

The GGOS Bureau of Products and Standards

D. Angermann⁽¹⁾, T. Gruber⁽¹⁾, M. Gerstl⁽¹⁾, U. Hugentobler⁽¹⁾, L. Sánchez⁽¹⁾,
R. Heinkelmann⁽²⁾, P. Steigenberger⁽³⁾

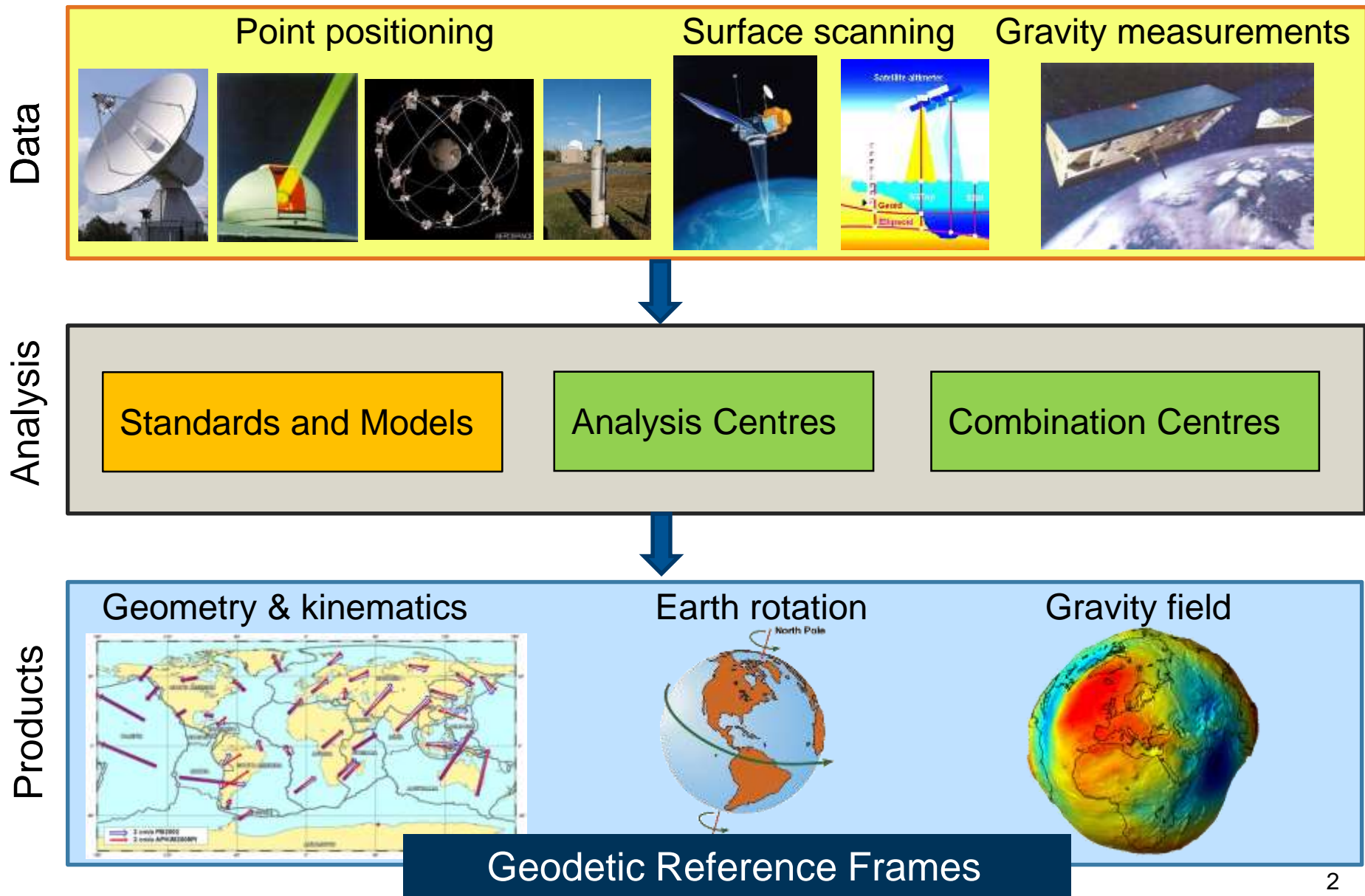
⁽¹⁾ Technical University of Munich (TUM), Germany

