The IGFS gravity field observations and products contributions to GGOS infrastructure

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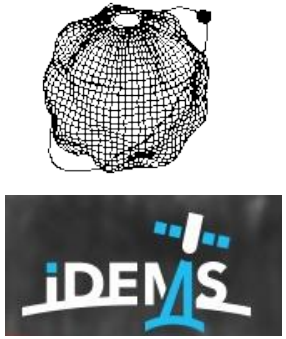
[3]Observatoire Midi-Pyrénées, Toulouse, France

[4]GFZ, Potsdam, Germany

[5]AIUB, Bern, Switzerland

[6]BKG, Leipzig, Germany

[7]ESRI, Redlands CA, USA



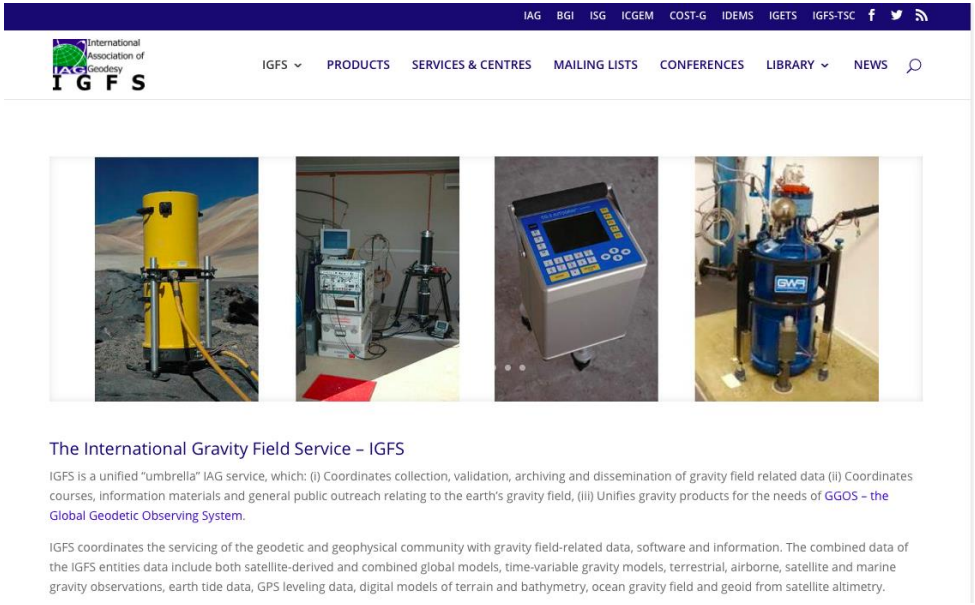
EGU2020 General Assembly

Vienna, Austria, May 4-8, 2020

The International Gravity Field Service (IGFS)

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

Director : Riccardo Barzaghi - CB Director: Georgios S. Vergos

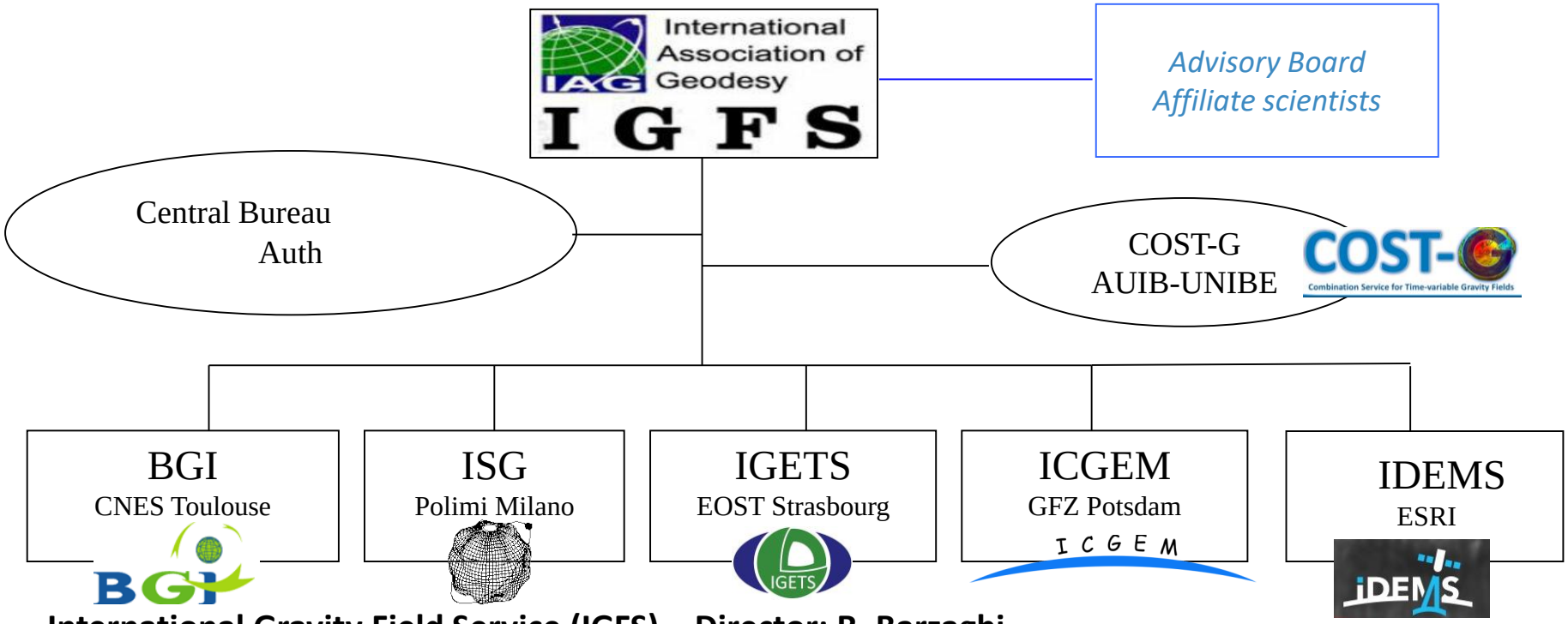


Main IGFS tasks

IGFS is an "umbrella" IAG Service which :

- Coodinates collection, validation, archiving and dissemination of gravity field related data
- Coordinates courses, information materials and general public outreach relating to the Earth's gravity field
- Unifies gravity products for the needs of GGOS

The IGFS structure



International Gravity Field Service (IGFS) – Director: R. Barzaghi

Central Bureau – Director: G.S. Vergos

International Gravimetric Bureau (BGI) – Director: S. Bonvalot

International Center for Global Earth Models (ICGEM) – Director: E. S. Ince

International Service for the Geoid (ISG) – President: M. Reguzzoni; Director: D. Carrion

International Geodynamics and Earth Tide Service (IGETS) – Director: H. Wziontek

International DEM Service (IDEMS) – K.Kelly

International Combination Service for Time-variable Gravity field solutions (COST-G) – A. Jäggi

