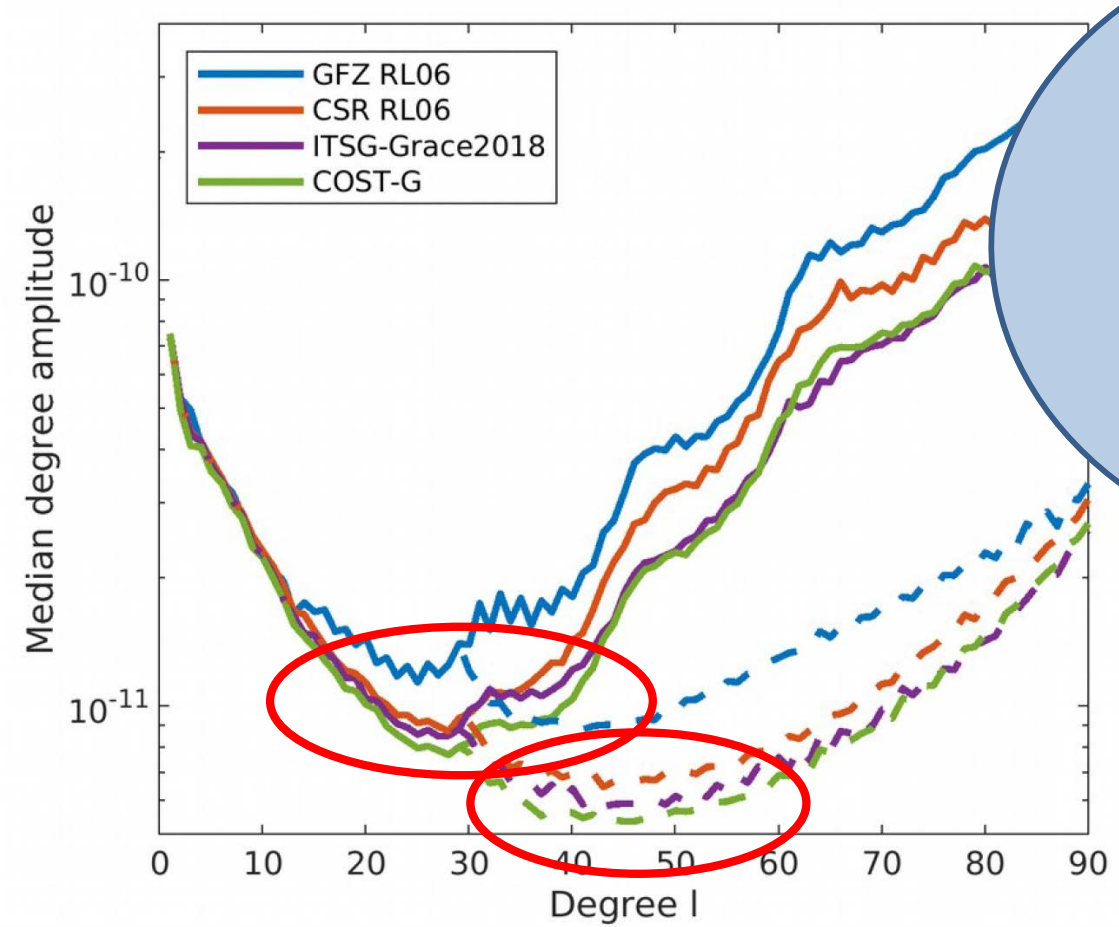
In the absence of systematic differences the VCE-derived weights are inversely proportional to the noise levels of the individual monthly gravity fields.
The somewhat different evaluation of noise over the oceans therefore indicates systematic differences in the individual time-series (to be further investigated)