⁽²⁾ Helmholtz Centre Potsdam, German Research Centre for Geosciences (GFZ), Germany

⁽³⁾ German Aerospace Centre (DLR), Germany

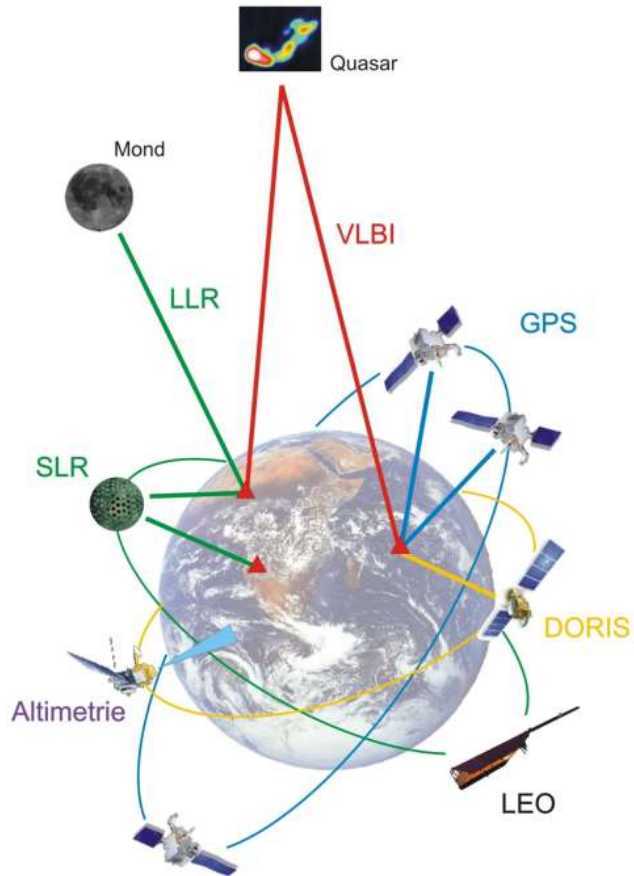
Joint SIRGAS / GGOS Session, November 12, 2019, Rio de Janeiro, Brazil

Overview

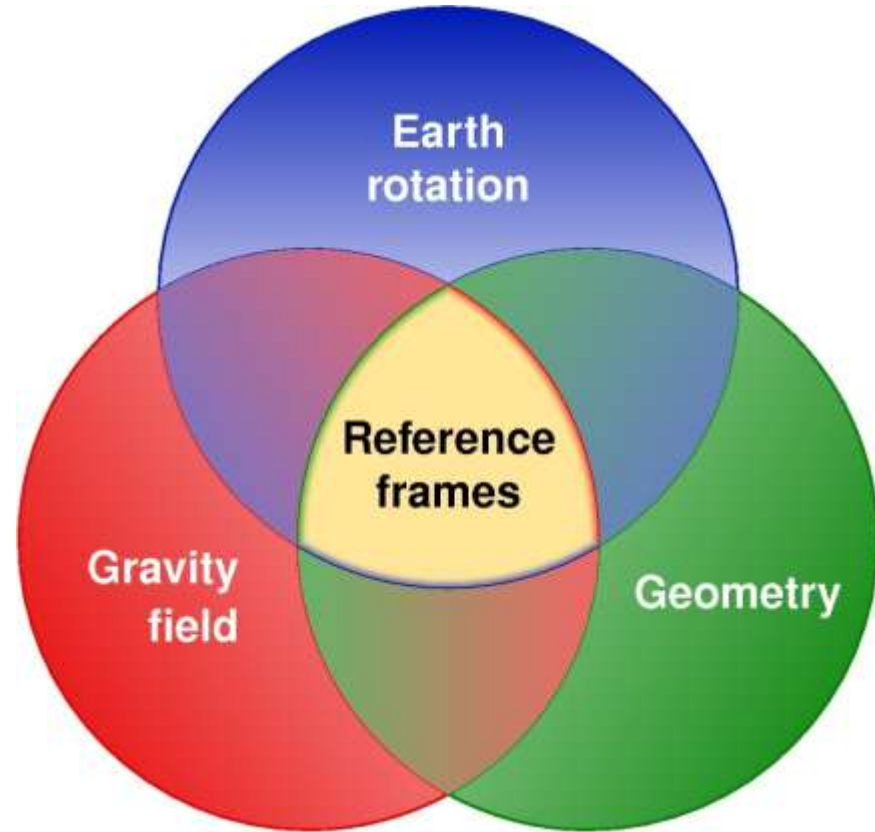


IAG's Global Geodetic Observing System (GGOS)