IGFS&GGOS

- *IGFS representatives attended GGOS meetings*:
- ✓ GGOS Days Meetings, Frankfurt, Germany (October 21st-23rd, 2015)
- ✓ GGOS Days Meetings, Cambridge, USA (October 24th-27th, 2016)
- ✓ GGOS Bureaus meetings held in San Francisco (during AGU 2015, 2016)
- ✓ GGOS Bureaus meetings held in Vienna (during EGU 2016, 2017, 2018, 2019)

IGFS participates into the activities of the GGOS Focus area on "Unified Height System" for establishing the IHRS/IHRF ***(participation to a JWG on IHRS/IHRF in the next four years term)***

IGFS is participating in the definition of the Essential Geodetic Variables (gravity)

Main activities of the Gravity Services

Data/Products contributions to GGOS

Bureau Gravimetrique International (BGI)

(http://bgi.obs-mip.fr)

Director : Sylvain Bonvalot

Main BGI tasks

- To collect, on a world-wide basis, all gravity measurements and pertinent information about the gravity field of the Earth
- To compile and store them in a computerized data base
- To redistribute them on request to a large variety of users for scientific purposes.

The new International Gravity Reference System

BGI & IGETS Services
(existing databases in cooperation with BKG)

Providing a **long term & precise absolute gravity reference** at given stations (time variable gravity field)

- **Reference stations** with continuous monitoring (Superconducting or Quantum Gravimeter) preferred but no exclusive
- Should also includes
- ✓ **GGOS Core stations :** Link to space geodetic techniques (GNSS, SLR; VLBI)
- ✓ **Comparison sites**: with extended facilities for instrumental comparisons (meter traceability)

Providing a **worldwide infrastructure of absolute gravity values** (static gravity field)

- **Global dense network of AG stations** needs for referencing relative land & marine surveys
- **Progressive replacement of the IGSN71** (mostly based on relative measurements)
- Advantage of **increasing facilities for field AG measurements** (Ex: A10, Quantum ?)
- Expected support and collaboration from National agencies

International Centre for Global Earth Models (ICGEM)

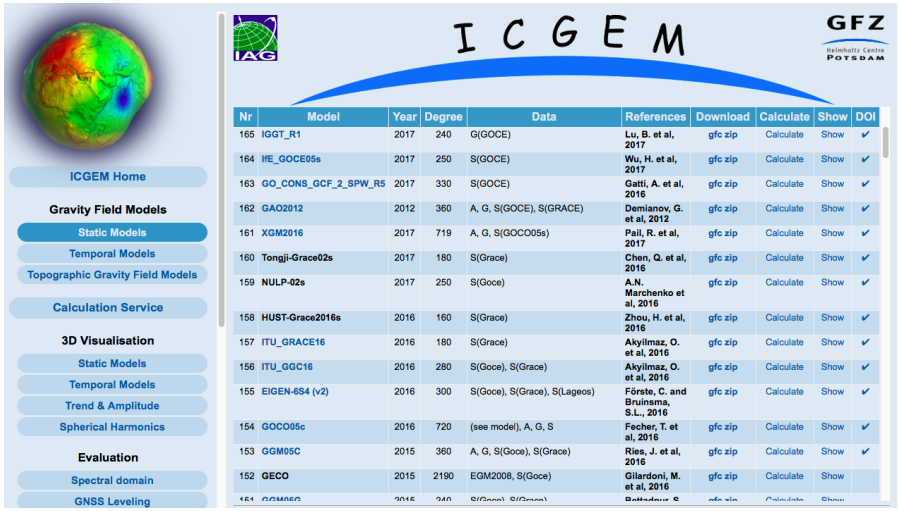
(http://icgem.gfz-potsdam.de/home)

Director : Elmas Sinem Ince

Main ICGEM tasks

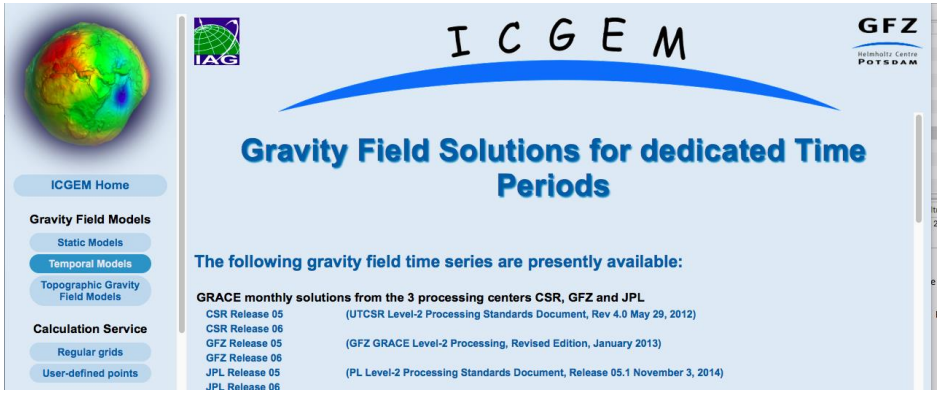
- To collect and long-term archiving of existing global gravity field models
- To use standardized format in storing the models
- To develop tools for the visualization of the models
- To compute solutions from dedicated time periods (e.g. monthly GRACE models)
- To develop web-interface to calculate gravity functionals from the spherical harmonic models on selectable grids/user defined points
- To evaluate the global geopotential models

