

Precise orbit determination based on COST-G time-variable gravity fields

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PSD.1: SATELLITE DYNAMICS

- **Introduction to COST-G**
- **Fitted Signal Model (FSM) for operational LEO-POD**
- **Orbit validation (Sentinel/GOCE)**

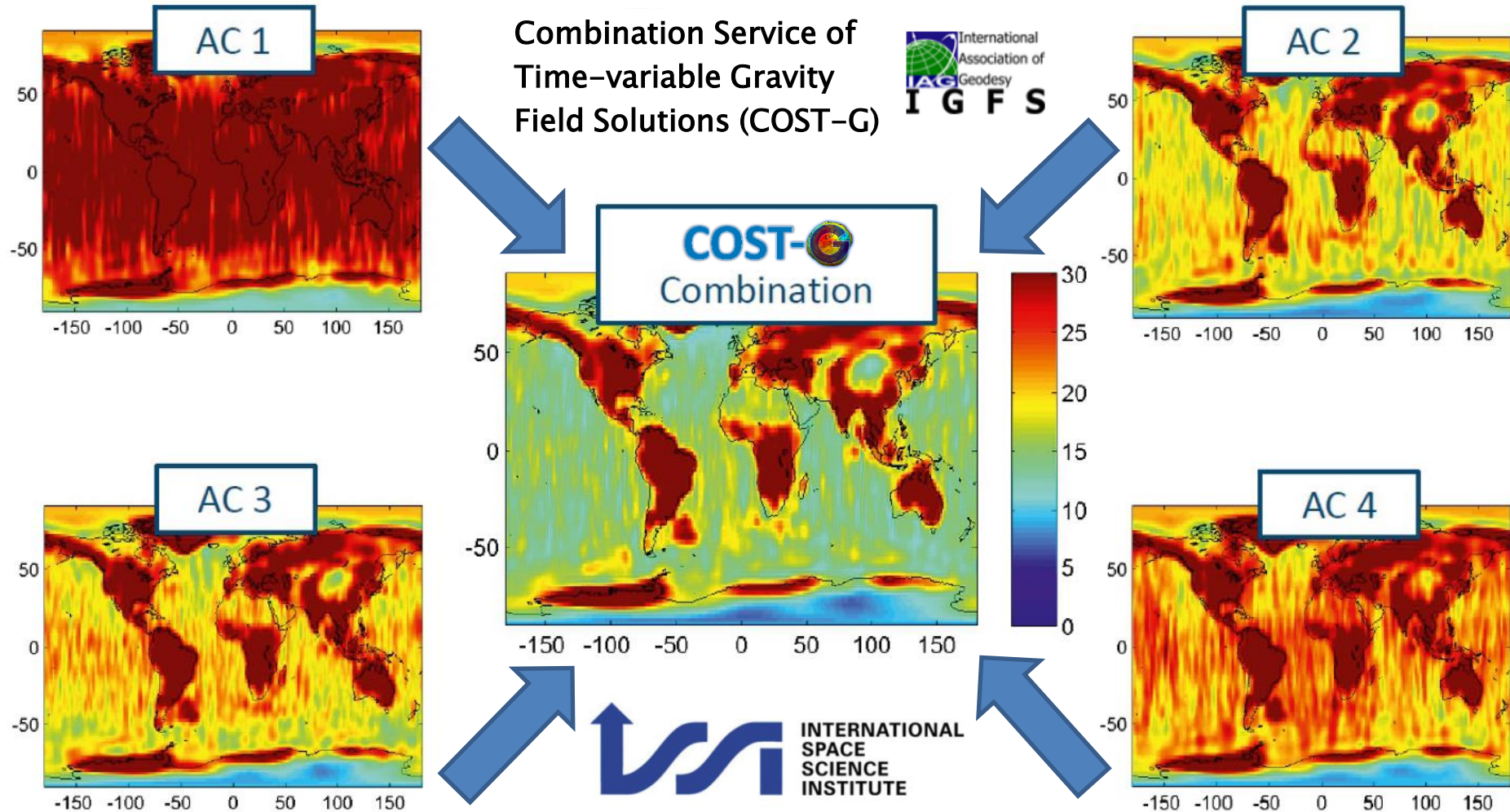
Combination Service for Time-variable Gravity Fields (COST-G)



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PSD.1: SATELLITE DYNAMICS

Introduction to COST-G



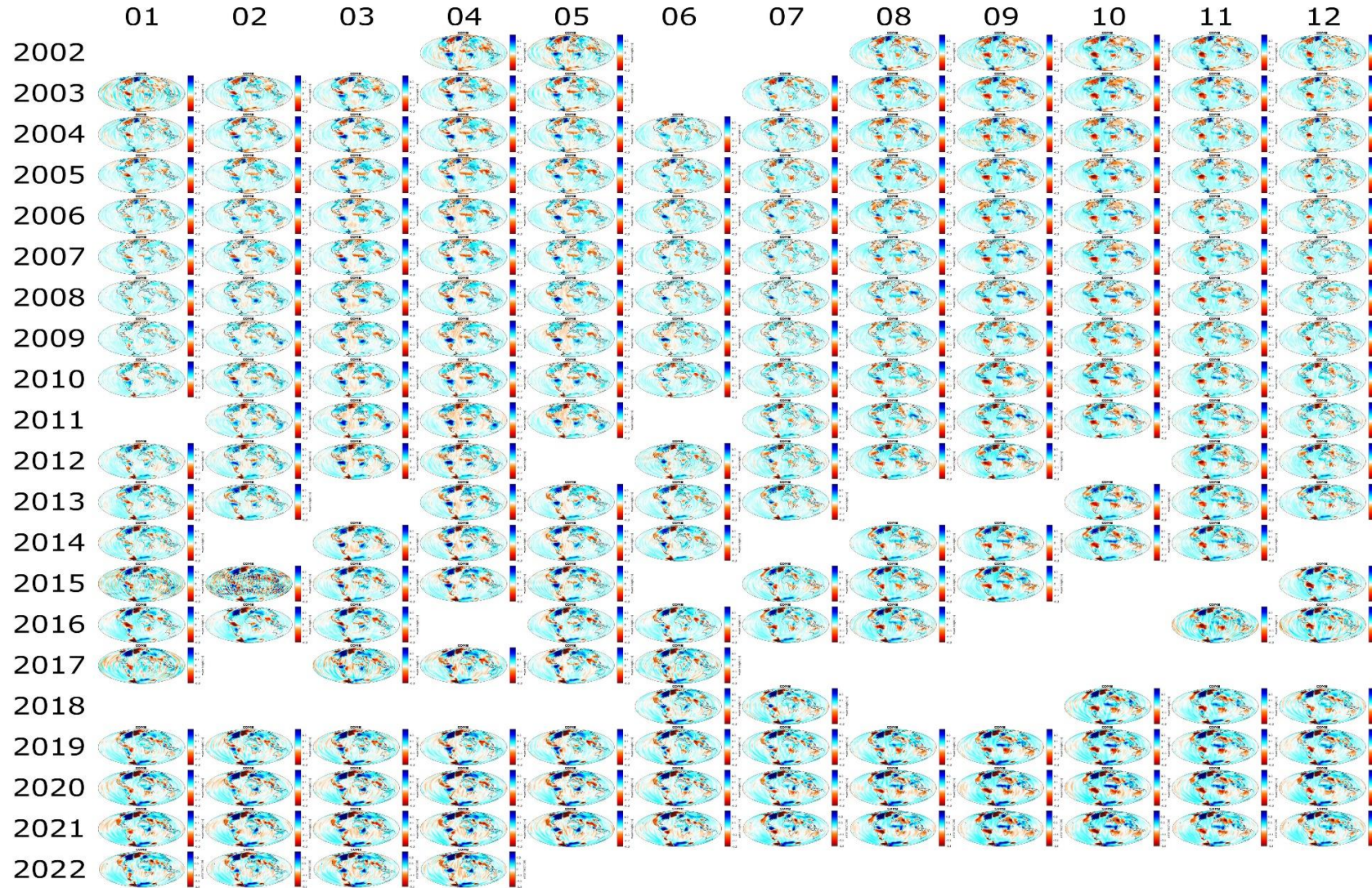
Improved and consolidated product integrating the strengths of all ACs