Integration of the geodetic observation techniques

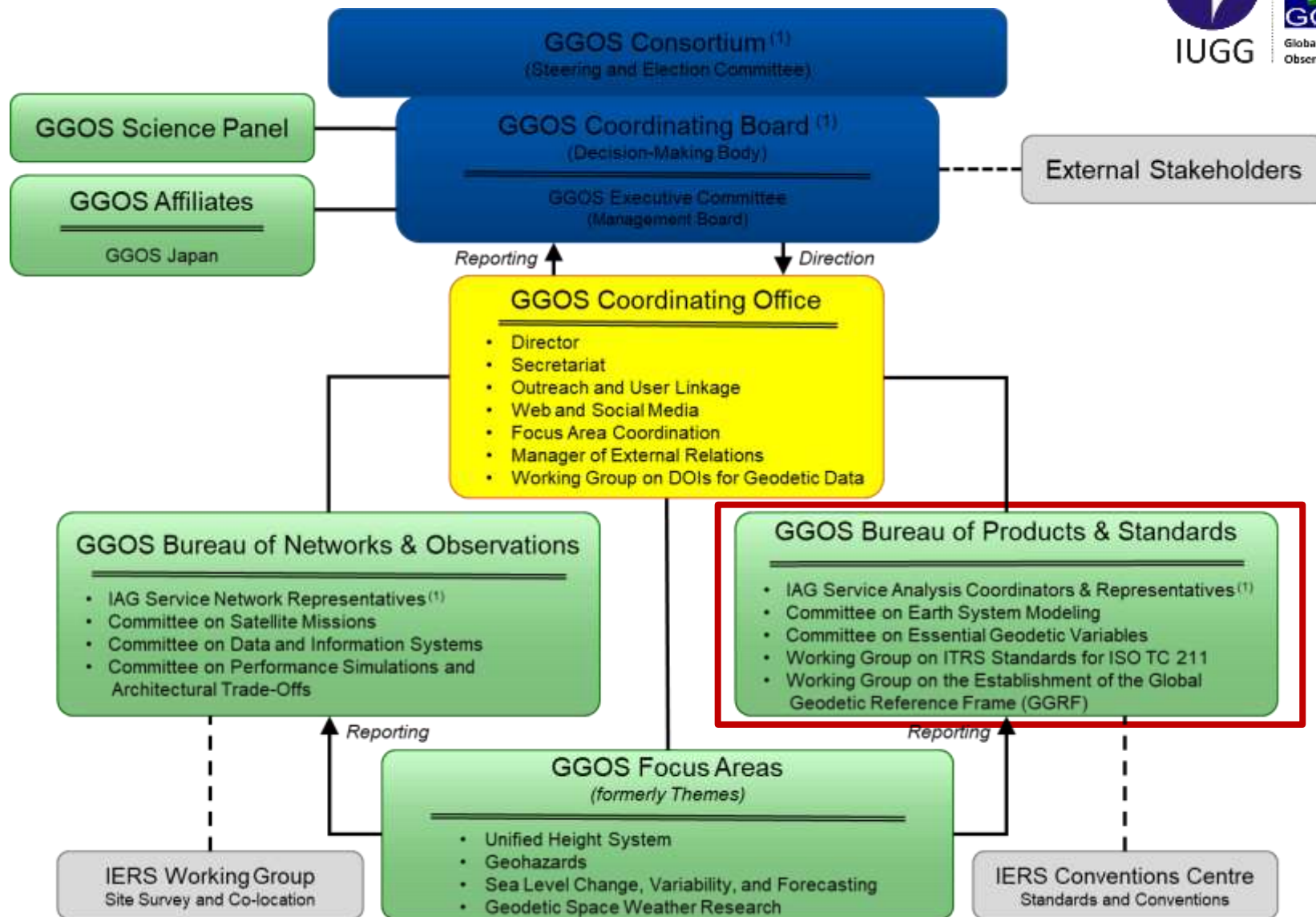


[Rothacher et al. 2009]