The available GGM at the ICGEM database

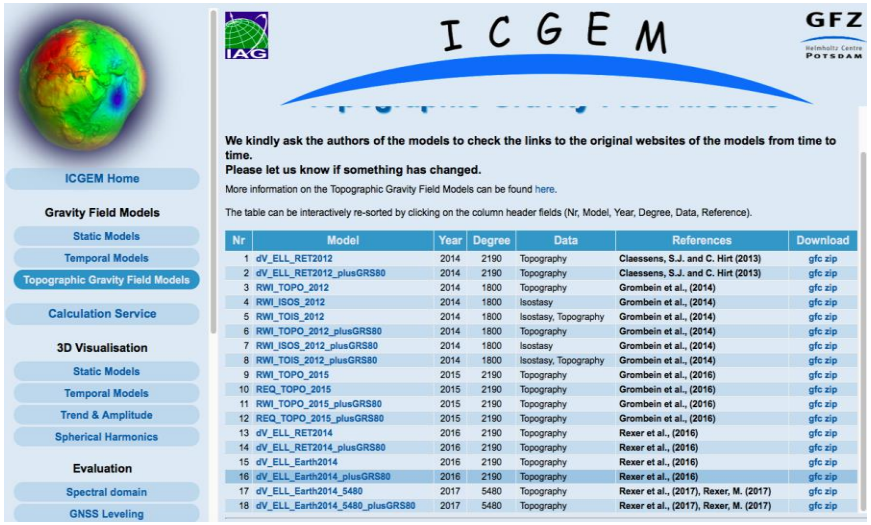


Nr	Model	Year	Degree	Data	References	Download	Calculate	Show	DOI
165	IGGT_R1	2017	240	G(GOCE)	Lu, B. et al, 2017	gfc zip	Calculate	Show	✔
164	IfE_GOCE05s	2017	250	S(GOCE)	Wu, H. et al, 2017	gfc zip	Calculate	Show	✔
163	GO_CONS_GCF_2_SPW_R5	2017	330	S(GOCE)	Gatti, A. et al, 2016	gfc zip	Calculate	Show	✔
162	GAO2012	2012	360	A, G, S(GOCE), S(GRACE)	Demianov, G. et al, 2012	gfc zip	Calculate	Show	✔
161	XGM2016	2017	719	A, G, S(GOCO05s)	Pail, R. et al, 2017	gfc zip	Calculate	Show	✔
160	Tongji-Grace02s	2017	180	S(Grace)	Chen, Q. et al, 2016	gfc zip	Calculate	Show	✔
159	NULP-02s	2017	250	S(Goce)	A.N. Marchenko et al, 2016	gfc zip	Calculate	Show	✔
158	HUST-Grace2016s	2016	160	S(Grace)	Zhou, H. et al, 2016	gfc zip	Calculate	Show	✔
157	ITU_GRACE16	2016	180	S(Grace)	Akyilmaz, O. et al, 2016	gfc zip	Calculate	Show	✔
156	ITU_GGC16	2016	280	S(Goce), S(Grace)	Akyilmaz, O. et al, 2016	gfc zip	Calculate	Show	✔
155	EIGEN-6S4 (v2)	2016	300	S(Goce), S(Grace), S(Lageos)	Förste, C. and Bruinsma, S.L., 2016	gfc zip	Calculate	Show	✔
154	GOCO05c	2016	720	(see model), A, G, S	Fecher, T. et al, 2016	gfc zip	Calculate	Show	✔
153	GGM05C	2015	360	A, G, S(Goce), S(Grace)	Ries, J. et al, 2016	gfc zip	Calculate	Show	✔
152	GECO	2015	2190	EGM2008, S(Goce)	Gilardoni, M. et al, 2016	gfc zip	Calculate	Show	

A screenshot of the list of available static gravity fields (175 models)



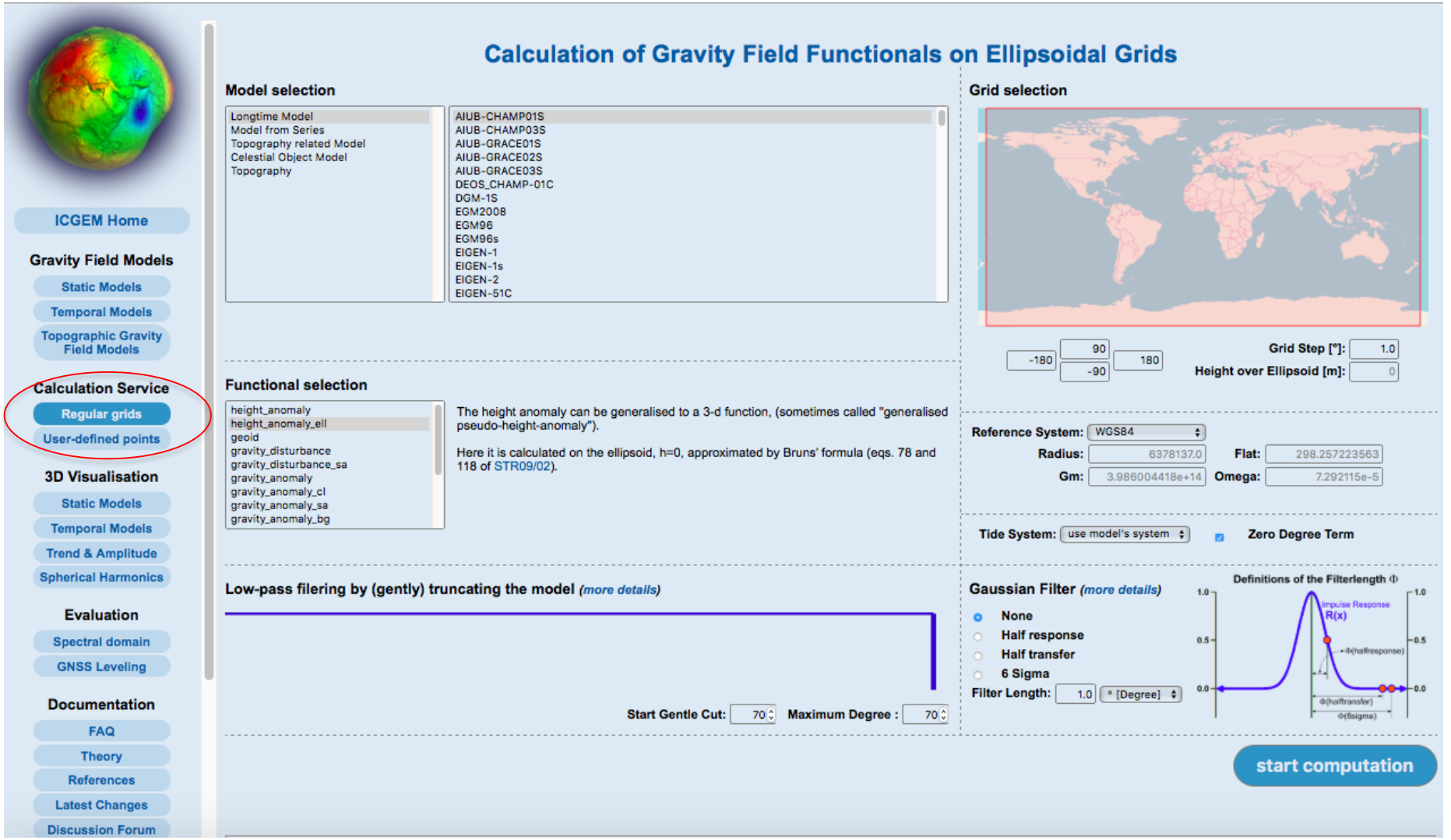
A screenshot of the list of the computed time varying solutions (e.g monthly solutions)