COST-G – Validation



Internal Validation: spectral domain

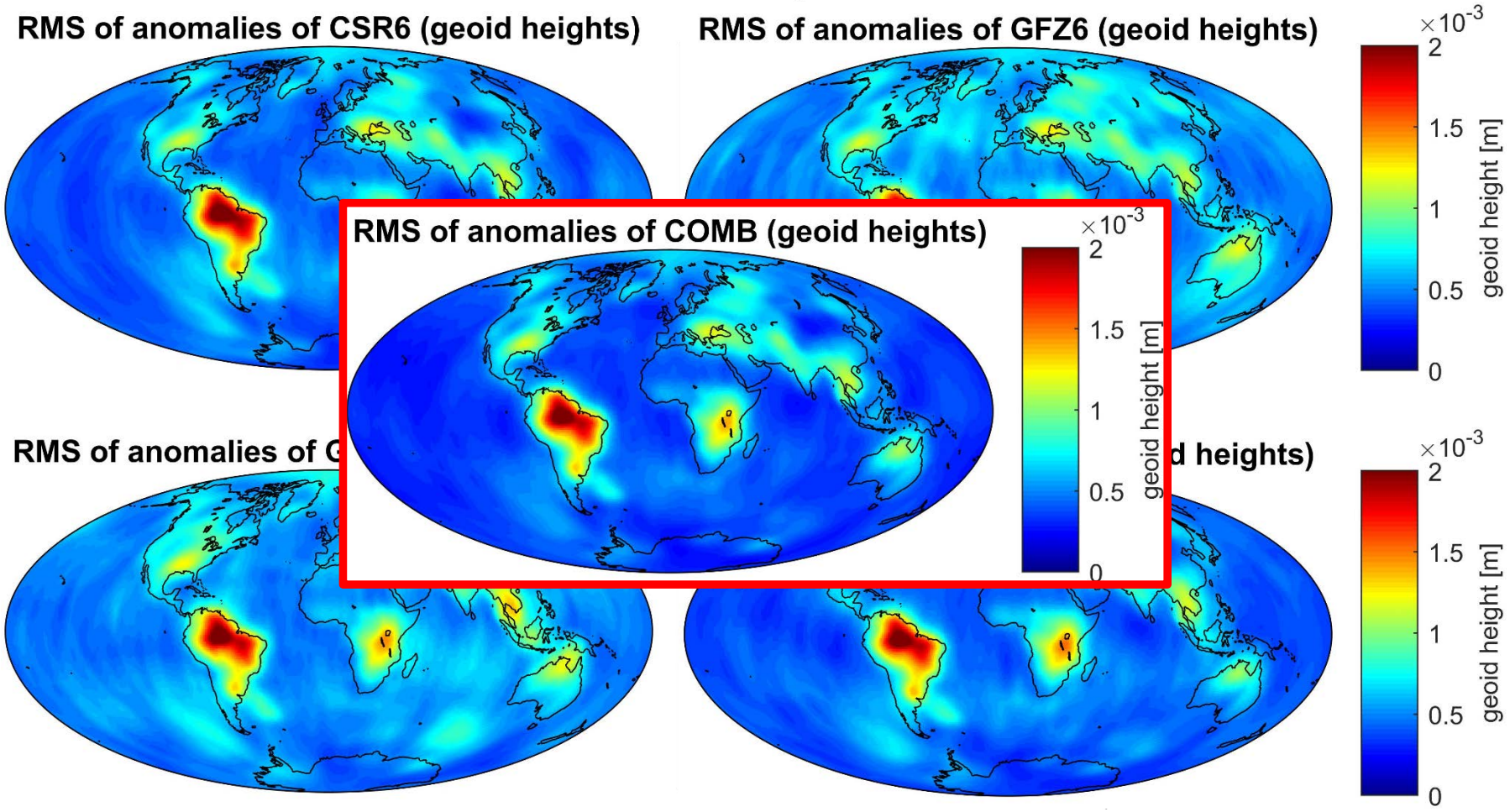
Median degree amplitudes of anomalies wrt a linear and seasonal model (no filtering applied)



For the COST-G GRACE-FO combination no external validation is yet available, in the following slides we therefore provide examples on the validation of the COST-G GRACE combination released in July 2019.