[Rummel 2000], modified by [Plag and Pearlman 2009]

GGOS Organizational Structure



⁽¹⁾ GGOS is built upon the foundation provided by the IAG Services, Commissions, and Inter-Commission Committees

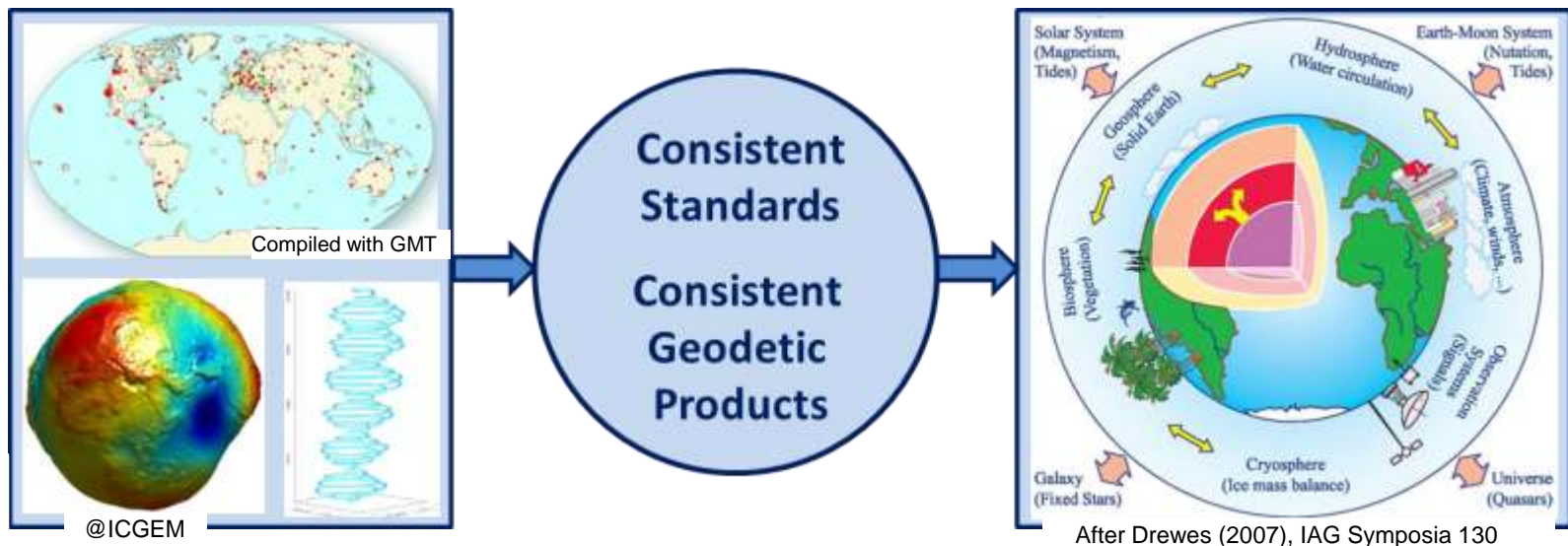
GGOS Bureau of Products and Standards (BPS)



The BPS supports GGOS in its key goal to obtain consistent products describing the geometry, rotation and gravity field of the Earth.

Objectives

- contact & coordinating point for homogenization of IAG standards and products
- keep track of the adopted geodetic standards and conventions across all IAG components, and initiate steps to close gaps and deficiencies
- integrate geometric and gravimetric parameters
- develop new geodetic products, needed for Earth sciences and society



BPS Organizational Structure



- The BPS is hosted at Technical University of Munich
- BPS staff:
 - D. Angermann (Director), T. Gruber (Deputy Director), M. Gerstl, R. Heinkelmann (GFZ), U. Hugentobler, L. Sánchez, P. Steigenberger (DLR)
- Entities associated to the BPS
 - Committee “**Earth System Modelling**” (Chair: M. Thomas)
 - Committee “**Essential Geodetic Variables (EGVs)**” (Chair: R. Gross)
 - WG “**ITRS Standards for ISO TC 211**” (Chair: C. Boucher), dissolved because work has been completed
 - JWG “**Establishment of the Global Geodetic Reference Frame (GGRF)**” (Chair: U. Marti), setup of a continuation WG in progress
- Associated members of the BPS:
 - ~ 25 representatives designated by the IAG Services and other relevant entities involved in standards and geodetic products