Nr	Model	Year	Degree	Data	References	Download
1	dV_ELL_RET2012	2014	2190	Topography	Claessens, S.J. and C. Hirt (2013)	gfc zip
2	dV_ELL_RET2012_plusGRS80	2014	2190	Topography	Claessens, S.J. and C. Hirt (2013)	gfc zip
3	RWI_TOPO_2012	2014	1800	Topography	Grombein et al., (2014)	gfc zip
4	RWI_ISOS_2012	2014	1800	Isostasy	Grombein et al., (2014)	gfc zip
5	RWI_TOIS_2012	2014	1800	Isostasy, Topography	Grombein et al., (2014)	gfc zip
6	RWI_TOPO_2012_plusGRS80	2014	1800	Topography	Grombein et al., (2014)	gfc zip
7	RWI_ISOS_2012_plusGRS80	2014	1800	Isostasy	Grombein et al., (2014)	gfc zip
8	RWI_TOIS_2012_plusGRS80	2014	1800	Isostasy, Topography	Grombein et al., (2014)	gfc zip
9	RWI_TOPO_2015	2015	2190	Topography	Grombein et al., (2016)	gfc zip
10	REQ_TOPO_2015	2015	2190	Topography	Grombein et al., (2016)	gfc zip
11	RWI_TOPO_2015_plusGRS80	2015	2190	Topography	Grombein et al., (2016)	gfc zip
12	REQ_TOPO_2015_plusGRS80	2015	2190	Topography	Grombein et al., (2016)	gfc zip
13	dV_ELL_RET2014	2016	2190	Topography	Rexer et al., (2016)	gfc zip
14	dV_ELL_RET2014_plusGRS80	2016	2190	Topography	Rexer et al., (2016)	gfc zip
15	dV_ELL_Earth2014	2016	2190	Topography	Rexer et al., (2016)	gfc zip
16	dV_ELL_Earth2014_plusGRS80	2016	2190	Topography	Rexer et al., (2016)	gfc zip
17	dV_ELL_Earth2014_5480	2017	5480	Topography	Rexer et al., (2017), Rexer, M. (2017)	gfc zip
18	dV_ELL_Earth2014_5480_plusGRS80	2017	5480	Topography	Rexer et al., (2017), Rexer, M. (2017)	gfc zip

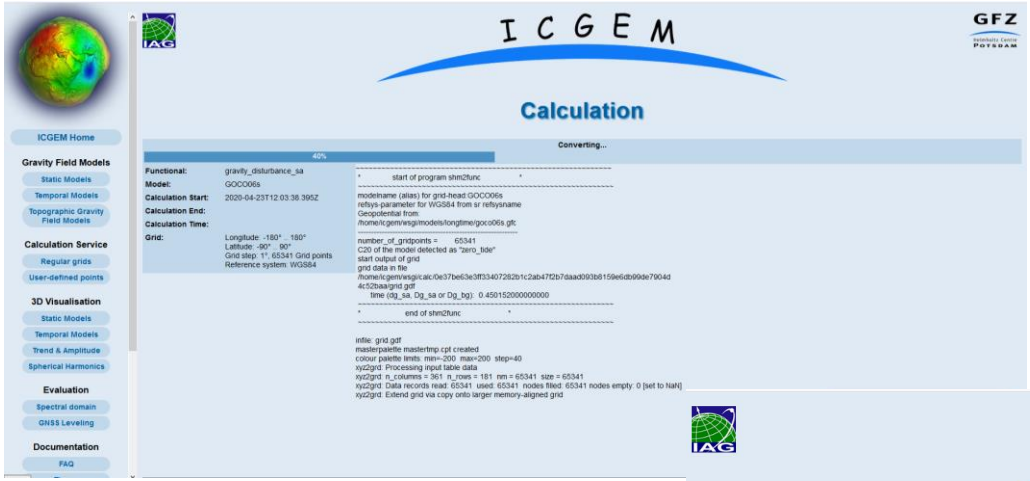
A screenshot from the table of topographic gravity fields in the website (18 models)

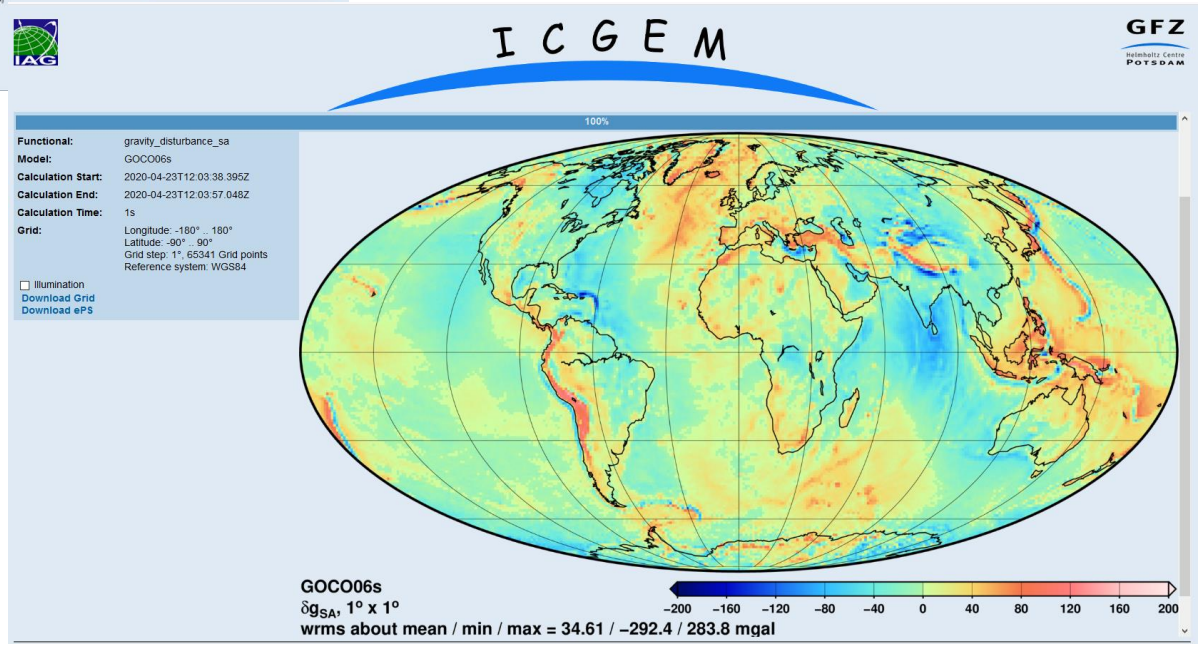
The Calculation Service



GGM computation either on a given grid or at user defined points

The Calculation Service

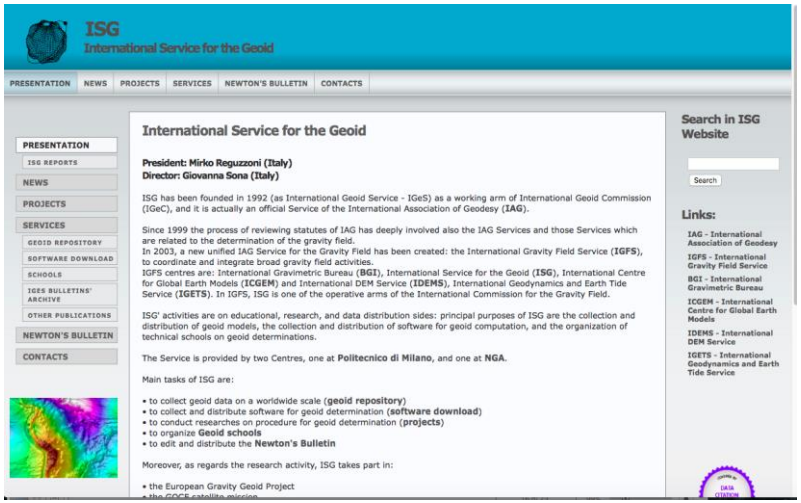




International Service for the Geoid (ISG)