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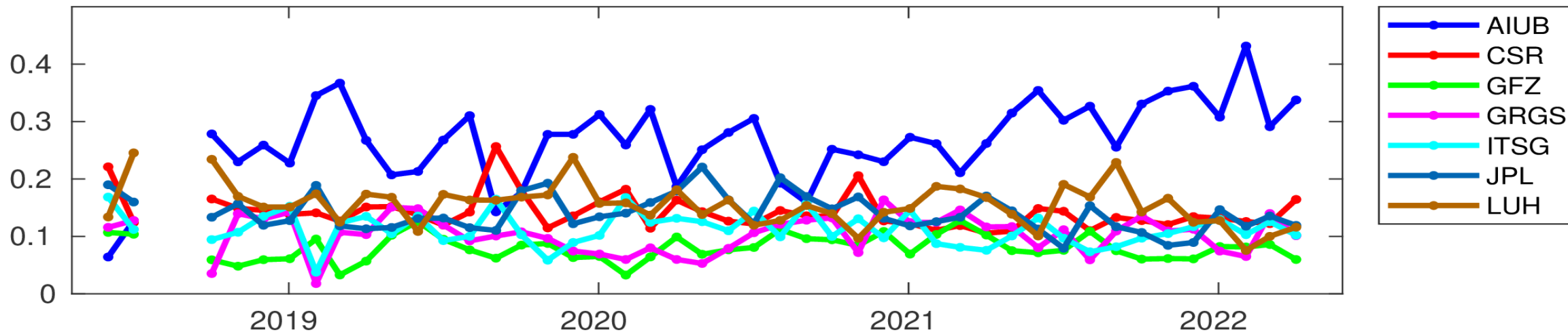
GRACE-FO operational combined monthly gravity fields



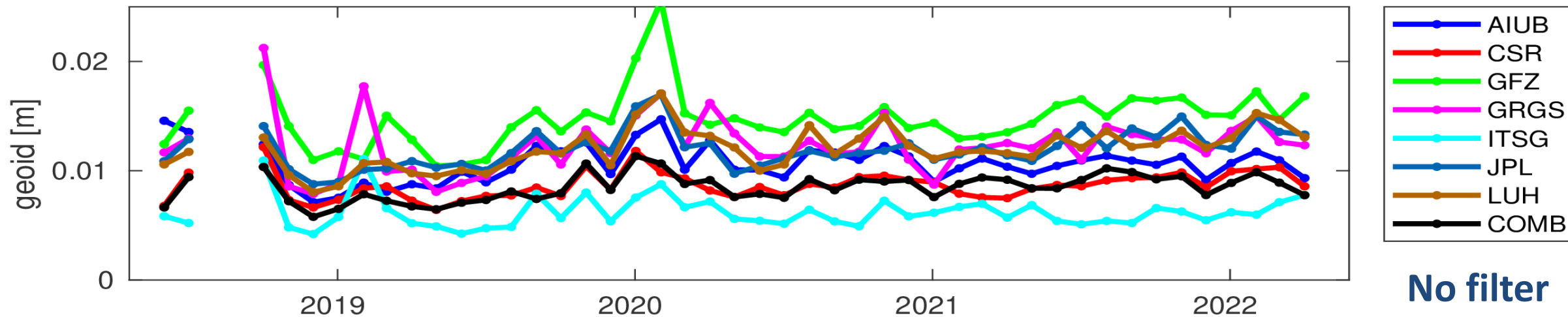
Flawless and uninterrupted operational combination with a latency < 3 months.

Weighted combination and validation of the Combined Solution

VCE-derived weights (normalized):

