Combination Service for Time-variable Gravity Models

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

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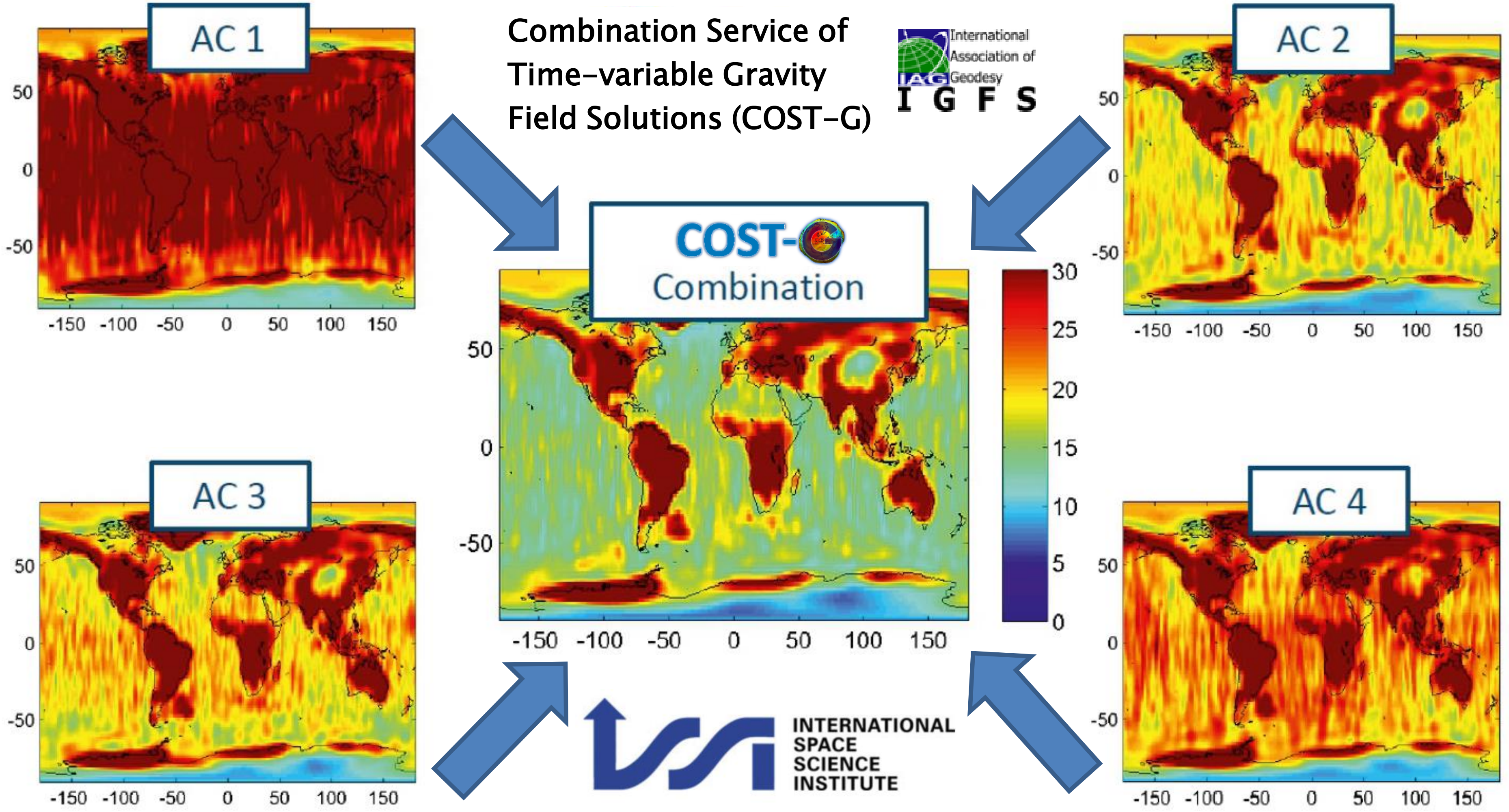
POSITIM