(http://www.isgeoid.polimi.it)

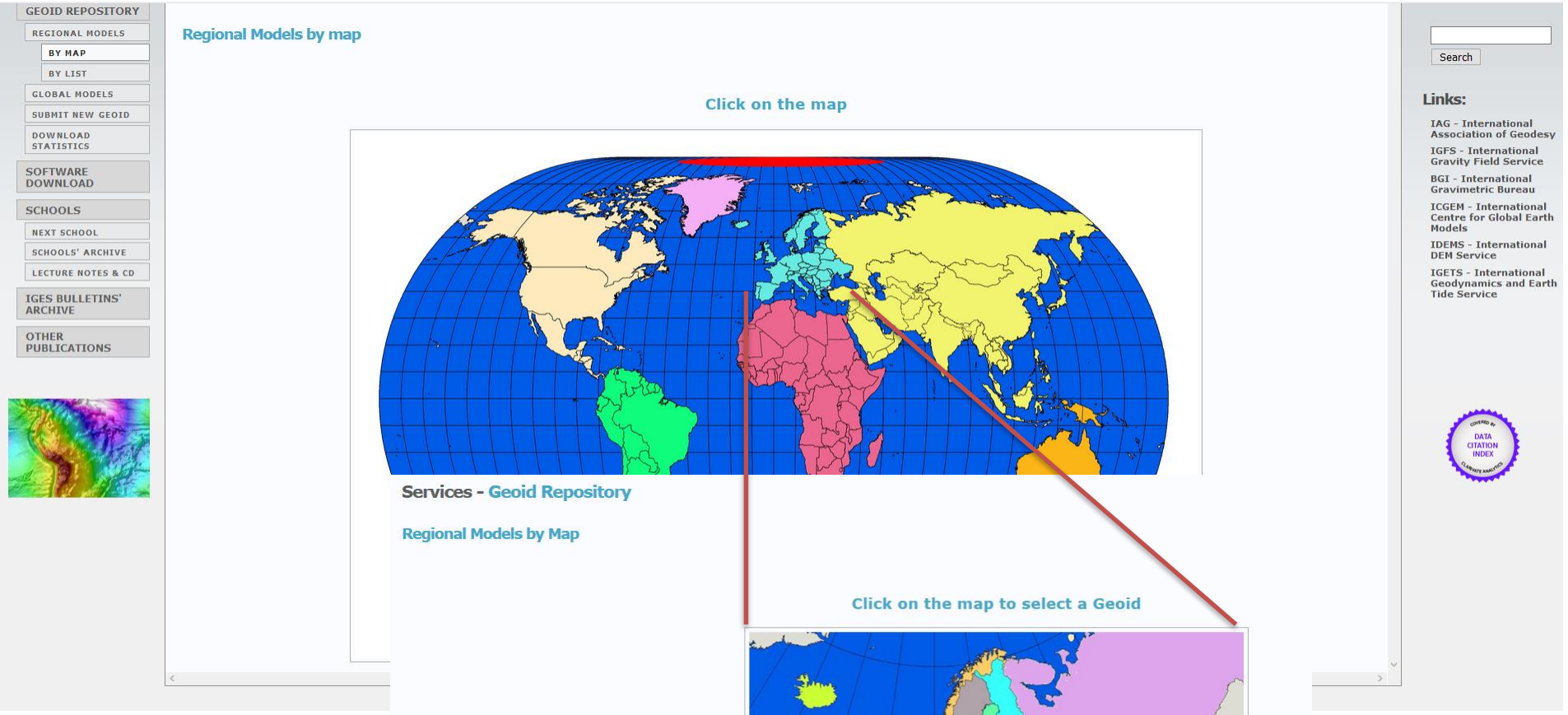
President : Mirko Reguzzoni Director: Daniela Carrion



Main ISG tasks

- To collect geoid estimates worldwide and to disseminate them among the scientific community
- To collect, test and, when allowed, to distribute software for the geoid determination
- To conduct researches on methods for the geoid determination
- To organize schools on geoid determination
- To disseminate special publications on geoid computations (e.g. lecture notes of the schools)
- To support Agencies or scientists in computing regional geoids

The local/regional geoid repository



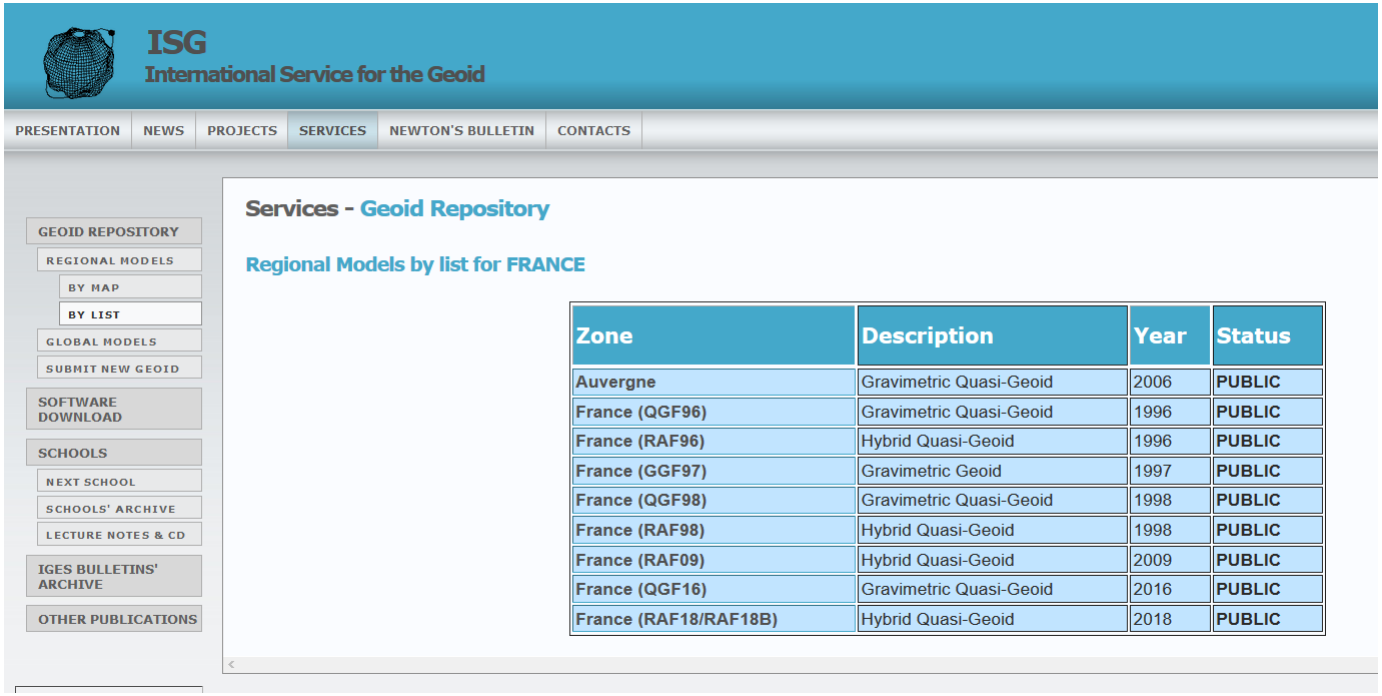
- Continent-based summary
- Then zoom in each country