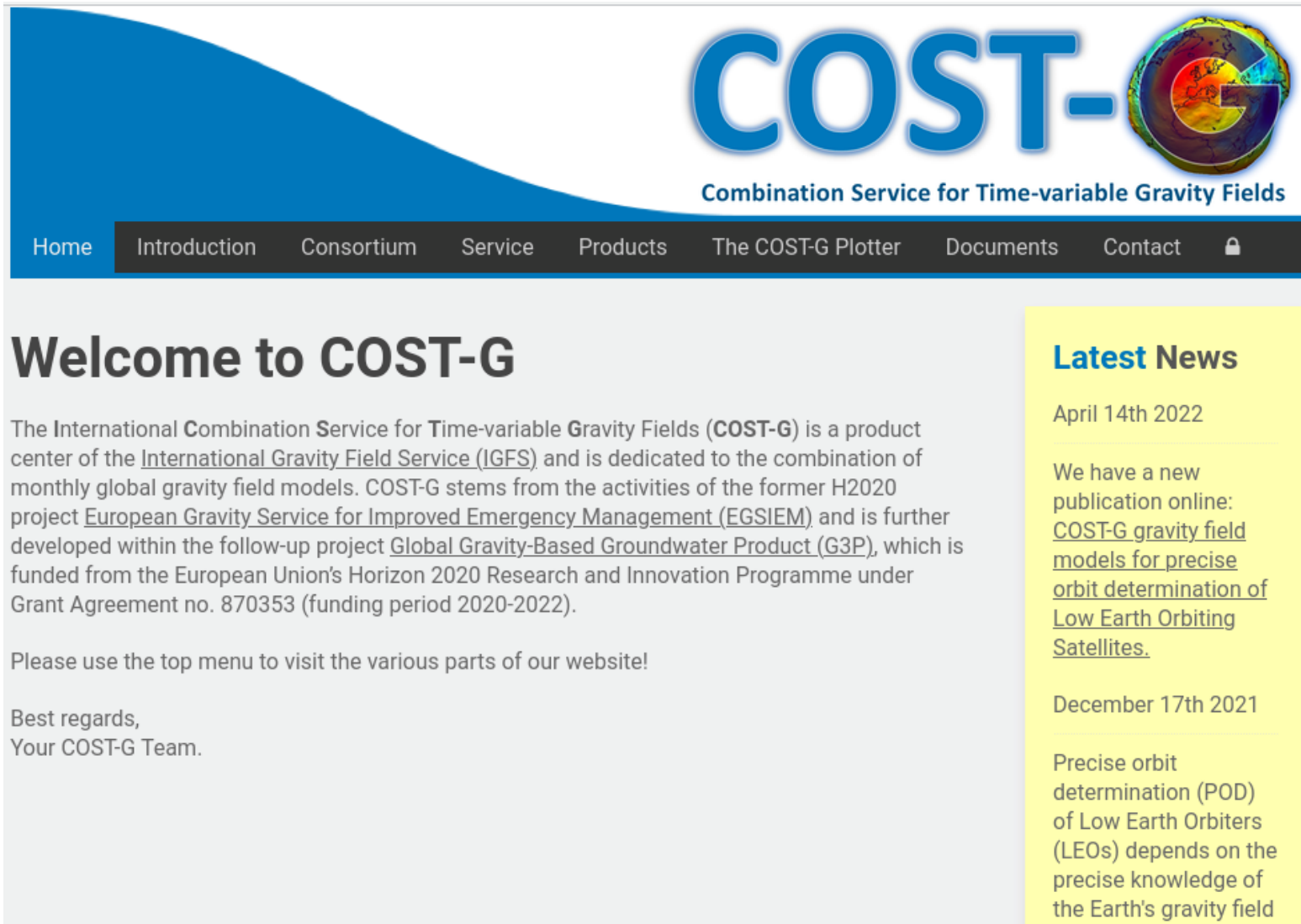


Noise over the oceans:



No filter

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



The screenshot shows the homepage of the COST-G website. At the top, there is a blue header with the COST-G logo and the text "Combination Service for Time-variable Gravity Fields". Below the header is a navigation menu with links for Home, Introduction, Consortium, Service, Products, The COST-G Plotter, Documents, and Contact. The main content area features a large heading "Welcome to COST-G" followed by a paragraph describing the service. To the right, there is a "Latest News" section with two entries: one dated April 14th 2022 about a new publication on gravity field models, and another dated December 17th 2021 about precise orbit determination of Low Earth Orbiters.

COST-G

Combination Service for Time-variable Gravity Fields

Home Introduction Consortium Service Products The COST-G Plotter Documents Contact

Welcome to COST-G

The International Combination Service for Time-variable Gravity 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 stems from the activities of the former H2020 project [European Gravity Service for Improved Emergency Management \(EGSIEM\)](#) and is further developed within the follow-up project [Global Gravity-Based Groundwater Product \(G3P\)](#), which is funded from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement no. 870353 (funding period 2020-2022).

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

Best regards,
Your COST-G Team.

Latest News

April 14th 2022

We have a new publication online: [COST-G gravity field models for precise orbit determination of Low Earth Orbiting Satellites.](#)

December 17th 2021

Precise orbit determination (POD) of Low Earth Orbiters (LEOs) depends on the precise knowledge of the Earth's gravity field

For background information on COST-G and links to products take a look at: <https://cost-g.org/>

For more information on the Fitted Signal Model (FSM): Peter H, Meyer U, Lasser M, Jäggi A (2022): COST-G gravity field models for precise orbit determination of Low Earth Orbiting Satellites. *Advances in Space Research* (69), **12**, 4155-4168. doi: 10.1016/j.asr.2022.04.005