Content

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

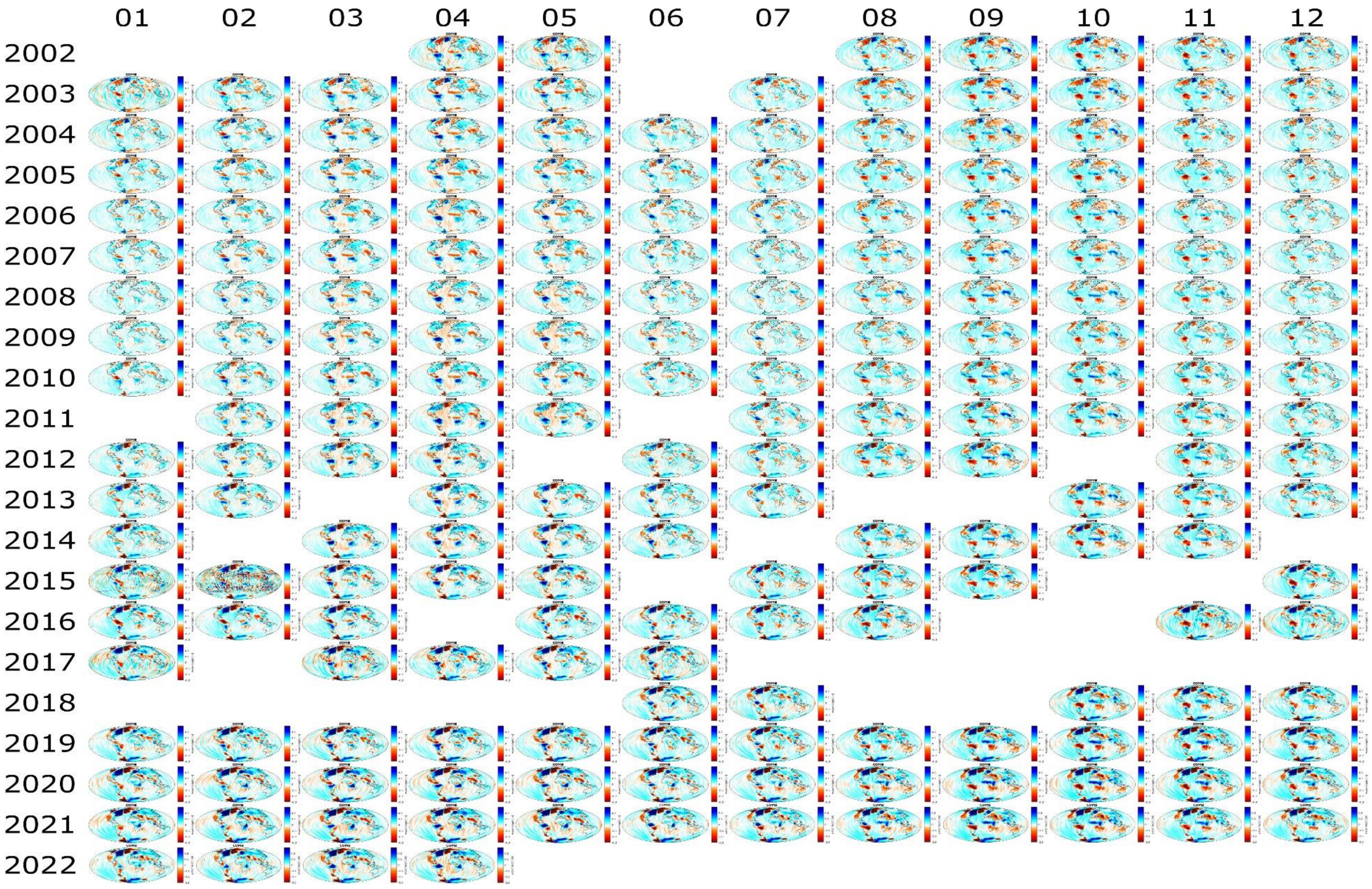
Combination Service for Time-variable Gravity Fields (COST-G)

Introduction to COST-G



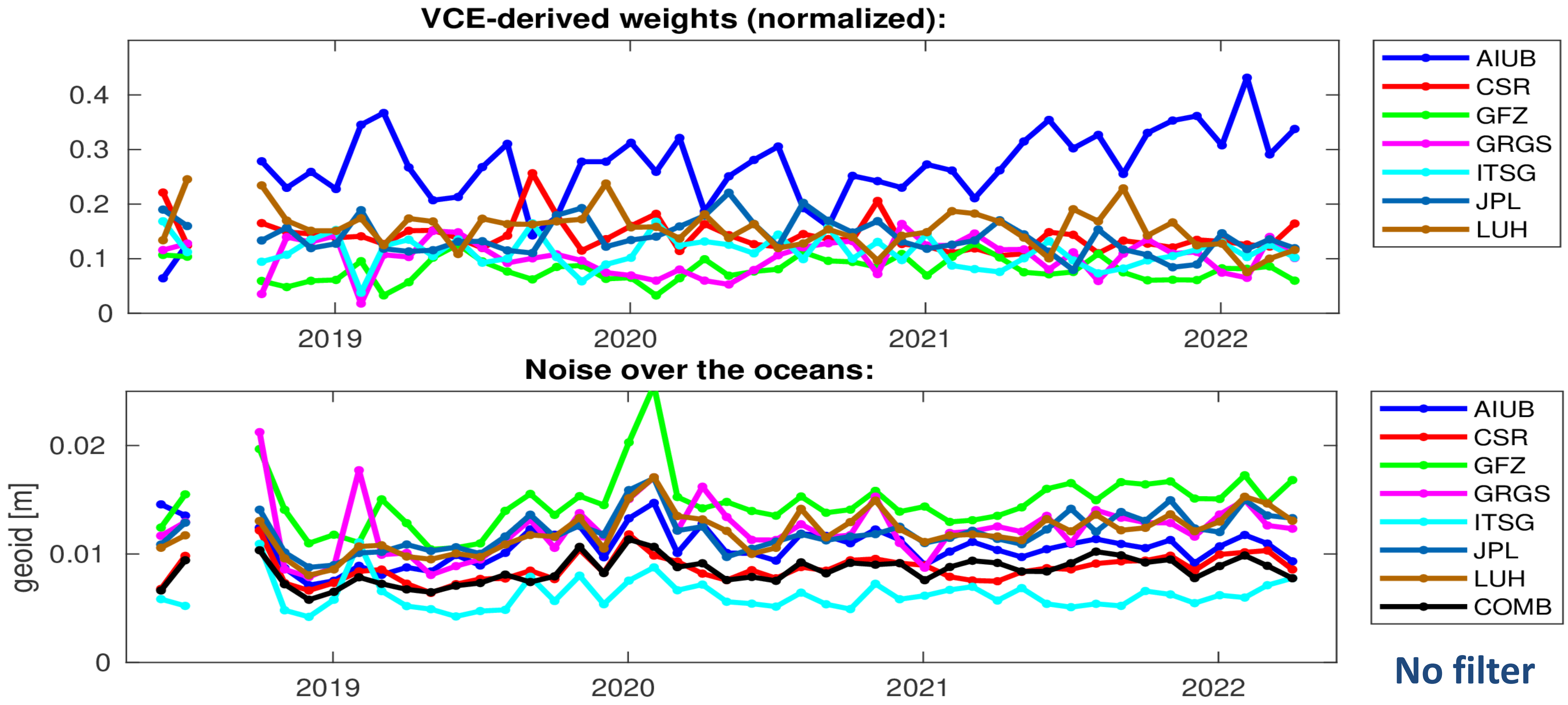
Improved and consolidated product integrating the strengths of all ACs