International Association of Geodesy
IAG
I G F S

EGU General Assembly 2020
Vienna | Austria | 3–8 May 2020

The local/regional geoid repository

- Almost 200 models are currently available in the ISG repository
- Each model has a dedicated webpage with some information



Zone	Description	Year	Status
Auvergne	Gravimetric Quasi-Geoid	2006	PUBLIC
France (QGF96)	Gravimetric Quasi-Geoid	1996	PUBLIC
France (RAF96)	Hybrid Quasi-Geoid	1996	PUBLIC
France (GGF97)	Gravimetric Geoid	1997	PUBLIC
France (QGF98)	Gravimetric Quasi-Geoid	1998	PUBLIC
France (RAF98)	Hybrid Quasi-Geoid	1998	PUBLIC
France (RAF09)	Hybrid Quasi-Geoid	2009	PUBLIC
France (QGF16)	Gravimetric Quasi-Geoid	2016	PUBLIC
France (RAF18/RAF18B)	Hybrid Quasi-Geoid	2018	PUBLIC

The local/regional geoid repository

- Almost 200 models are currently available in the ISG repository
- Each model has a dedicated webpage with some information

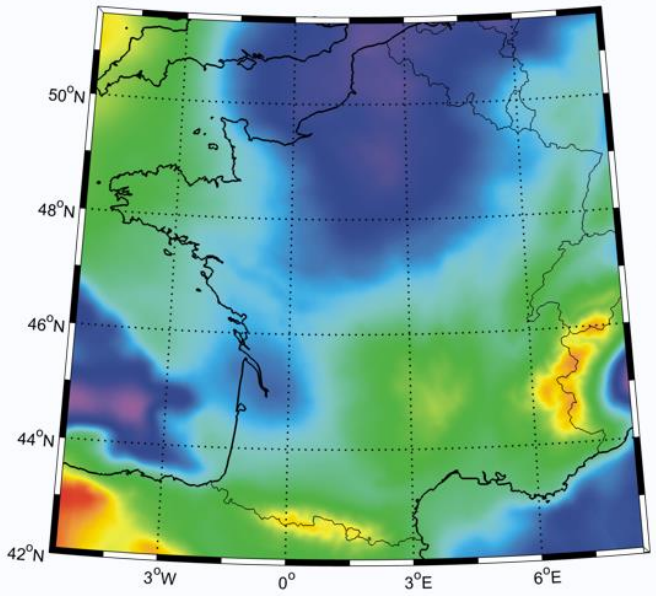
France (RAF18/RAF18B)

Author: F. L-Ecu **Created:** 2018 **Resp:** F. L'Ecu
Status: PUBLIC

Description:
RAF18 is a hybrid geoid model for France, covering the area 42° < lat < 51.5°, -5.5° < lon < 8.5° with a grid spacing of 1.5' in latitude and 2' in longitude. It is an update of the previous RAF09 model. In particular it is an adaptation of the QGF16 model to 10000 high accuracy GNSS/levelling points. The RAF18 model represents the height of the IGN69 reference surface above the GRS80 ellipsoid (RGF93 datum). It has been assessed by using 5000 independent GNSS/levelling points, showing differences with a standard deviation of 1 cm. RAF18 was an intermediate solution that was consistent with RGF93, while RAF18b is the final and official solution that is consistent with RGF93b, where the transformation between the two frames is a Helmert 7-parameter transformation

References:
IGN (2018). **Comment obtenir des altitudes NGF – IGN69 ou IGN78 à partir de levés GPS?**. Laboratoire de Recherche en Geodesie, Service de Geodesie et de Métrologie. IGN (2019). **National Report - France**. EUREF Symposium 2019, 22-24 May 2019, Tallinn, Estonia.

Retrieve RAF18 model | Retrieve file RAF18 - ISG format | Send email
Retrieve RAF18b model | Retrieve file RAF18b - ISG format



Authors, year, distr. policy

Short description

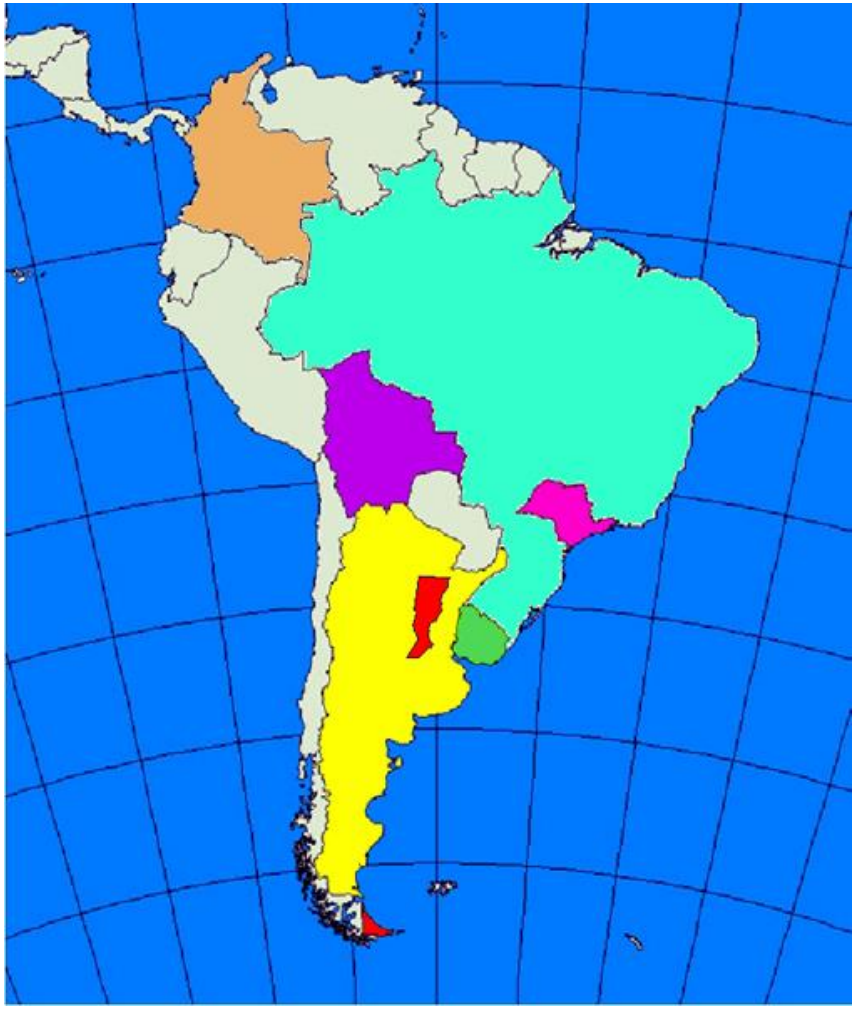
Bibliographic reference

Web of Science index

Download and email links

Model visualization

The local/regional geoid repository



Continental

South America	Blitzkow et al.	2010
South America (GEOID2015)	Blitzkow et al.	2015

