ICGEM Service Developments: New functionals, altimetry, new data representations and infrastructure

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ICGEM

International Centre for Global Earth Models, a service of the International Association of Geodesy, has been collecting and distributing quality-checked global gravity field models (GGMs) with a possibility of assigning DOI number.
Furthermore, it offers calculation and visualization services, enabling researchers to process and graphically represent the GGMs.
With more than 20 years of experience; now the service takes initiative to grow and fulfill the requirements of today's scientific needs and reach excellence in delivering scientific products and outreach scientists via the SAMDAT project.

Why reforming the ICGEM matters!

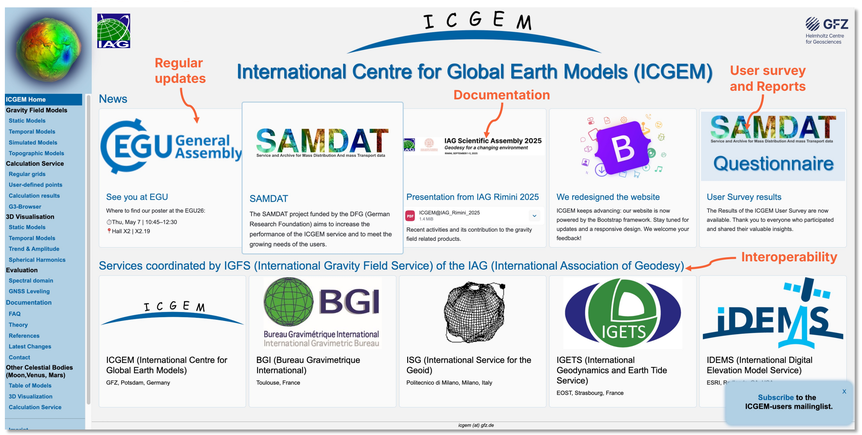
Increasing the current capabilities of the ICGEM service **responds state-of-the-art developments** and **demands by the users**.

Integrating with other IAG services and international platforms via metadata enrichment to provide a more **supportive** and **interoperable** data platform to users.

Modernized service helps maintaining and delivering not only a sustainable and open-access **GGM data archive** but also other **essential geodetic products** for interdisciplinary research.

Enhanced calculation service and documentation helps reaching out **broader scientific communities** and extending the **support for education, science, and society**.

New Webpage Design



SAMDAT

The Service and Archive for Mass Distribution And mass Transport data project expands the ICGEM service to a sustainable data and information center.
New types of GGMs and representations will be made available together with metadata scheme that is carefully designed for global gravity field models.
Highly requested geodetic products that are essential for geophysical and oceanographic research will also be delivered via a newly designed data portal.
The project supports the FAIR data principles, is the basis for an online portal, and enriches and harmonizes DOI metadata.

SAMDAT project in a nutshell

Sustainable Data & Information Center

New gravity field related data types

Global high-resolution models in different representations

Data reliability and quality-assurance tool

Metadata enrichment and standardisation

Improved DOI Service

Metadata Elements and Data Standards

PID + controlled vocabularies

A) New Gravitational Functionals

Two new gravitational functionals for calculating complete Bouguer and isostatic gravity anomalies have been integrated into the ICGEM Calculation Service.

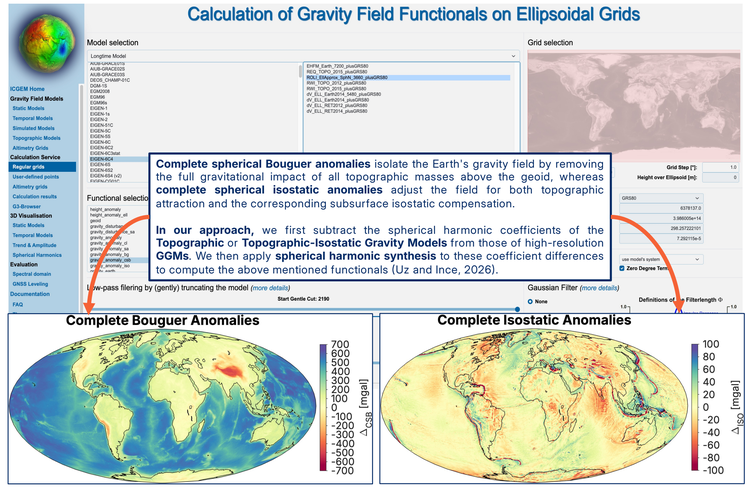


Figure A1: Complete Bouguer Anomalies (left) and Isostatic Anomalies (right) that are calculated using EIGEN-6C4 (Förste et al., 2014) and ROLI_EllApprox_SphN_3660 (Abrykosov et al., 2019) andRWI_TOIS_2012 (Grombein et al., 2014) topographic gravity models, respectively.