GRACE-FO operational combined monthly gravity fields



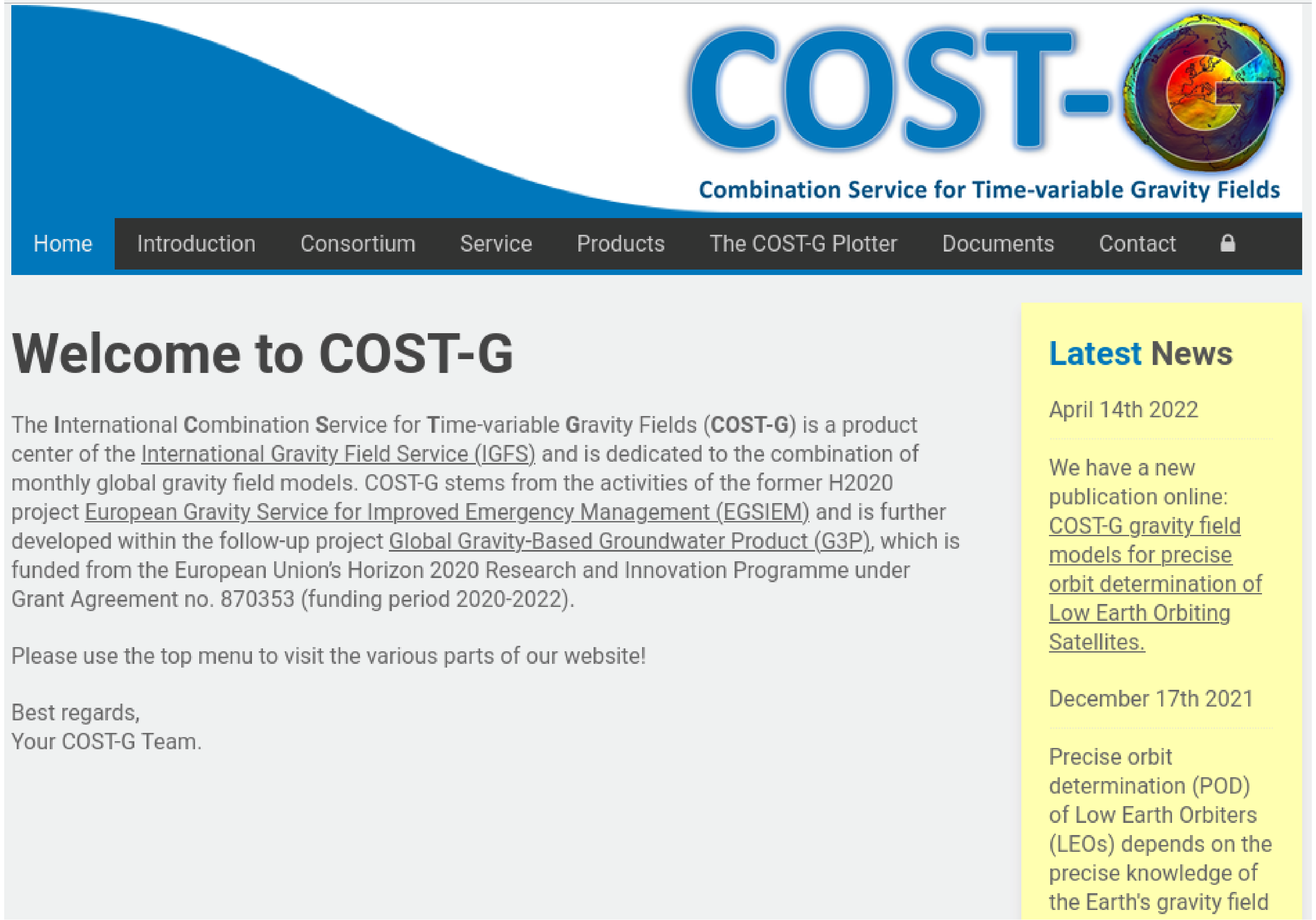
Flawless and uninterrupted operational combination with a latency < 3 months.