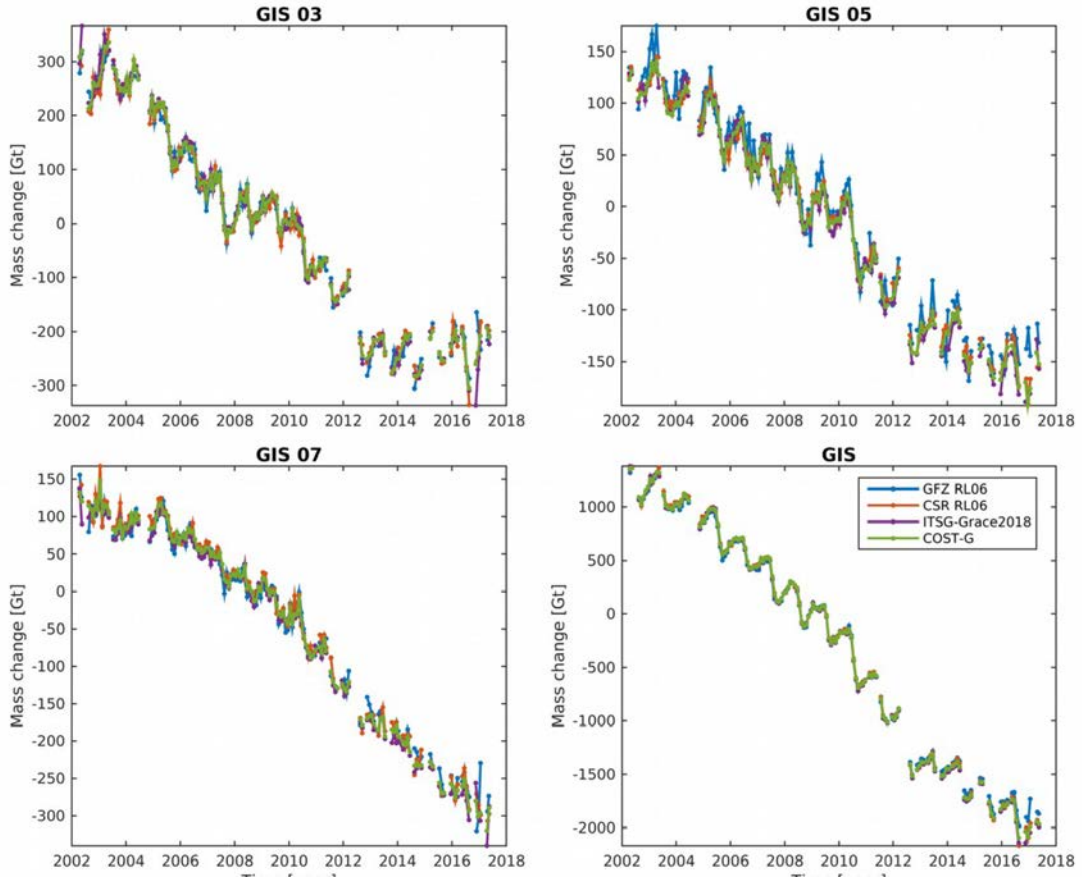
The main gain of the combination is in the range of degrees 15-45.