Representatives of IAG Services and other entities

Position (IAG Service, other entity)	Representatives	Affiliation, Country
IERS Conventions Center	Gérard Petit (until 2016)	BIPM (France)
IERS Analysis Coordinator	Nick Stamatakos (since 2017)	USNO (USA)
IGS Representative	Thomas Herring	MIT (USA)
ILRS Analysis Coordinator	R. Heinkelmann (since 2019, BPS)	GFZ (Germany)
IVS Analysis Coordinator	Urs Hugentobler (BPS staff)	TUM (Germany)
IDS Representatives	Erricos Pavlis	UMBC/NASA (USA)
	John Gipson	GSFC/NASA (USA)
	Frank Lemoine, John Ries,	GSFC/CSR (USA)
	Jean-M. Lemoine, H. Capdeville	CNES/GRGS (France)
IGFS Chair	Riccardo Barzaghi	Politec. Milano (Italy)
BGI Chair	Sylvain Bonvalot	IRD (France)
ISG President	Mirko Reguzzoni	Politec. Milano (Italy)
ICGEM Chair	Franz Barthelmes (until 2017)	GFZ (Germany)
	E. Sinem Ince (since 2018)	GFZ (Germany)
IDEMS Director	Kevin M. Kelly	ESRI (USA)
IGETS Chair	Hartmut Wziontek	BKG (Germany)
Gravity Comm. (corresp. Member)	Jürgen Kusche	Univ. Bonn (Germany)
IAG Representative to ISO	Johannes Ihde (until 2017)	BKG, GFZ (Germany)
	Detlef Angermann (since 2018)	TUM (Germany)
IAG Communication and Outreach	Josef Ádám	Univ. Budapest (Hungary)
IAU Commission A3 Representative	Catherine Hohenkerk (until 2018)	United Kingdom
	James L. Hilton (since 2018)	USNO (USA)
IAU Representative	Robert Heinkelmann (BPS staff)	GFZ (Germany)
Control Body for ISO Geodetic	Michael Craymer (Chair)	NRCan (Canada)
Registry	Larry Hothem (Vice Chair)	USA

BPS inventory of standards and conventions



- Inventory of standards and conventions used for the generation of IAG products (published in IAG Geodesists Handbook 2016, see below)
 - Assessment of the present status
 - Identification of gaps
 - Provision of recommendations (interaction with IAG Components)
- 2nd version of the BPS inventory almost finalized, updates on:
 - IAG/GGOS Structure
 - General issues and numerical standards
 - ICRF2 → ICRF3
 - ITRF2008 → ITRF2014
 - EOP08C04 → EOP14C04
 - GNSS orbits, IGFS activities, Height Systems
- 2nd version will be published online at the GGOS Website (Januar 2020)

Preface

Scope of the document

Acknowledgements

1 Introduction

1.1 GGOS: Mission, goals and structure

1.2 Standards and conventions

2 GGOS Bureau of Products and Standards

2.1 Mission and objectives

2.2 Tasks

2.3 Staff and representatives

3 Evaluation of numerical standards

3.1 Defining parameters

3.2 Solid Earth tide systems

3.3 Geopotential value W_0

3.4 Open problems and recommendations

4 Product-based review

4.1 Celestial reference systems and frames

4.2 Terrestrial reference systems and frames

4.3 Earth Orientation Parameters (EOP)

4.4 GNSS satellite orbits

4.5 Gravity and geoid

4.6 Height systems and their realizations

5 Summary

Glossary

Bibliography

Angermann D., Gruber T., Gerstl M., Heinkelmann R., Hugentobler U., Sánchez L., Steigenberger P.: **GGOS Bureau of Products and Standards: Inventory of standards and conventions used for the generation of IAG products**. In: Drewes H., Kuglitsch F., Adám J. (Eds.) **The Geodesist's Handbook 2016**. Journal of Geodesy 90(10), 1095-1156, [10.1007/s00190-016-0948-z](https://doi.org/10.1007/s00190-016-0948-z), 2016