Weighted combination and validation of the Combined Solution



No filter

https://cost-g.org/

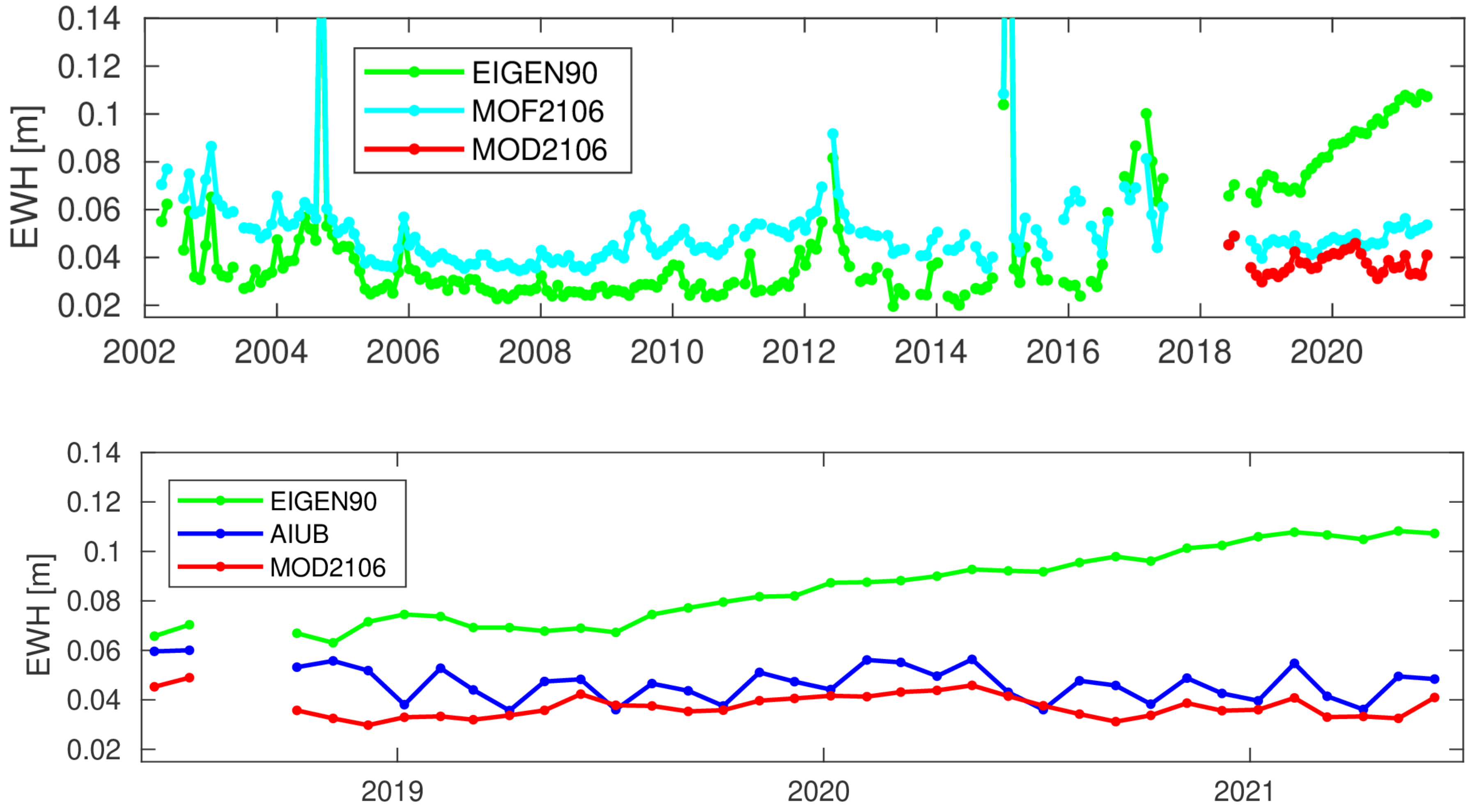


For background information on COST–G and links to products take a look at: https://cost-g.org/