Internal Validation: spatial domain



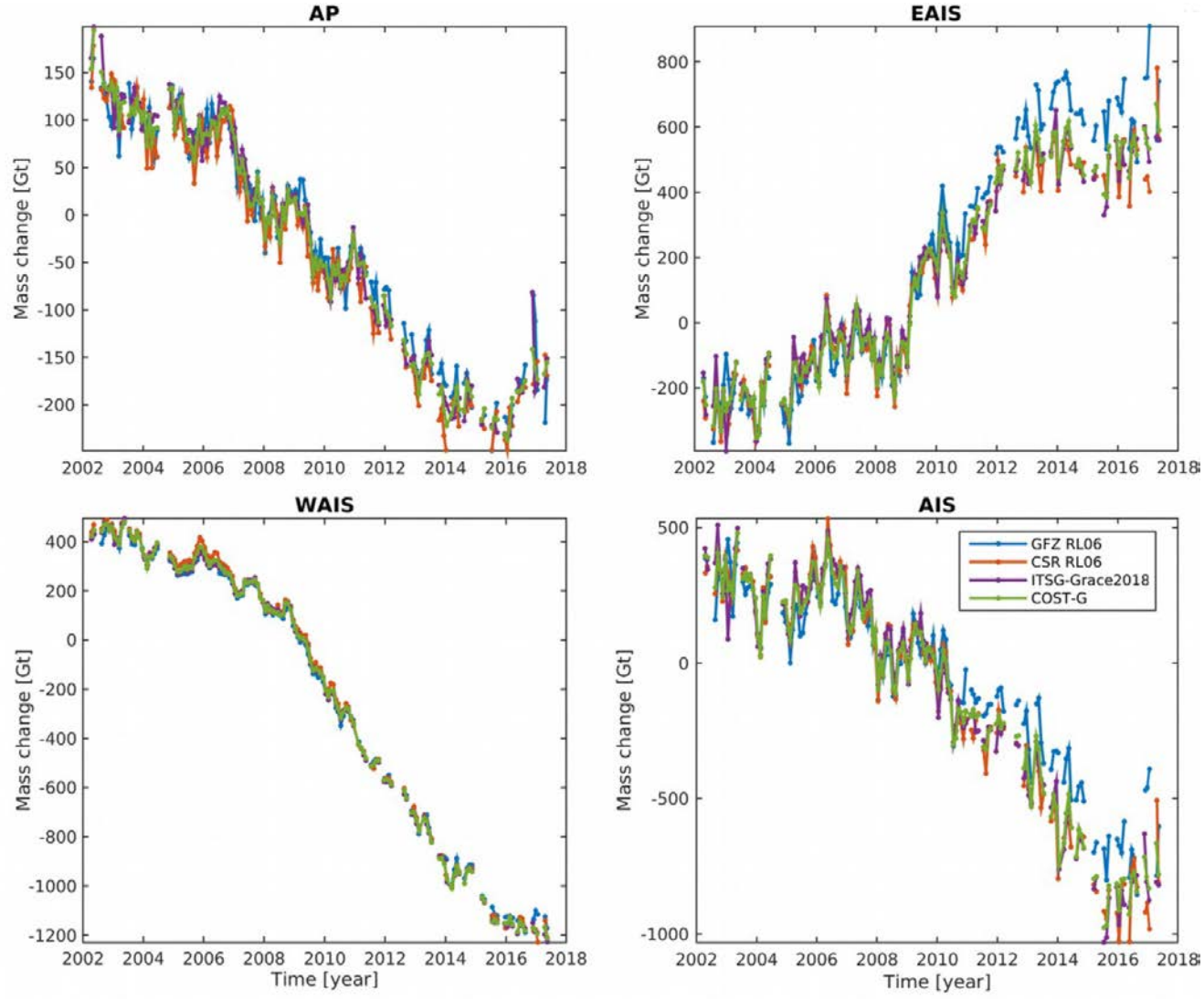
Basin-Averaged GIS Mass Changes

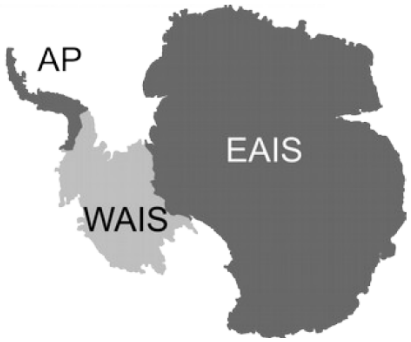
Basin-integrated AIS/GIS mass changes based on the sensitivity kernel approach by TU Dresden