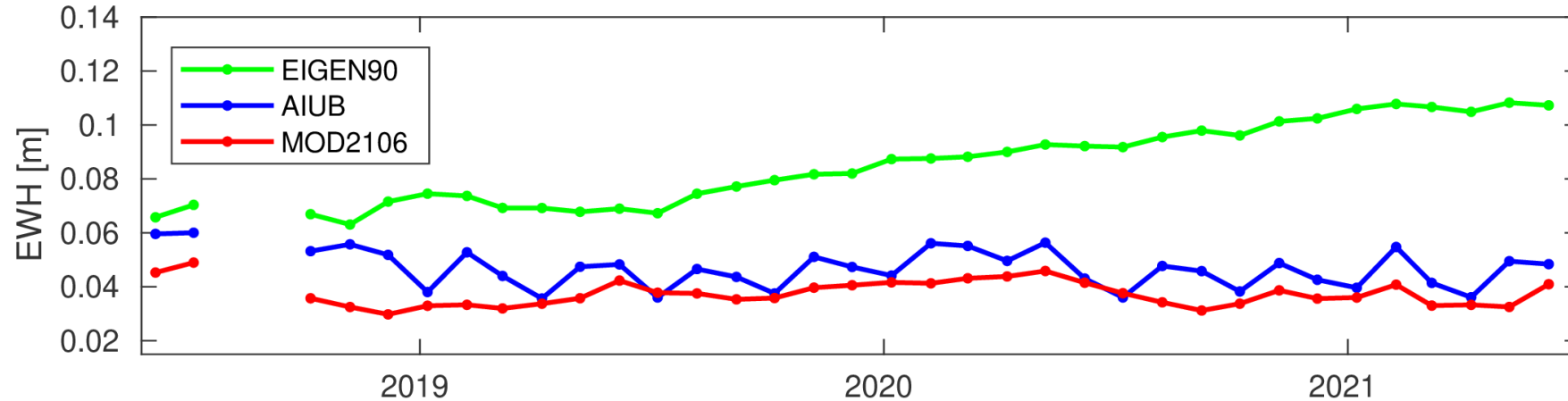
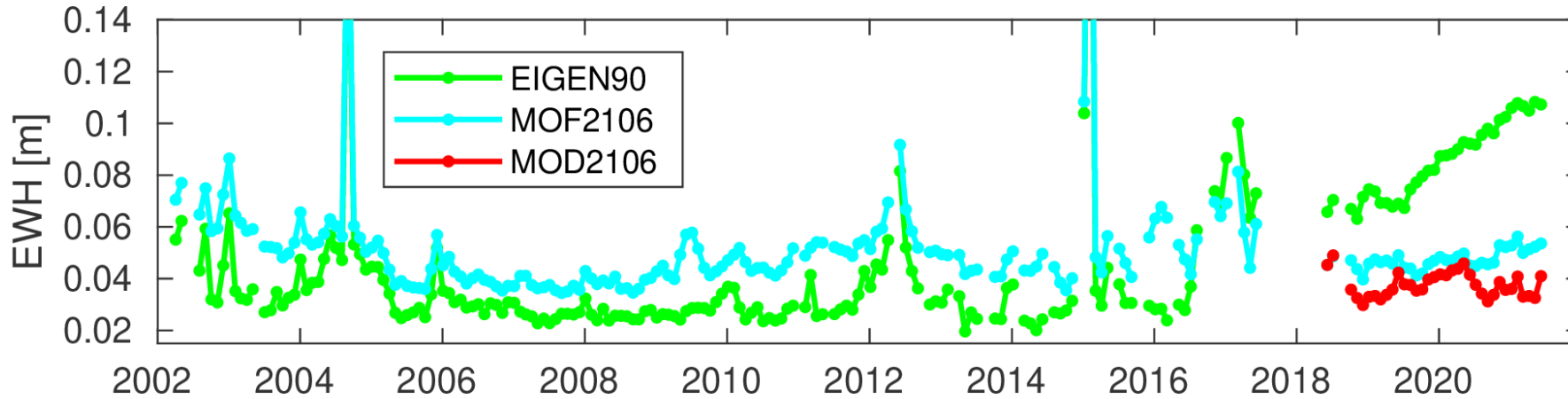


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Fitted Signal Model (FSM) for operational LEO-POD

RMS of differences (over land, 300 km Gauss): FSM - monthly gravity fields



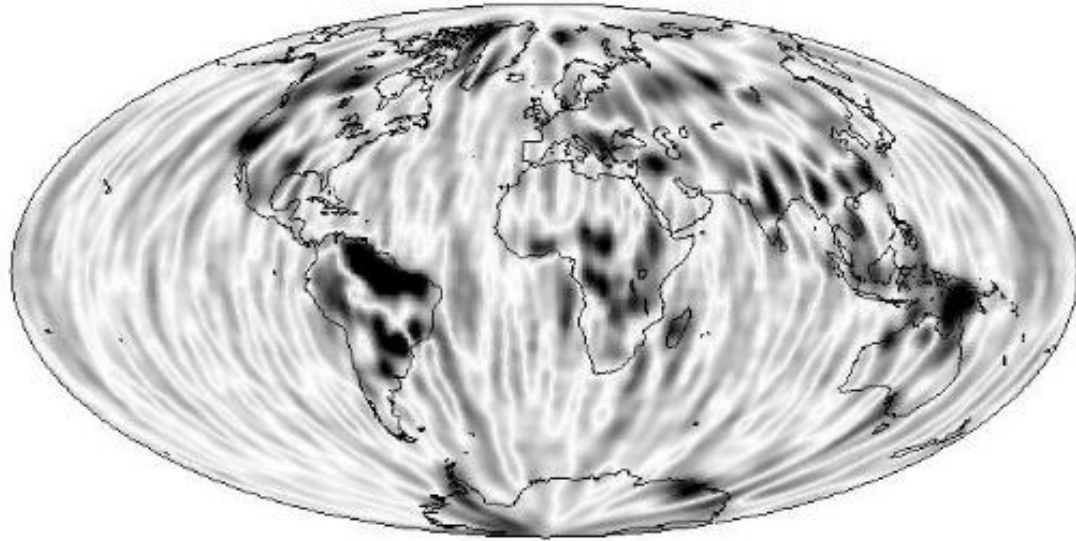
Operational precise orbit determination (POD) of low Earth orbiters (LEO) relies on a Earth gravity model including time-variable gravity (TVG).

The EIGEN-GRGS-RL04 model (green) has been the standard for LEO-POD of altimeter satellites, but the extrapolation to the GRACE-FO period reveals large prediction errors.

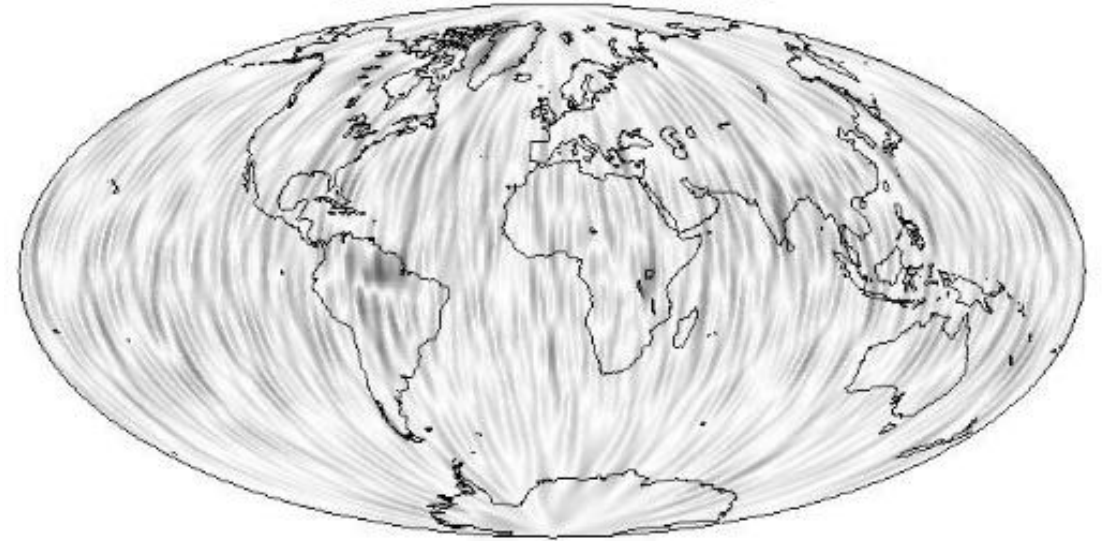
For comparison, a model fitted to COST-G GRACE-FO gravity fields is shown (red).