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

Fitted Signal Model (FSM) for operational LEO-POD

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

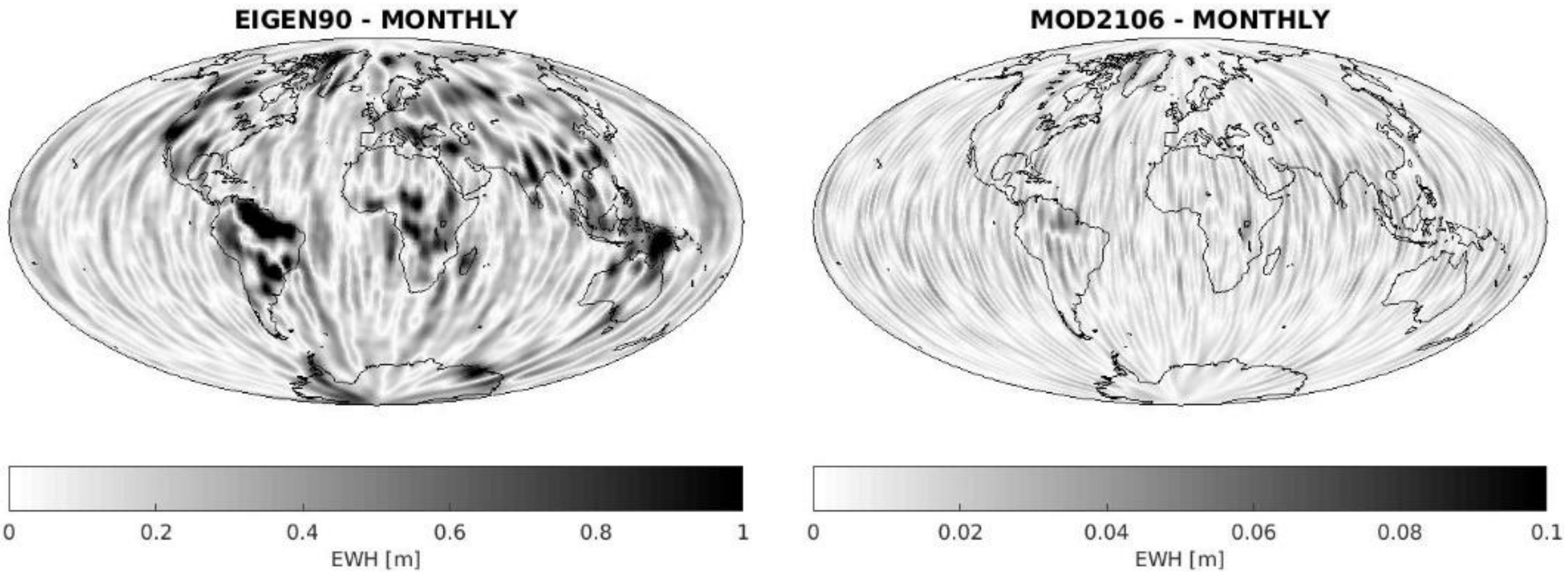


Operational precise orbit determination (POD) of low Earth orbiters (LEO) relies on a Earth gravity model including time-variable gravity (TVG).

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.

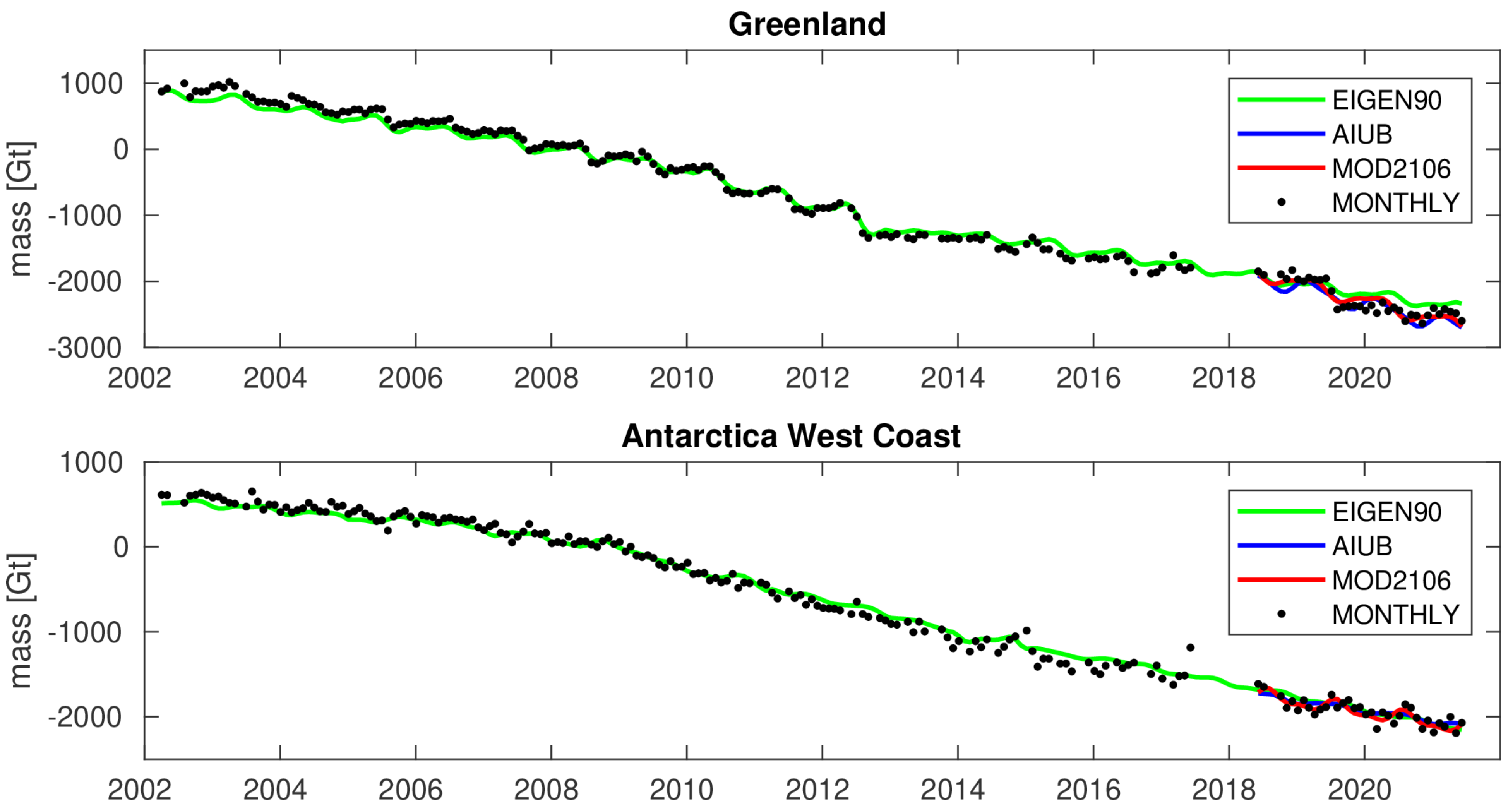
For comparison, a model fitted to COST-G GRACE-FO gravity fields is shown (red).