Trends agree fairly well for the Greenland Ice Sheet

Basin-Averaged AIS Mass Changes



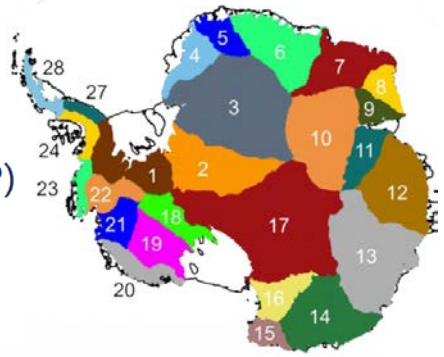


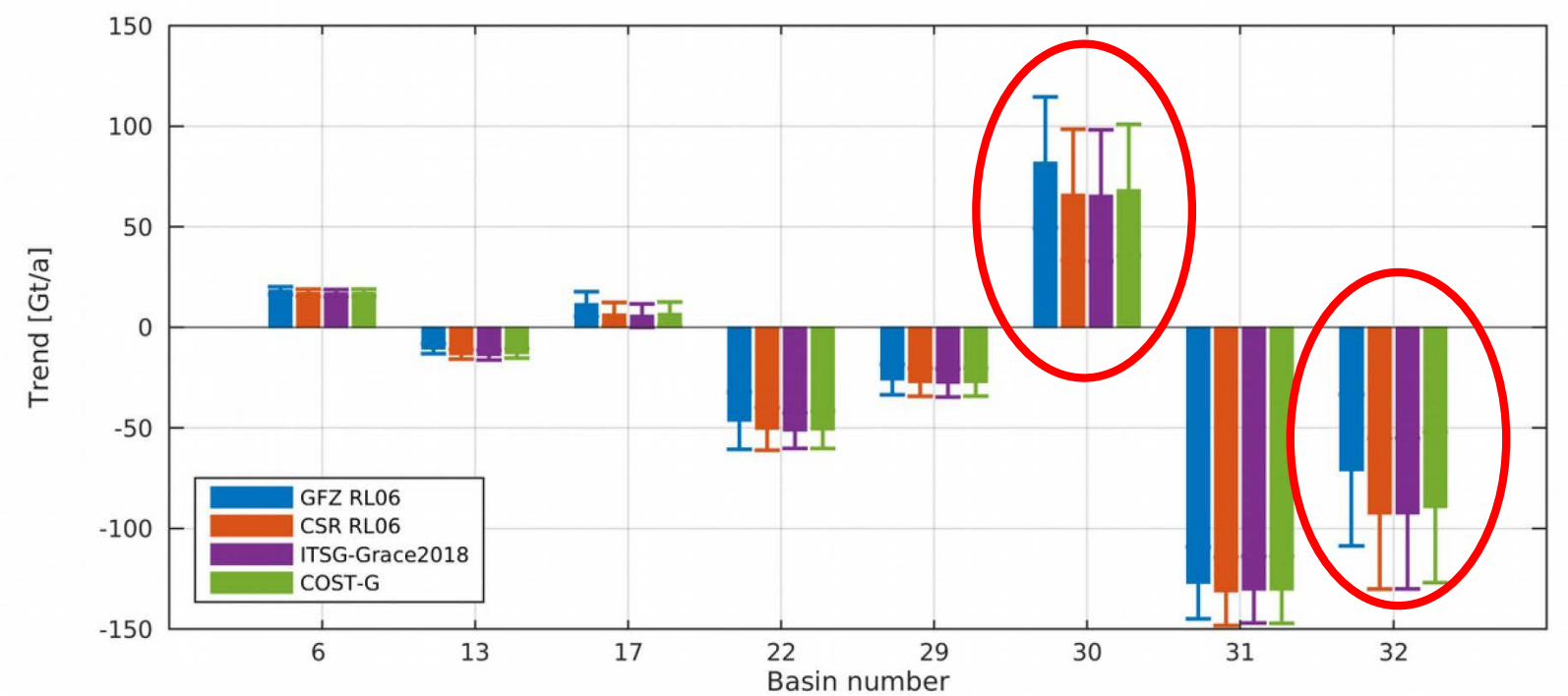
Larger trend differences for Antarctic Ice Sheet

Basin-Averaged AIS Mass Changes

Trends from GFZ seem to be different for East Antarctica. A slight influence on COST-G products may be seen (under investigation).