Localization of differences (300 km Gauss): FSM - monthly gravity fields

EIGEN90 - MONTHLY

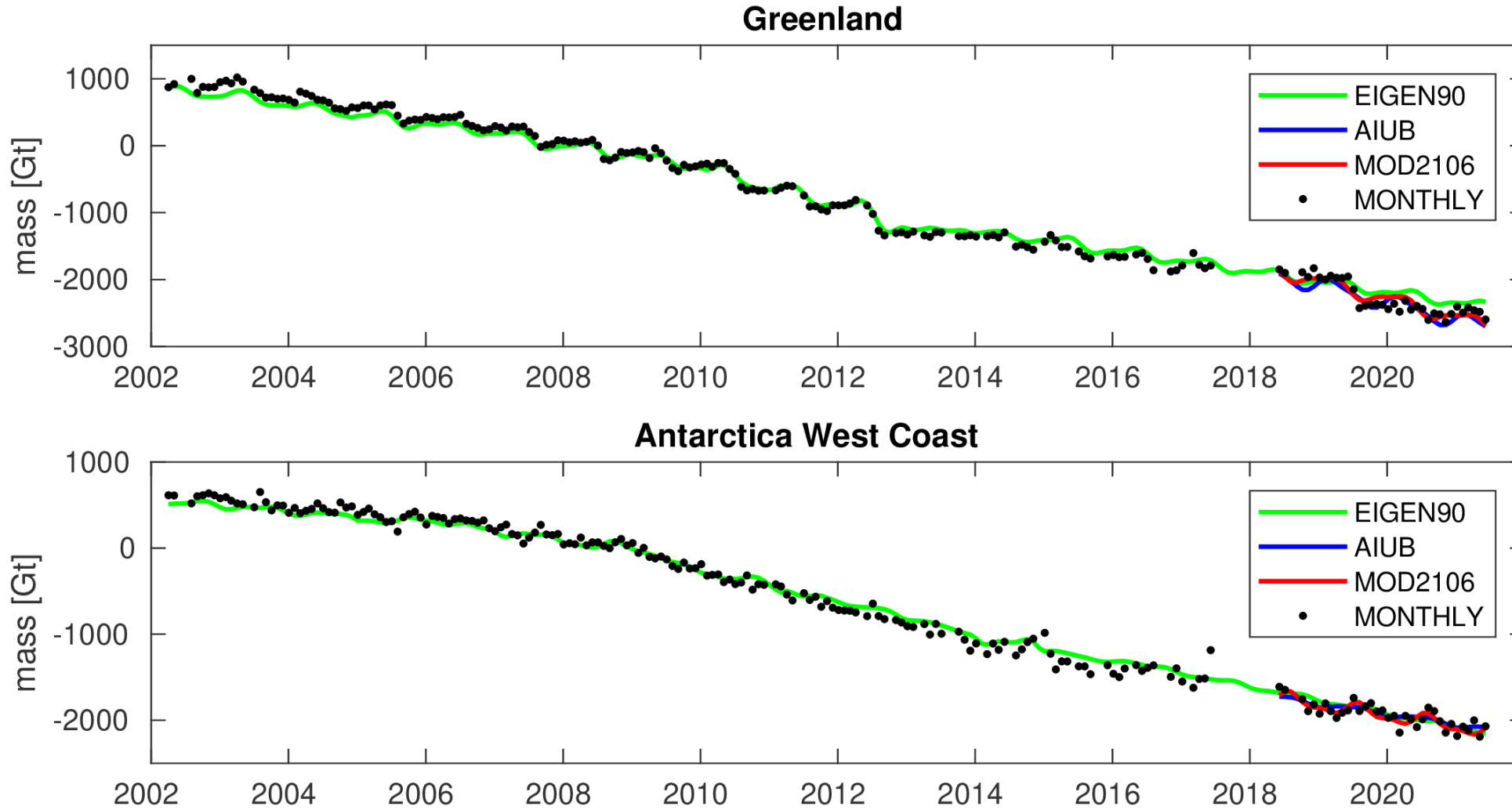


MOD2106 - MONTHLY



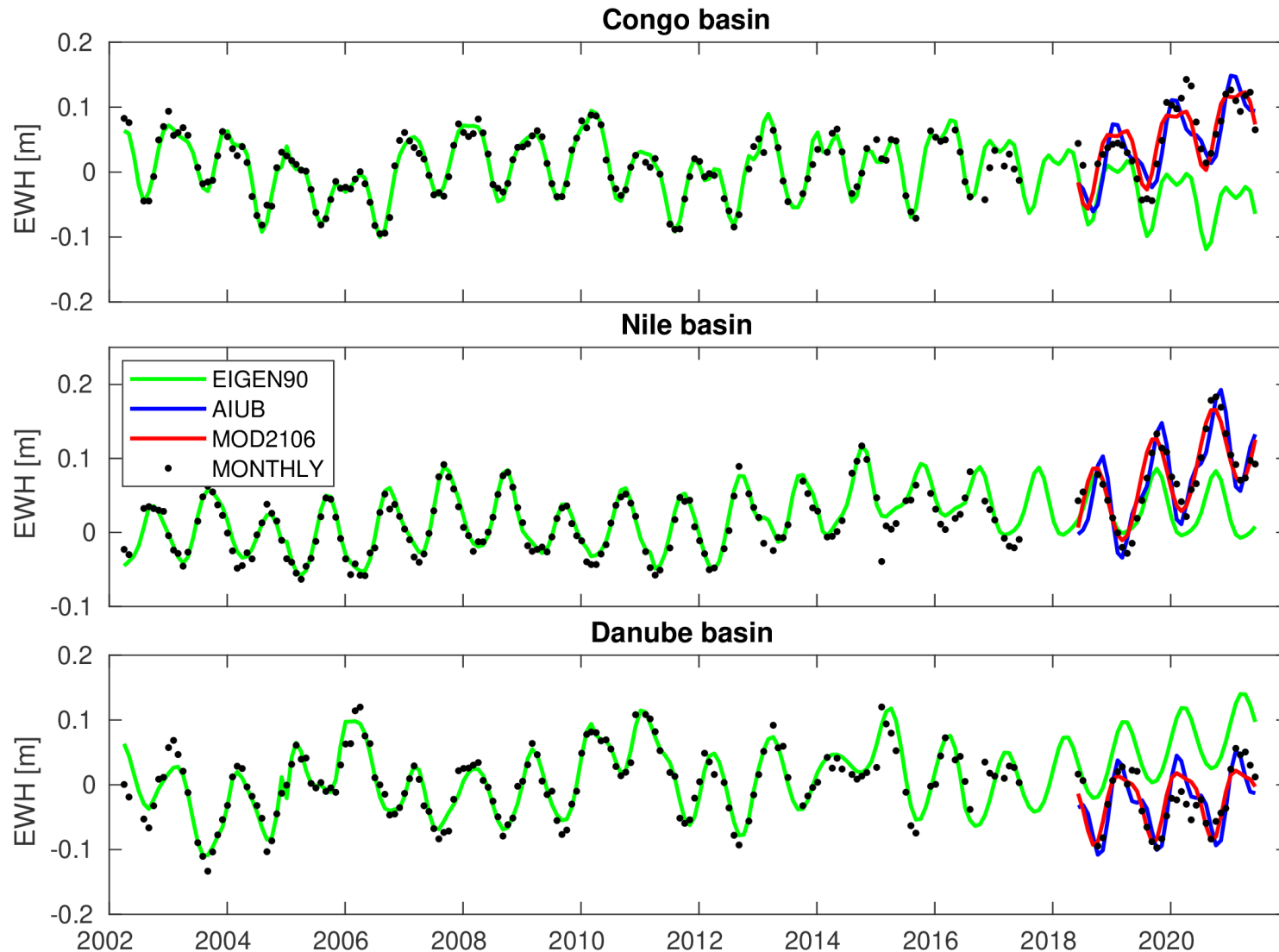
Differences are not restricted to areas of strong mass trends (polar), but mainly occur in areas of large seasonal variations.