C) Truncation Error

The ICGEM calculation service allows to truncate a GGM at any degree n_{trunc}, but the truncation in spherical harmonics (SH) can lead to truncation errors of multiple cm (see Fig. C1). A solution is to transform the GGM to ellipsoidal harmonics (EH), truncate, and transform it back to SH, before it's used for the calculation.

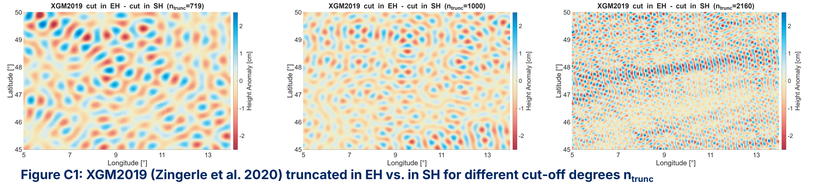


Figure C1: XGM2019 (Zingerle et al. 2020) truncated in EH vs. in SH for different cut-off degrees n_{trunc}

The errors from truncating the model in SH can also be observed when compared with gravity data (Fig. C2).
The transformation from EH to SH results in SH coefficients exceeding n_{trunc}. Typically, 30-50 additional degrees are necessary to account for the relevant signal (see Fig. C3).

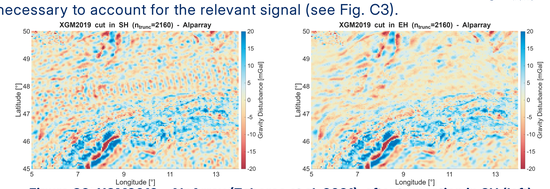


Figure C2: XGM2019 - AlpArray (Zahorec et al. 2021), after truncation in SH (left) and EH (right)

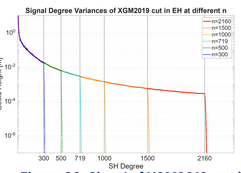
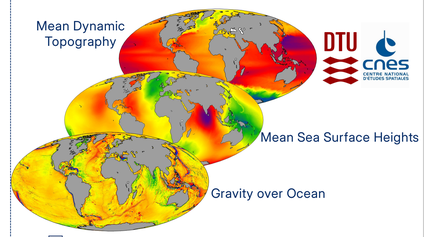


Figure C3: Signal of XGM2019, cut in EH and transformed back to SH

B) Altimetry-derived Gravity Data

Aiming to establish a centralized database for altimetry-derived gridded gravity anomalies for collection, evaluation, and combination of oceanic gravity data provided by various institutions

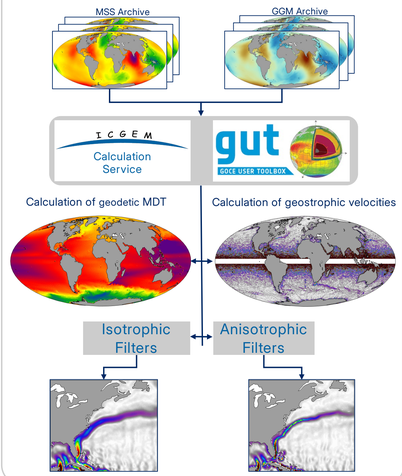


Collect → Compare → Calculate → Deliver

This service will provide a **processing engine** that is powered by the **ESA GOCE User Toolbox** (GUT, 2026). It includes filtering of calculated geodetic MDT for optimized spatial resolution and to mitigate noise in both open and shallow waters.

New calculation service for Mean Dynamic Topography

The MDT calculation service directly integrates quality-assured GGMs with systematically collected MSS datasets and offers filtering for geostrophic velocities.



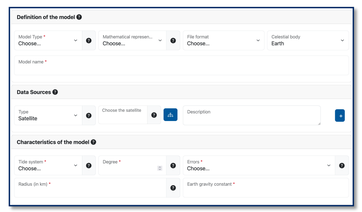
D) Metadata Editor and data portal

Enhanced metadata lifecycle: From systematic metadata collection to the display on the website.

DOI assignment via GFZ Data Services is built-in into model publication on the ICGEM.

How to increase the Findability and Accessibility of the gravity field model?

Step 1: provide the bibliometric data and gravity-specific variables using the **metadata editor**



All models can be:

- filtered by the metadata key properties
- searched using free text across all properties

Step 2: find and access your model on the **data discovery portal**:

Filter parameters:

Model type:
- Static models
- MASCONs
- Altimetry models
- Temporal models
- Topographic models

Mathematical representation:
- Spherical harmonics
- Ellipsoidal harmonics

Data sources
- Satellite only
- With ground data
- With topographic data

Year: 1960 – 2026

Degree: 50 – 5000

Search: by name, keywords, authors, ...

Optional: request a DOI via GFZ Data Services

The metadata is recorded in inter-operable format following well-defined structure

The record is stored in the database for the long-term

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