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	**7,38**	**6,84**	**6,23**	**6,18**
AIUB_RL02	**8,69**	**8,56**	**7,39**	**7,21**
CSR_RL06	**6,88**	**9,09**	**6,65**	**6,20**
GRGS_RL04f	**5,88**	**7,30**	**5,47**	**5,83**
ITSG_2018_tide_free	**5,51**	**5,12**	**4,19**	**4,54**
COSTG_RL01	**5,03**	**5,54**	**4,52**	**4,72**

Level-2 Product Availability

- **Monthly combined GRACE gravity field models:**
  - **from Apr. 2002 to Jun. 2017 available at ICGEM**
  - **http://icgem.gfz-potsdam.de/series/02_COST-G/GRACE**

- **Monthly combined Swarm gravity field models:**
  - **from Dec. 2013 to Dec. 2019 available at ICGEM**
  - **http://icgem.gfz-potsdam.de/series/02_COST-G/Swarm**

Level-2 Product Availability

ICGEM

GFZ Helmholtz Centre Potsdam

GRACE and Grace-FO solutions from the Science Data System centers CSR, GFZ and JPL	expand all
+ CSR	Center for Space Research at University of Texas, Austin
+ GFZ	Helmholtz Centre Potsdam German Research Centre for Geosciences
+ JPL	Jet Propulsion Laboratory

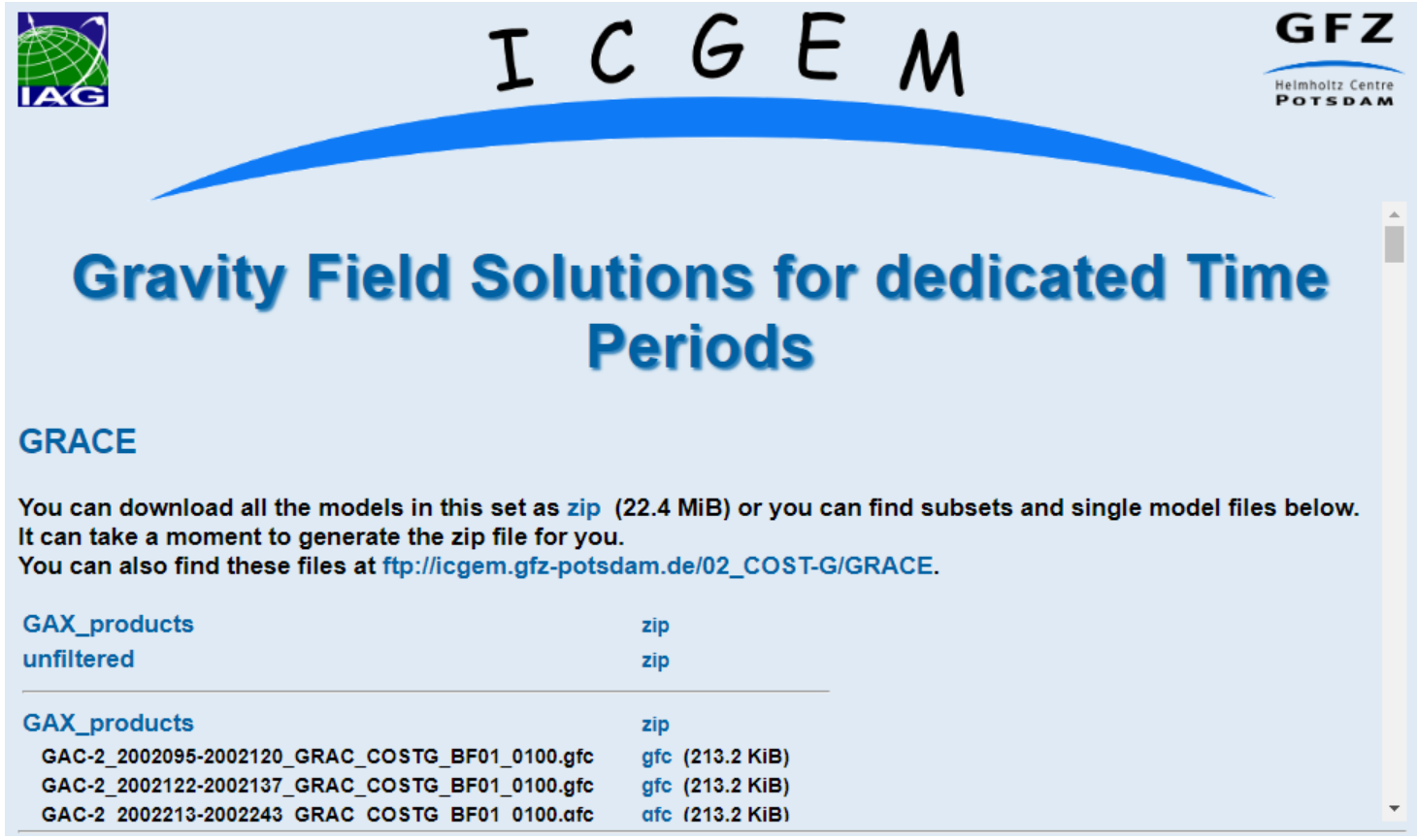
The processing standards to generate the GRACE Level-2 products of CSR, GFZ and JPL are also available in the Document Section of the GRACE archives at GFZ ISDC or JPL PO.DAAC