Numerical standards used within IAG



	semi-major axis a [m]	Geocentric Grav. Constant GM [$10^{12} \text{m}^3 \text{s}^{-2}$]	Dyn. form factor J_2 [10^{-6}]	Earth's rotation ω [rad s^{-1}]	Normal potential U_0 or W_0 [$\text{m}^2 \text{s}^{-2}$]
GRS80 (1979)	6 378 137	398.600 5	1 082.63	7.292 115	62 636 860.850
EGM2008	6 378 136.3	398.600 4415 ⁽¹⁾	1 082.635 9	7.292 115	62 636 856.0 (1998)
IERS Conv. (2010)	6 378 136.6 ⁽²⁾	398.600 4418 ⁽³⁾	1 082.635 9	7.292 115	62 636 856.0 (1998)
IERS Conv. (update 2017)	6 378 136.6 ⁽²⁾	398.600 4418 ⁽³⁾	1 082.635 9	7.292 115	62 636 853.4 (2015)
IAG Resol. No. 1 (2015)					62 636 853.4 (2015)

(1) TT-compatible value; (2) value given in zero-tide system; (3) TCG-compatible value

- **GRS80** (still) provides the **conventional values** (IUGG 1979 / IAG 1980)
- The geodetic work is based on **different numerical standards** (e.g., GRS80 values, IERS Conventions, standards used for gravity and altimetry)
- Thus, a unique and consistent set of numerical standards **does not exist within IAG**, moreover different time and tide systems are in use within geodesy

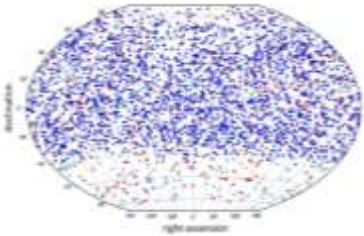
BPS recommendations on numerical standards

- **REC 1:** The used numerical standards including time and tide systems must be clearly documented for all geodetic products.
- **REC 2:** The W_0 value issued by the IAG resolution No. 1 (2015) should be used as the conventional reference value for geodetic work.
- **REC 3:** The development of a new Geodetic Reference System GRS20XX based on best estimates of the major parameters is desired.

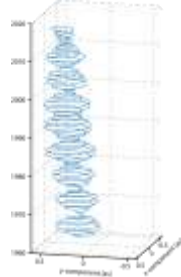
Review of IERS products



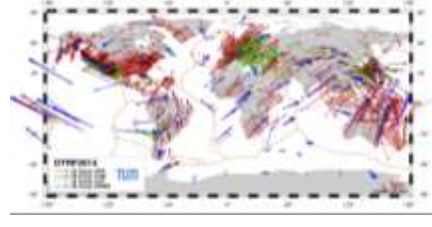
ICRF



EOP



TRF

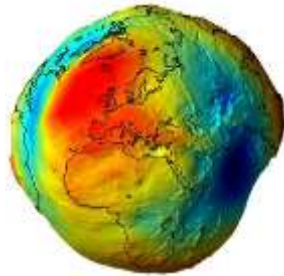


- BPS inventory provides 3-4 recommendations for each product
- Three general recommendations for IERS products:
 - Consistency of CRF, TRF and EOP (IUGG Res. 2011, IAG Res. 2019)
 - Processing standards should be consistently applied by all ACs
 - Core networks and co-locations need to be further improved
- Ongoing activities of the technique-specific IAG Services and the IERS
- GGOS/IERS Unified Analysis Workshop (... , Pasadena 2014, Paris 2017 and 2019)
- IAU is involved concerning the celestial reference system and frame

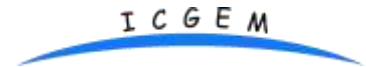
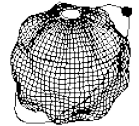
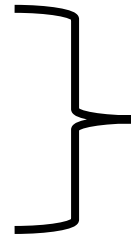
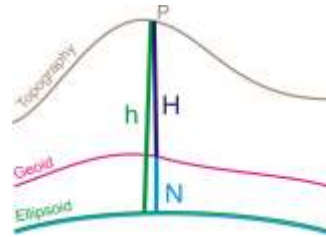
Gravity-related products



Geoid



Heights



- The IGFS Central Bureau (igfs.topo.auth.gr) provides a new updated IGFS webpage, including a dedicated products portal and metadata information (e.g., geoid, GGMs, DEM, SG, tide data)
- Many static and temporal gravity field models are available at the ICGEM website, open access of data products, DOI for data sets
- A conventional GGM (as official IAG product) may be useful, this issue is under discussion within the IGFS
- Combination Service for Time-variable Gravity Field Solutions (COST-G)
- Developments on the unification of height systems (GGOS Focus Area “Unified Height System”, Chair: L. Sánchez)

International Centre for Global Earth Models



ICGEM

Global Gravity Field Models

We kindly ask the authors of the models to check the links to the original websites of the models from time to time. Please let us know if something has changed.