Polar mass trend (no filter)



Surprisingly, the reason for the prediction error in the EIGEN-GRGS-RL04 model (green) seems not to be in regions with strong mass trends.

Hydrological cycle in large river basins (300 km Gauss)

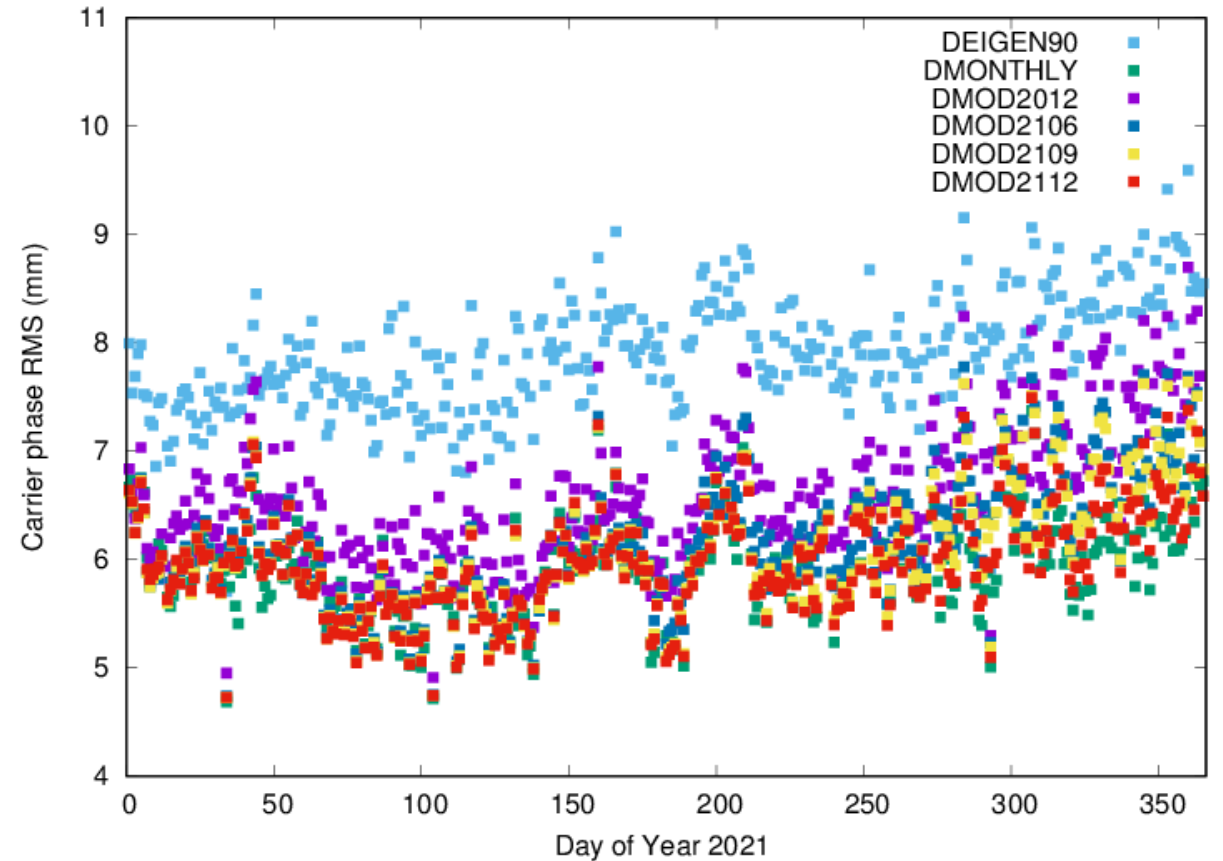
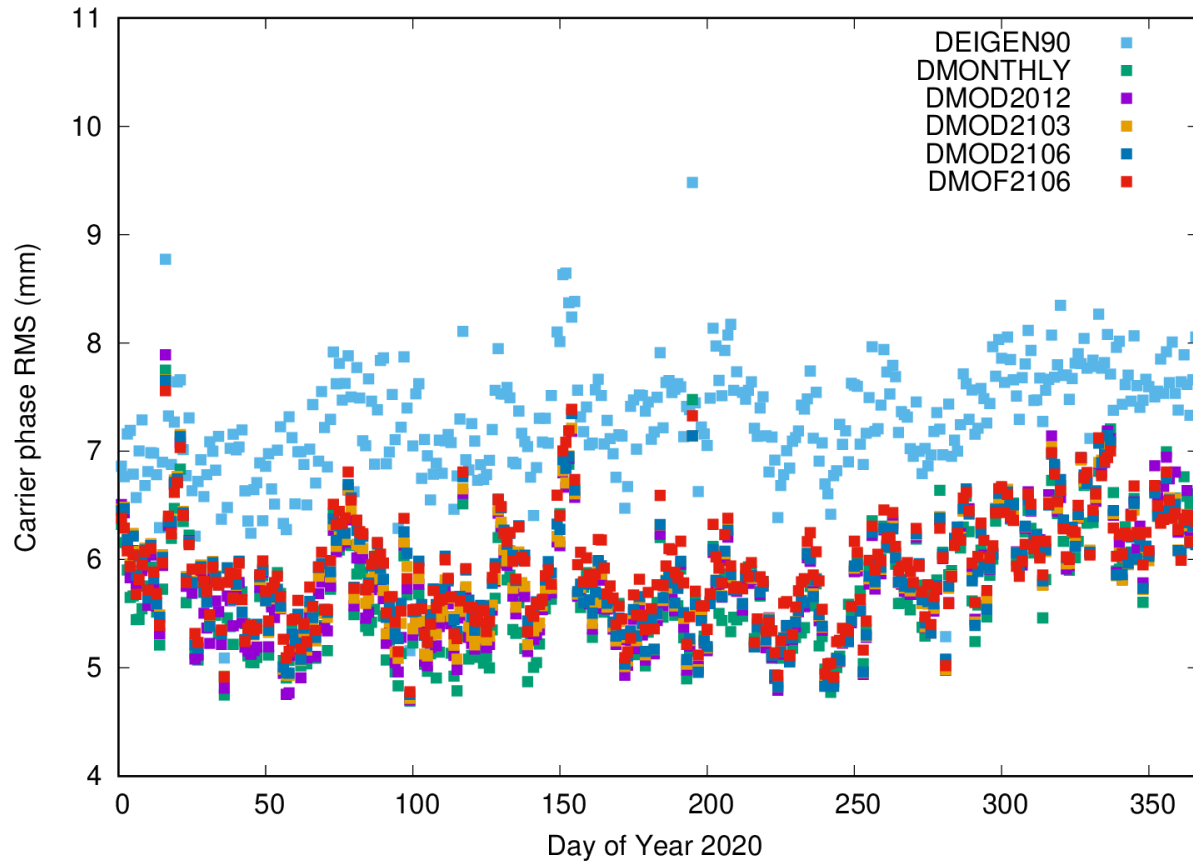