COST-G (International Combination Service for Time-variable Gravity Field)		collapse all
GRACE		monthly
Swarm	DOI	monthly

GRACE / CHAMP solutions from other groups	expand all
+ AIUB	Astronomical Institute University Bern
+ CNES	Centre national d'études spatiales
+ DMT	Delft University of Technology
+ EGSIEM	European Gravity Service for Improved Emergency Project

COST-G

Level-2 Product Availability: GRACE



I C G E M

GFZ Helmholtz Centre Potsdam

Gravity Field Solutions for dedicated Time Periods

GRACE

You can download all the models in this set as zip (22.4 MiB) or you can find subsets and single model files below.
It can take a moment to generate the zip file for you.
You can also find these files at ftp://icgem.gfz-potsdam.de/02_COST-G/GRACE.

GAX_products	zip
unfiltered	zip

GAX_products	zip
GAC-2_2002095-2002120_GRAC_COSTG_BF01_0100.gfc	gfc (213.2 KiB)
GAC-2_2002122-2002137_GRAC_COSTG_BF01_0100.gfc	gfc (213.2 KiB)
GAC-2_2002213-2002243_GRAC_COSTG_BF01_0100.gfc	gfc (213.2 KiB)

unfiltered	zip
GSM-2_2002095-2002120_GRAC_COSTG_BF01_0100.gfc	gfc (368.8 KiB)
GSM-2_2002122-2002137_GRAC_COSTG_BF01_0100.gfc	gfc (368.8 KiB)
GSM-2_2002213-2002243_GRAC_COSTG_BF01_0100.gfc	gfc (369.0 KiB)

Level-2 Product Availability: Swarm

ICGEM

GFZ Helmholtz Centre Potsdam

Gravity Field Solutions for dedicated Time Periods

Swarm

Citation: Encarnacao, J, Visser, P, Jaeggi, A, Bezdek, A, Mayer-Gürr, T, Shum, C K, Arnold, D, Doornbos, E, Elmer, M, Guo, J, van den IJssel, J, Iorfida, E, Klokocnik, J, Krauss, S, Mao, X, Meyer, U, Sebera, J, Zhang, C, Zhang, Y, and Dahle, C 2019 Multi-approach Gravity Field Models from Swarm GPS data. DOI: https://doi.org/10.5880/ICGEM.2019.006

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Summary and Outlook

- COST-G RL01 Level-2 products for GRACE and Swarm are available from ICGEM
- COST-G RL01 Level-3 products for GRACE are currently being processed and will be made available via GFZ's GravIS portal (http://gravis.gfz-potsdam.de/)
- Operational GRACE-FO combination will start shortly after EGU
- CSR and JPL are listed as Partner Analysis Centers in the COST-G ToR
- Inclusion of candidate Analysis Centers (LUH, Chinese ACs) is envisaged in the near future.