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



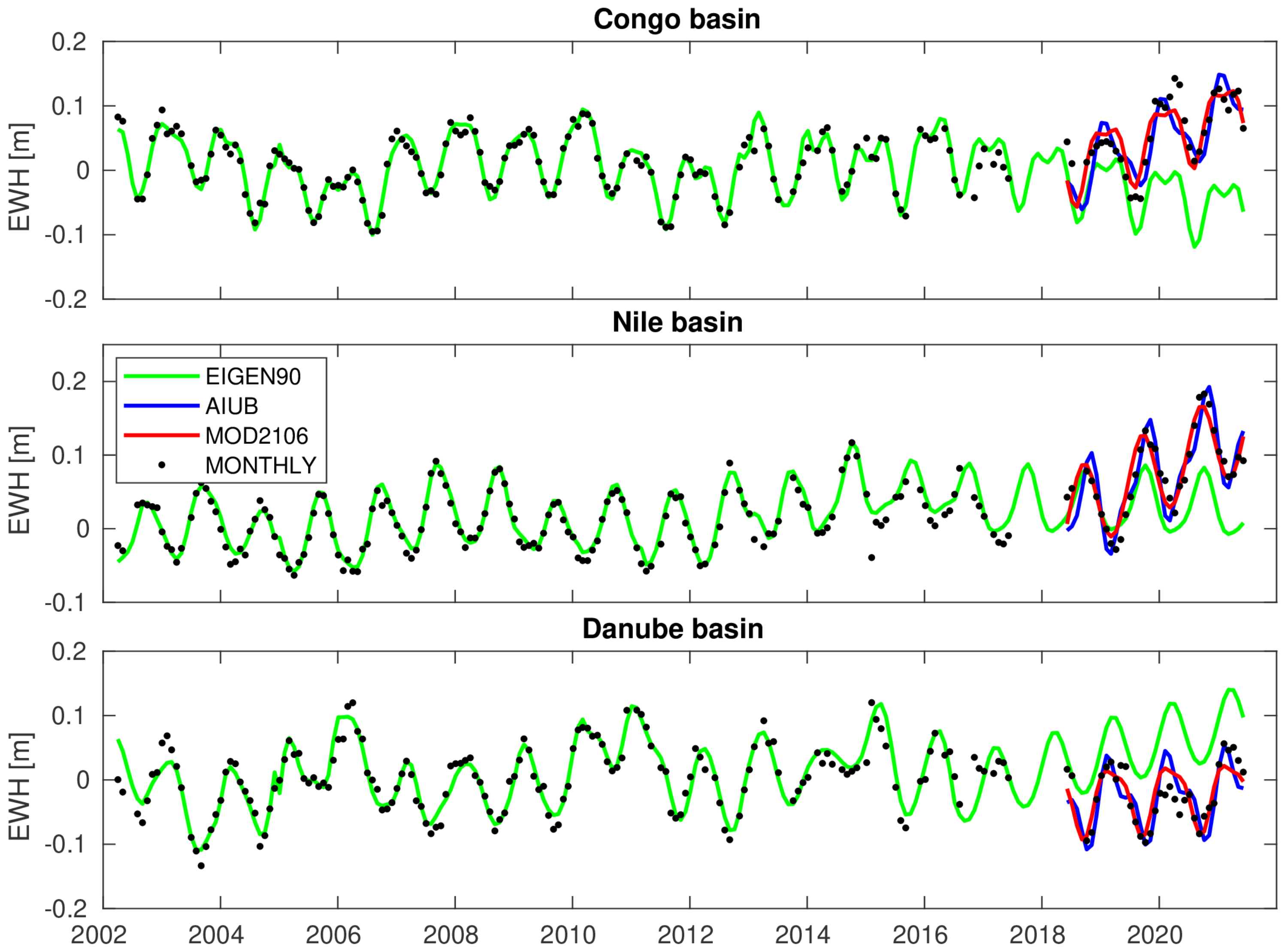
Differences are not restricted to areas of strong mass trends (polar), but mainly occur in areas of large seasonal variations.

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)