The time-series of monthly GRACE gravity field solutions was fitted in yearly batches for the EIGEN-GRGS-RL04 model.

While the fit in the GRACE period is very good, the extrapolation of the last of these batches leads to large errors in river basins with strong non-seasonal variations.

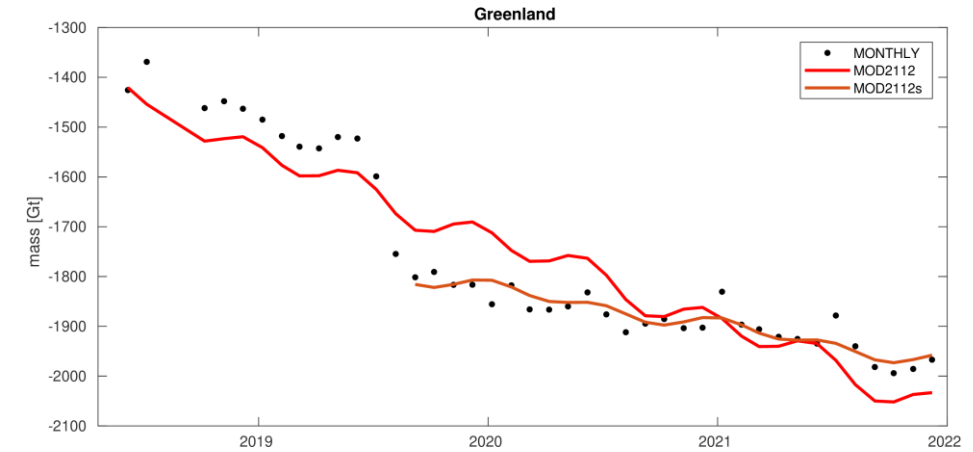
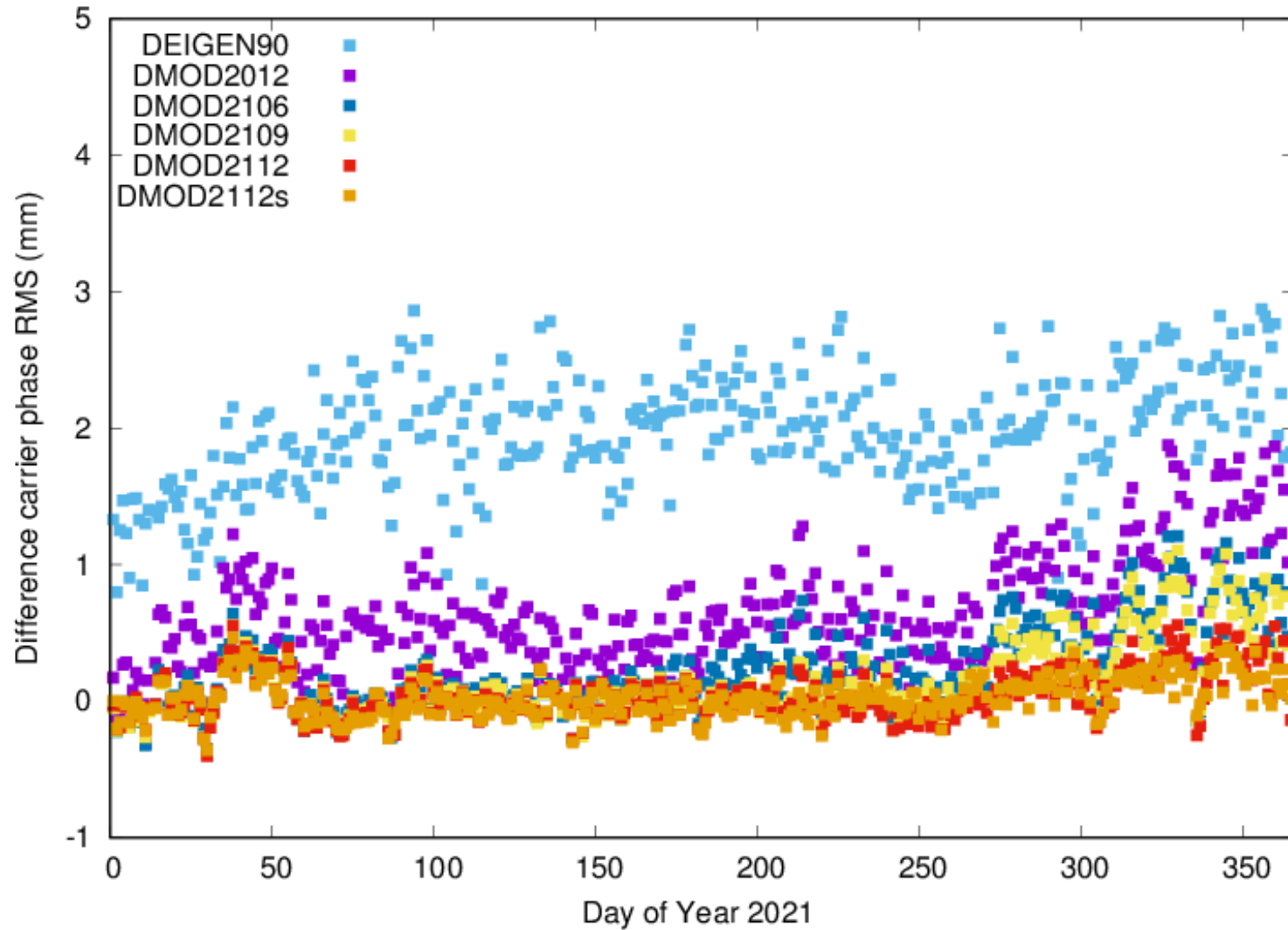
Application to Sentinel orbit POD