National

Argentina (GAR)	Corchete & Pacino	2007
Argentina (GEOIDEAR16)	Pinon et al.	2016
Bolivia (BOLGEO)	Corchete et al.	2006
Brazil (MAPGEO2004)	Blitzkow et al.	2004
Brazil (MAPGEO2010)	Blitzkow et al.	2010
Brazil (MAPGEO2015)	Blitzkow et al.	2015
Colombia (GEOCOL2004)	Sanchéz	2004
Uruguay (URUGEOIDE2000)	Subiza Piña	2000
Uruguay (URUGEOIDE2007)	Subiza Piña	2007

Regional

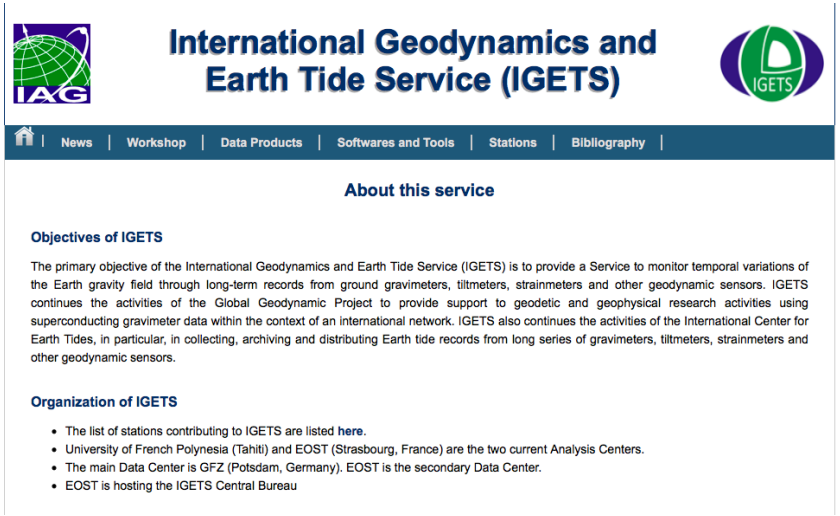
Santa Fe Province - Argentina	Cornero et al.	2018
Sao Paulo State - Brazil (GEOID-SP)	Guimarães et al.	2014
Tierra del Fuego	Gomez et al.	2014

When more than one models are available, a detailed list is given

International Geodynamics and Earth Tide Service (IGETS)

(http://igets.u-strasbg.fr)

Director: Hartmut Wziontek



Main ICET tasks

- To monitor temporal variations of the Earth gravity field through long-term records from ground gravimeters, tiltmeters, strainmeters and other geodynamic sensors
- To continue the activities of the Global Geodynamic Project, to provide support to geodetic and geophysical research activities using superconducting gravimeter data within the context of an international network for field gravimetry, absolute gravity measurements and for tilt measurements
- To continue the activities of the International Center for Earth Tides

Data and products at IGETS

i) Several SG data are available at ISDC at GFZ:

- Raw gravity and local pressure records sampled at 1 or 2 seconds, in addition to the same records decimated at 1-minute samples
- (*Level 1 products*)
- Gravity and pressure data corrected for instrumental perturbations, ready for tidal analysis
- (*Level 2 products*)
- Gravity residuals after particular geophysical corrections (including solid Earth tides, polar motion, tidal and non-tidal loading effects)
- (*Level 3 products*)
- Corrected gravity data (Level 2) can also be found at Univ. of French Polynesia, along with the Bulletin d'Information des Marees Terrestres at **http://www.bim-icet.org/.**

ii) SG data for major Earthquakes (minute and second sampling)

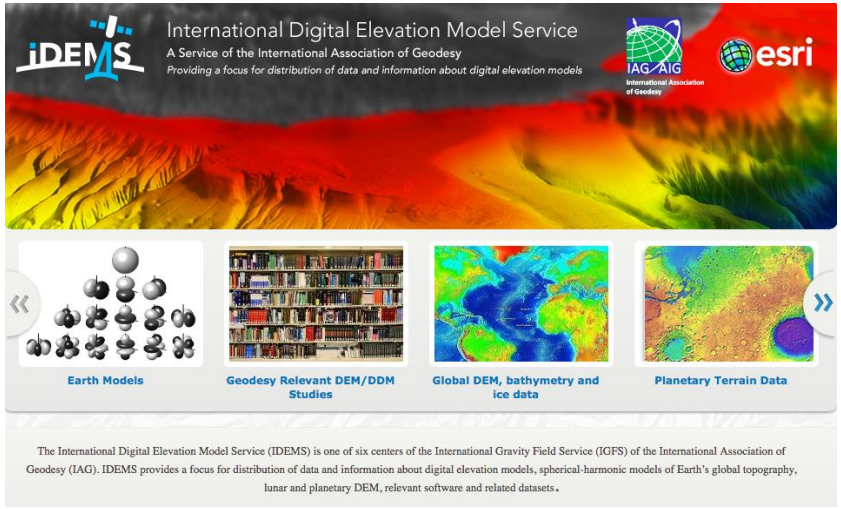
iii) ATMACS, Atmospheric Attraction Computation Servics at BKG

iv) mGlobe Matlab/Octave toolbox for computation of global hydrological, atmospheric and non-tidal ocean loading effects

v) EOST loading service (displacements, gravity, tilts)

International Digital Elevation Model Service (IDEMS)
(https://idems.maps.arcgis.com/home/index.html)

Director: Kevin Kelly



Main IDEMS tasks

- To provide a focus for distribution of data and metadata about digital elevation models (DEMs)
- To provide spherical-harmonic models of Earth's global topography
- To provide lunar and planetary DEM
- To provide relevant software for managing DEMs and related datasets.