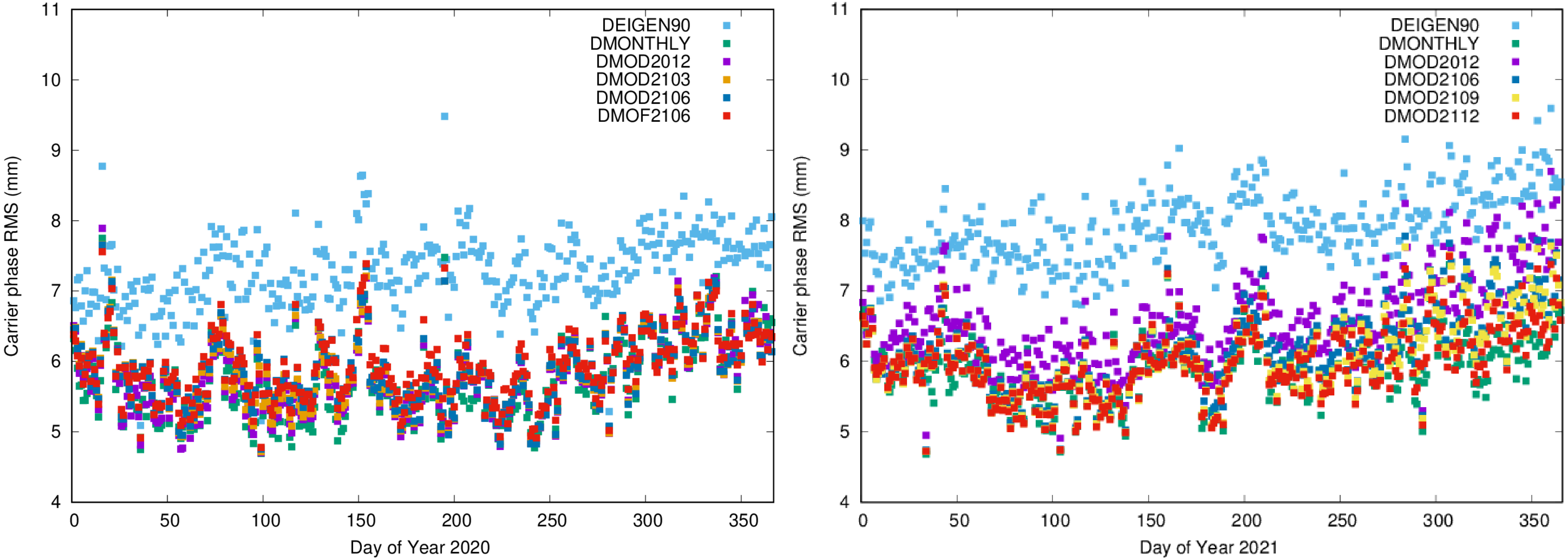


The time-series of monthly GRACE gravity field solutions was fitted in yearly batches for the EIGEN-GRGS-RL04 model.

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.