The table can be interactively re-sorted by clicking on the column header fields (Nr, Model, Year, Degree, Data, Reference). In the data column, the datasets used in the development of the models are summarized, where **S** is for satellite (e.g., GRACE, GOCE, LAGEOS), **A** is for altimetry, and **G** for ground data (e.g., terrestrial, shipborne and airborne measurements).

The links [calculate](#) and [show](#) in the last columns of the table directly invoke the *Calculation Service* and *Visualization page* for the selected model. For models with a registered [doi](#) ("digital object identifier") the last column contains the symbol ✓, which directly opens the page on "http://dx.doi.org". If you click on the reference, the complete list of references can be seen.

Nr	Model	Year	Degree	Data	References	Download	Calculate	Show	DOI
174	ITSG-Grace2018a	2019	200	S(Grace)	Mayer-Gürr, T. et al, 2018	gfc zip	Calculate	Show	✓
173	EIGEN-GRGS.RL04.MEAN-FIELD	2019	300	S	Lemoine et al, 2019	gfc zip	Calculate	Show	
172	GOCO06s	2019	300	S	Kvas et al., 2019	gfc zip	Calculate	Show	✓
171	GO_CONS_GCF_2_TIM_R6	2019	300	S(Goce)	Brockmann, J. M. et al, 2014	gfc zip	Calculate	Show	✓
170	GO_CONS_GCF_2_DIR_R6	2019	300	S	Bruinsma, S. L. et al, 2014	gfc zip	Calculate	Show	✓

icgem@gfz-potsdam.de

Dataset Released

The satellite-only gravity field model GOCO06s

Cite as: [Copy citation to clipboard](#)

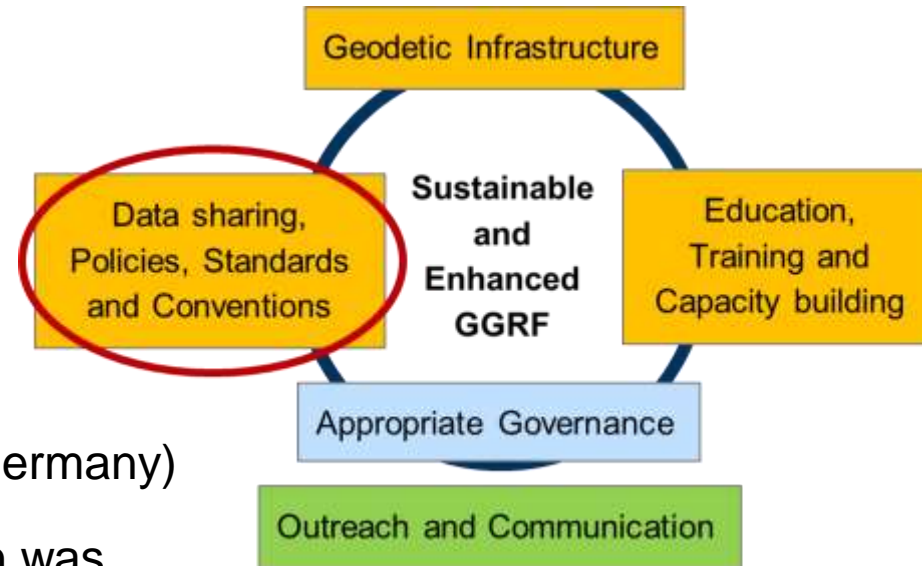
Kvas, Andreas; Mayer-Gürr, Torsten; Krauss, Sandro; Brockmann, Jan Martin; Schubert, Till; Schuh, Wolf-Dieter; Pail, Roland; Gruber, Thomas; Jäggi, Adrian; Meyer, Ulrich (2019): The satellite-only gravity field model GOCO06s. GFZ Data Services. <http://doi.org/10.5880/ICGEM.2019.002>