Data and products at IDEMS

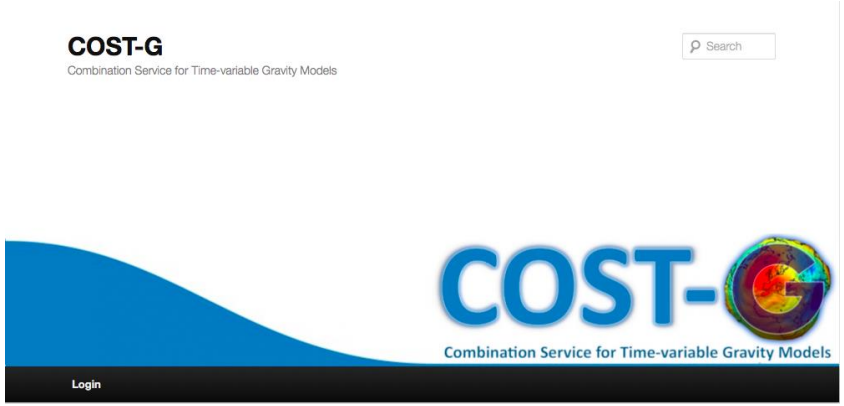
- Compilation of available national elevation data sets with information on data resolution, methods used for DEM generation and links to providers
- Generation and dissemination of spherical-harmonic models of Earth's global topography and bathymetry
- Compilation of geodesy relevant DEMs studies
- Extension of the focus from Earth to Moon and terrestrial planets through compilation of information on available planetary topography models.
- Website managing in order to separate regional DEMs and global DEMs
- Ongoing updates of existing DEMs

<u>Establishment of a JSG with ICCT on DTM/bathymetry integration</u>

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

(https://cost-g.org)

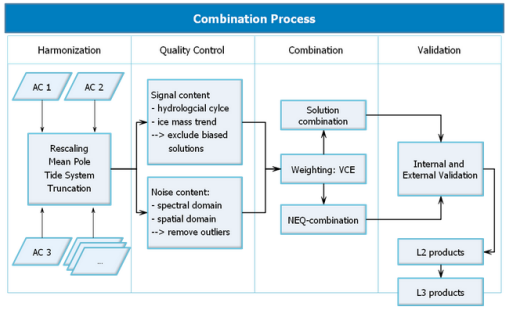
Chair: Adrian Jäggi



COST-G combines the gravity field solutions of various analysis centers (ACs). Currently, solutions are provided for GRACE and Swarm. In the near future also solutions of GRACE-FO will be processed and combined.

The combination procedure in reprocessing mode consists of four major steps:

1. Harmonization: the various solutions are transformed to a common system
2. Quality control: the signal content as well as the noise content is evaluated in order to eliminate biased solutions and/or outliers.
3. Combination is performed on two levels:
   - Solution level, i.e. the spherical harmonic coefficients are combined using variance component estimation (VCE); details can be found in Jean et al. (2018) : https://link.springer.com/article/10.1007/s00190-018-1123-5
   - Normal-EQuation-level (NEQ), i.e. the normal equations fo the analysis centers are combined; details can be found in Meyer et al. (2019): https://link.springer.com/article/10.1007/s00190-019-01274-6
3. Internal and external validation ensure the quality of the product



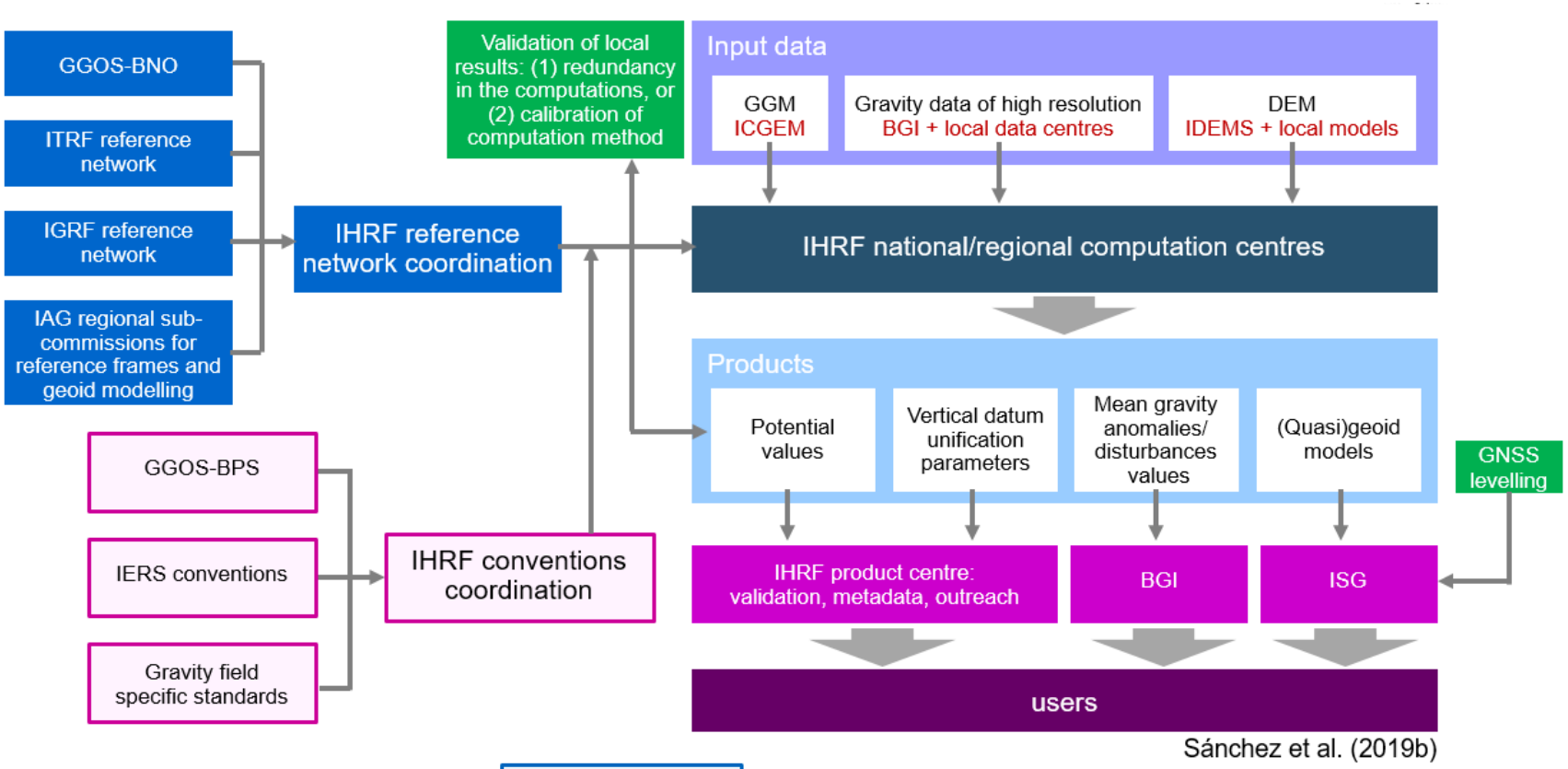
Main COST-G tasks

The International Combination Service for Time-variable Gravity Fields (COST-G) is the Product Center of the International Gravity Field Service (IGFS) for time-variable gravity fields. COST-G provides consolidated monthly global gravity models in terms of spherical harmonic (SH) coefficients and thereof derived grids by combining solutions from individual Analysis Centers (ACs).

Recent Activities

- COST-G is currently working on the extension of combined GRACE monthly gravity field solutions (and also on combined Swarm monthly gravity field solutions)
- Preliminary combined solution presented at IAG/IUGG, Montreal (G03, July 14th, 2019)

IHRS within IGFS



Sánchez et al. (2019b)