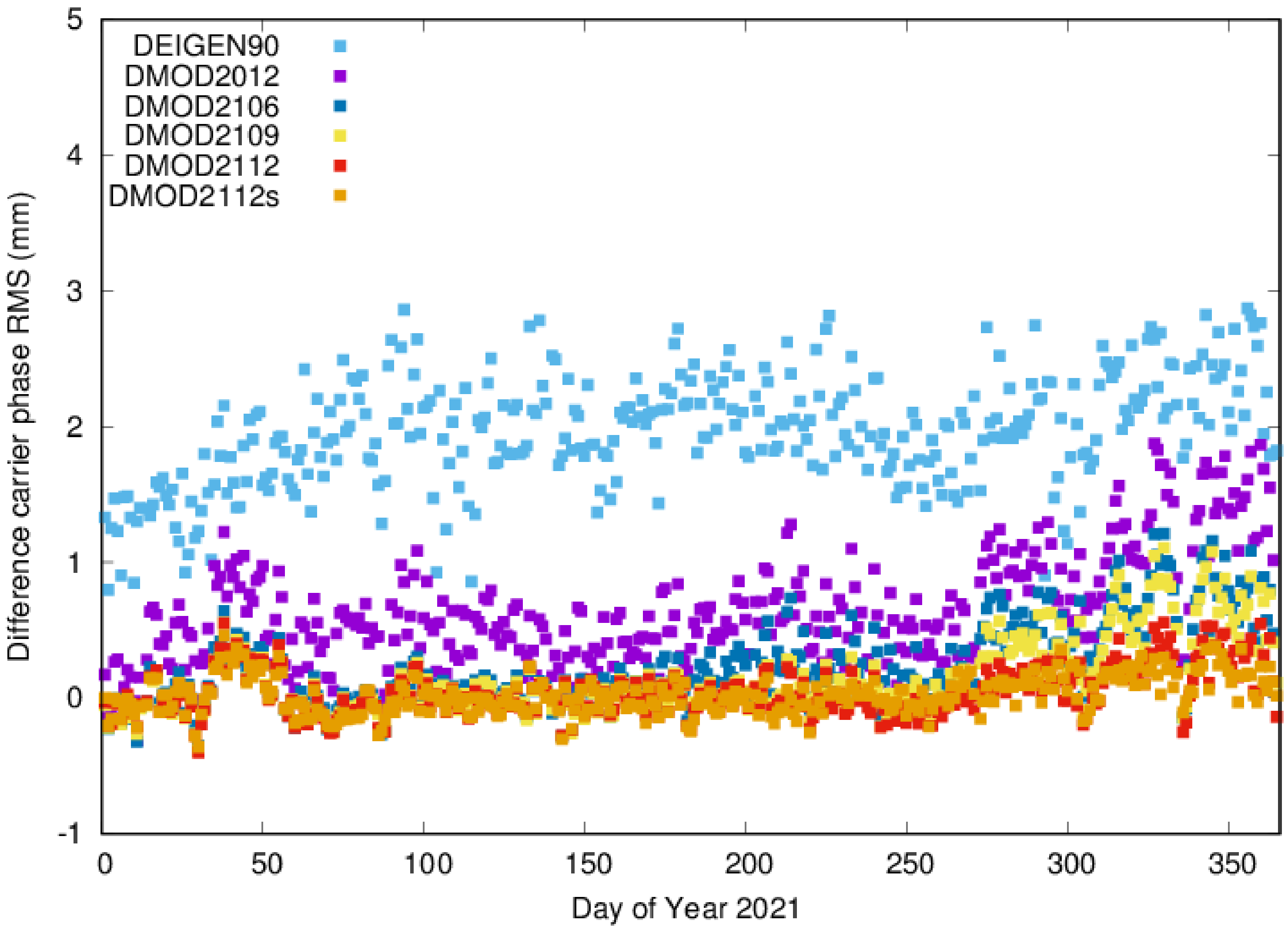
Application to Sentinel orbit POD

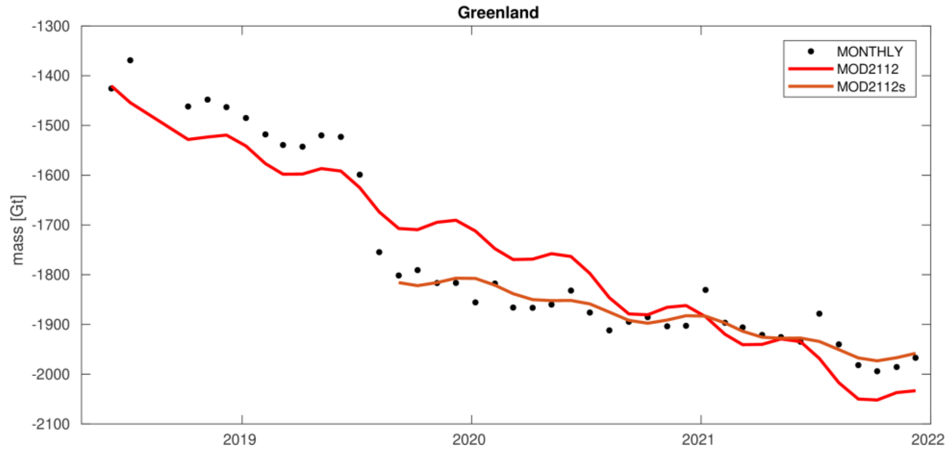
Sentinel - 3B (altitude 811 km) orbit determination



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

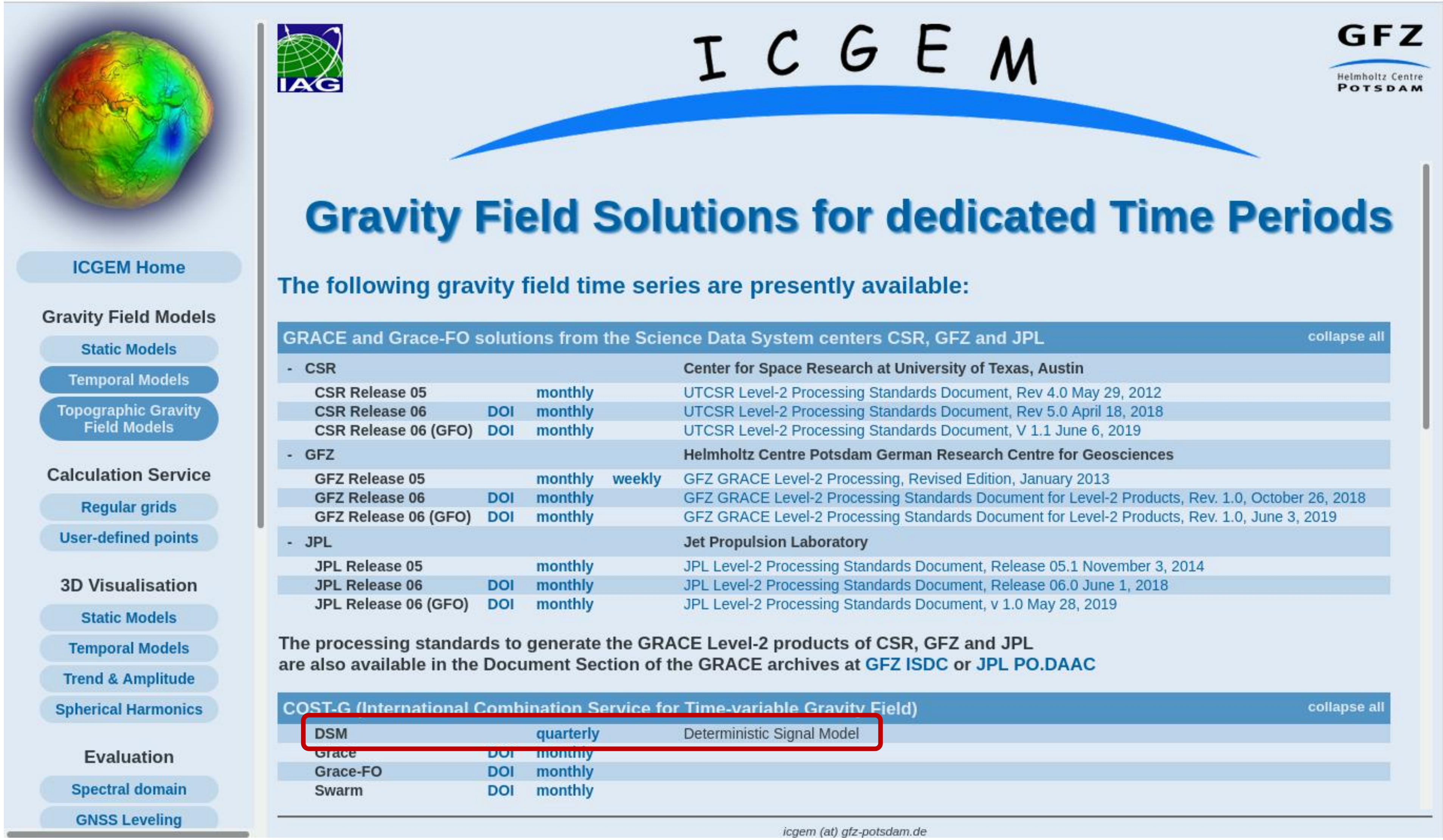
Mean 3D-RMS values [cm] of the GOCE orbit fit residuals:

- 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

	March			April			June			December		
Model/Month	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

ICGEM Home

Gravity Field Models
- Static Models
- Temporal Models
- Topographic Gravity Field Models

Calculation Service
- Regular grids
- User-defined points

3D Visualisation
- Static Models
- Temporal Models
- Trend & Amplitude
- Spherical Harmonics

Evaluation
- Spectral domain
- GNSS Leveling

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.