Sentinel - 3B (altitude 811 km) orbit determination



The carrier phase RMS of dynamic Sentinel-3B satellite orbits (orbit altitude 811 km) based on monthly GRACE-FO gravity fields (green) or different fitted signal models reveals the benefit of up-to-date models. All models were truncated at max. degree/order 90.

Impact of fit period on LEO-POD (Sentinel-3B, altitude 811 km)



Carrier phase residuals of Sentinel-3B orbits (811 km orbit altitude) confirm the sensitivity on the data period that entered the model.

Independent orbit validation by Satellite Laser Ranging (SLR)

Data: Year 2020, Sentinel-3B, SLR validation, 12 stations (cm)

Gravity field model	Mean (cm)	RMS (cm)	Standard deviation (cm)
DEIGEN120	0.29	1.01	0.97
DEIGEN90	0.29	1.01	0.97
D90MONTHLY	0.28	0.91	0.87
D90MODEL2012	0.28	0.92	0.88
RDEIGEN120	0.31	0.91	0.85
RDEIGEN90	0.31	0.91	0.85
RD90MONTHLY	0.31	0.88	0.82

The limited max. degree does not negatively affect LEO POD (S3B)

LEO POD profits from monthly gravity fields

The fitted signal models perform close to the monthly gravity fields

Reduced dynamic LEO POD is less sensitive to model deficiencies.

GOCE (250 km) orbit fits

Mean 3D-RMS values [cm] of the GOCE orbit fit residuals:

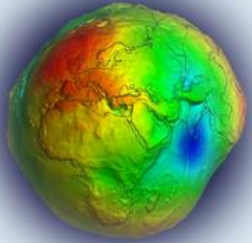
- Beyond degree 90 the monthly gravity fields are filled up to d/o 240 by the coefficients of the static gravity field model GOCE-DIR-6

Model/Month	March			April			June			December		
	2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021
COST-G FSM	5,53	5,77	6,30	5,37	5,72	6,39	5,39	5,86	6,63	5,48	6,05	7,78
COST-G operational	6,42	7,10	7,27	6,36	7,06	7,84	6,40	7,36	7,62	6,94	7,51	7,57
COST-G G3P	5,92	6,76	6,79	5,99	6,55	7,30	5,85	6,68	6,86	6,38	6,77	7,21
ITSG operational	5,94	6,95	7,11	5,93	6,69	7,08	5,68	6,33	6,77	6,17	6,95	7,36

- G3P => COST-G GRACE-FO RL02
- Significant noise reduction in COST-G FSM for lowest LEO-POD!



Where to get the COST-G fitted signal models?



ICGEM



Gravity Field Solutions for dedicated Time Periods

The following gravity field time series are presently available:

GRACE and Grace-FO solutions from the Science Data System centers CSR, GFZ and JPL				collapse all
- CSR				Center for Space Research at University of Texas, Austin
CSR Release 05		monthly	UTCSR Level-2 Processing Standards Document, Rev 4.0 May 29, 2012	
CSR Release 06	DOI	monthly	UTCSR Level-2 Processing Standards Document, Rev 5.0 April 18, 2018	
CSR Release 06 (GFO)	DOI	monthly	UTCSR Level-2 Processing Standards Document, V 1.1 June 6, 2019	
- GFZ				Helmholtz Centre Potsdam German Research Centre for Geosciences
GFZ Release 05		monthly	weekly	GFZ GRACE Level-2 Processing, Revised Edition, January 2013
GFZ Release 06	DOI	monthly		GFZ GRACE Level-2 Processing Standards Document for Level-2 Products, Rev. 1.0, October 26, 2018
GFZ Release 06 (GFO)	DOI	monthly		GFZ GRACE Level-2 Processing Standards Document for Level-2 Products, Rev. 1.0, June 3, 2019
- JPL				Jet Propulsion Laboratory
JPL Release 05		monthly		JPL Level-2 Processing Standards Document, Release 05.1 November 3, 2014
JPL Release 06	DOI	monthly		JPL Level-2 Processing Standards Document, Release 06.0 June 1, 2018
JPL Release 06 (GFO)	DOI	monthly		JPL Level-2 Processing Standards Document, v 1.0 May 28, 2019

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
DSM		quarterly	Deterministic Signal Model	
Grace	DOI	monthly		
Grace-FO	DOI	monthly		
Swarm	DOI	monthly		

icgem (at) gfz-potsdam.de

The COST-G fitted signal model is available in the ICGEM.2-format from the International Center for Global Earth Models (ICGEM): <http://icgem.gfz-potsdam.de/series>

The COST-G FSM is updated quarterly with the newest combined monthly GRACE-FO gravity fields.

ICGEM Home

Gravity Field Models

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Calculation Service

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Evaluation

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GNSS Leveling



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