UN GGIM Subcommittee on Geodesy (SCoG)



Working Group **Data sharing and development of standards**

- 12 members (Australia, Canada, Germany, Jamaica, Kyrgyzstan, New Zealand, USA)
- Chair: M. Craymer (Canada)
- IAG Representative: D. Angermann (Germany)
- GGRF Road Map Implementation Plan was provided to the UN-GGIM Committee of Experts
- Three **recommendations** were provided:
 - (1) More open share data, standard operating procedures, expertise, and technology
 - (2) Resolve concerns that currently limit data sharing
 - (3) Support common standards and make them openly available



Committee on Essential Geodetic Variables (EGVs)



- The Committee on Essential Geodetic Variables (EGVs) has been established in 2018, associated to the BPS (Chair: R. Gross)
- It comprises the members of the GGOS Science Panel, Representatives of the IAG Services and GGOS
- Within the Group on Earth Observations (GEO), the Global Ocean Observing System (GOOS) and Global Climate Observing System (GCOS) have defined Essential Ocean and Climate Variables (EOVs/ECVs)



Essential Climate Variables (ECV)

- Atmospheric (air temperature, water vapour, pressure, ...)
- Oceanic (sea-surface temperature, sea level, sea ice, ...)
- Terrestrial (river discharge, ground water, glaciers and ice caps, ...)



- Examples of EGVs: position of reference objects (e.g., ground stations, radio sources), EOPs, ground- and space-based gravity observations, ...
- Such EGVs could then serve as a basis for a gap analysis to identify requirements concerning observations, networks and products

Committee on Essential Geodetic Variables (EGVs)



GGOS

Detlef Angermann (Germany)
Richard Gross, Chair (USA)
Harald Schuh (Germany)

GGOS Focus Area 1

(Unified Height System)
Bernhard Heck (Germany)

GGOS Focus Area 2

(Geohazards Monitoring)
Diego Melgar (USA)

GGOS Focus Area 3

(Sea Level Change)
Don Chambers (USA)

GGOS Focus Area 4

(Space Weather)
Ehsan Forootan (UK)

IAG Commission 1

Markus Rothacher (Switzerland)
Geoffrey Blewitt (USA)

IAG Commission 2

Kosuke Heki (Japan)
Thomas Gruber (Germany)

IAG Commission 3

Jianli Chen (USA)
Jose Ferrandiz (Spain)

IAG Commission 4

Jens Wickert (Germany)
Pawel Wielgosz (Poland)

IAG ICC Theory

Yoshiyuki Tanaka (Japan)
Mattia Crespi (Italy)

IERS

Tom Herring (USA)

IGS

Tom Herring (USA)
Michael Moore (Australia)

ILRS

Erricos Pavlis (USA)
Jürgen Müller (Germany)

IVS

John Gipson (USA)
Johannes Böhm (Austria)

IDS

Laurent Soudarin (France)
Jean-Michel Lemoine (France)

IGFS

Urs Marti (Switzerland)
Georgios Vergos (Greece)

BGI

Sylvain Bonvalot (France)

ICGEM

E. Sinem Ince (Germany)

ISG

Jianliang Huang (Canada)

IGETS

Hartmut Wziontek (Germany)
Jean-Paul Boy (France)

IDEMS

Christian Hirt (Germany)
Michael Kuhn (Australia)

PSMSL

Svetlana Jevrejeva (UK)

BIPM

none

Total: 35

Ongoing activities and planned actions

- to continue the work regarding **standards and conventions**, interaction with IAG components, and other entities involved
- to contribute to the **re-writing/revising of the IERS Conventions**, BPS Director has been nominated as Chapter Expert for Chapter 1 „General definitions and numerical standards“
- to focus on the **integration of geometric and gravimetric observations** and to support **the development of integrated products** (e.g., GGRF, IHRF, atmosphere products)
- to **interact with external stakeholders** (e.g., ISO, IAU, UN-GGIM, ...)
- to contribute to the UN GGIM Subcommittee on Geodesy (SCoG), IAG representation in GGRF Working Group **Data Sharing and Development of Geodetic Standards**
- to contribute to the **Committee on Essential Geodetic Variables (EGVs)**
- to compile a new **BPS Implementation Plan** for the next 4 years