International Association of Geodesy

of the International Union of Geodesy and Geophysics

Challenges to be faced by Geodesy in the coming years from the perspective of the International Association of Geodesy (IAG)

Retos para ser afrontados por la geodesia en los años que vienen desde la perspectiva de la Asociación Internacional de Geodesia (IAG)

Hermann Drewes
IAG Secretary General

Organisation of International Science

International Science Council (ISC) (2018: merger of ICSU and ISSC)

Sciences: IAU, ICA, IGA, …

IUGG

Social Sciences

International Union of Geodesy and Geophysics (IUGG)

IACS | IAGA | IAHS | IAPSO | IAG | IAMAS | IASPEI | IAVCEI

International Association of Geodesy (IAG): 71 Member countries

- **Council**: Representatives of the member countries
- **Executive Committee**: 16 members (elected by the Council)
- **Bureau**: Administrative work
- **Office**: Management (Secretary General)

Mission and objectives of the IAG

The **mission** of the IAG is the advancement of geodesy by
- furthering geodetic theory through research and teaching,
- collecting, analysing, modelling and interpreting observational data,
- by stimulating technological development and
- providing a consistent representation of the figure, rotation, and gravity field of the Earth and planets, and their temporal variations.

The **objectives** of the IAG are to achieve the mission by studying all geodetic problems related to Earth observation and global change, i.e.:
- Definition, establishment, and maintenance of global and regional *reference systems* for interdisciplinary use;
- *Gravity field* of the Earth;
- *Rotation and dynamics* of the Earth and planets;
- *Positioning and deformation*;
- Ocean, ice and sea level.
- Atmosphere and hydrosphere.

IAG Scientific Structure 2015 – 2019

Bureau

President: *Harald Schuh*, Germany
Vice-president: *Zuheir Altamimi*, France
Secretary General: *Hermann Drewes*, Germany

Commissions

1 Reference Frames (*G. Blewitt*, US)	2 Gravity Field (*R. Pail*, DE)	3 Geodynamics (*M. Hashimoto*, JP)	4 Applications (*M. Santos*, CA)

Inter-Commission Committee on Theory (*P. Novák*, CZ)

Scientific Services

Geom.:	IERS	IGS	Gravim.:	IGFS	BGI	ICGEM	General:	BIPM
IDS	ILRS	IVS		IDEMS	IGETS	ISG		PSMSL

(Representatives in the EC: *R. Neilan*, US, *R. Barzaghi*, IT, *A. Nothnagel*, DE)

Global Geodetic Observing System (GGOS) (*R. Gross*, US)

Communication and Outreach Branch (COB) (*J. Ádám*, HU)

(EC Members at Large: *Y. Dang*, CN, *M. C. Pacino*, AR; Past President: *Ch. Rizos*, AU)

Commission 1 “Reference Frames” Activities

1.1 Coordination of Space Techniques

- Co-location using clocks and new sensors: New site ties concepts
- Performance simulations and architectural trade-off (of the ITRF)

1.2 Global Reference Frames

- IERS Conventions: post-seismic model must be clarified

1.3 Regional Reference Frames

- EUREF, SIRGAS, NAREF, AFREF, APREF, Antarctica
- Time-dependent transformations between reference frames

1.4 Interaction of Celestial and Terrestrial Reference Frames

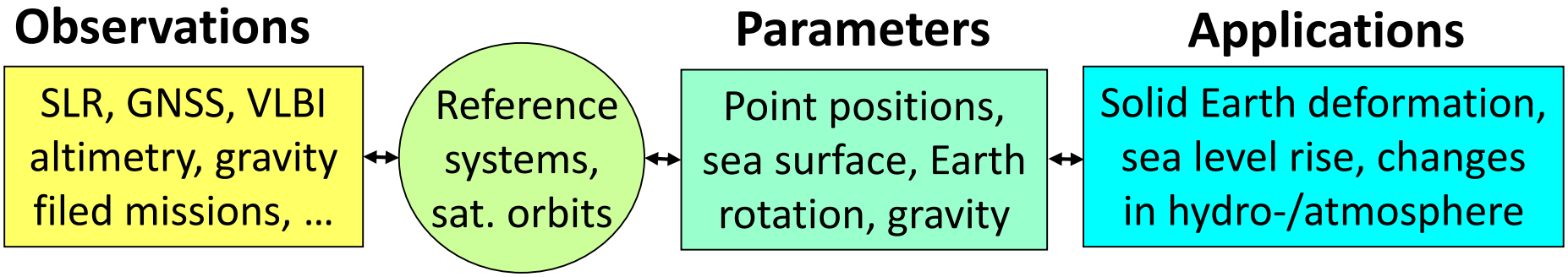
- Consistent realization of ITRF, ICRF and EOP: new ICRF3 (only AGU)

WG1: Site survey and co-location

WG2: Modelling environmental loading effects

WG3: Troposphere ties

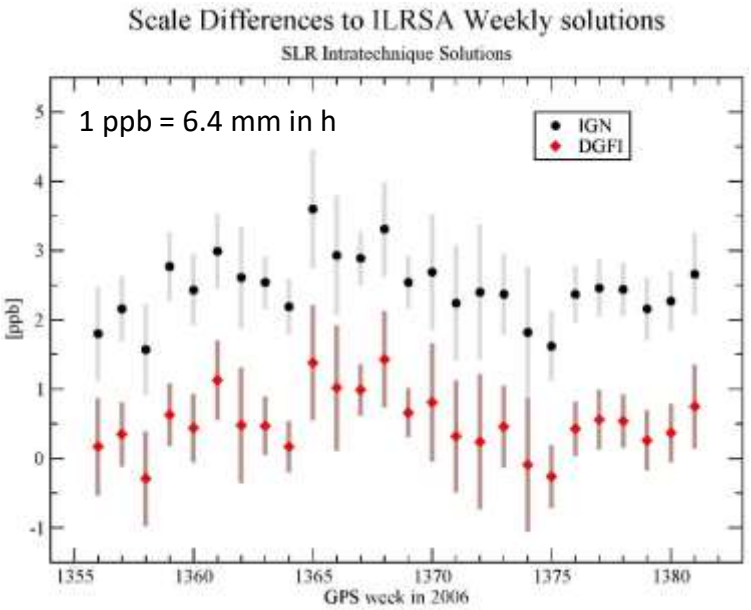
Challenges of geodesy to reference frames



Nearly all observations are done via satellites. The orbits are derived from observations at stations of the reference frame. Errors in the station coordinates enter into the orbits.

Problems to be solved:

- Time evolution of the reference frame: velocities or frequent epoch frames?
- Scale of the observation techniques;
- Realisation of the geocentric origin;
- Realisation of a non-rotating frame.



Commission 2 “Gravity Field” Activities

2.1 Gravimetry and Gravity Network

- Absolute and superconducting gravity measurements

2.2 Methodology for Geoid and Physical Height Systems

- Integration and validation of local geoid estimates

2.3 Satellite Gravity Missions

- GRACE Follow-On (GRACE FO) mission started on May 22, 2018

2.4 Regional Geoid Determination

- Europe, South, N & Central America, Africa, Asia-Pacific, Antarctica

2.5 Satellite Altimetry

- New International Altimetry Service under discussion

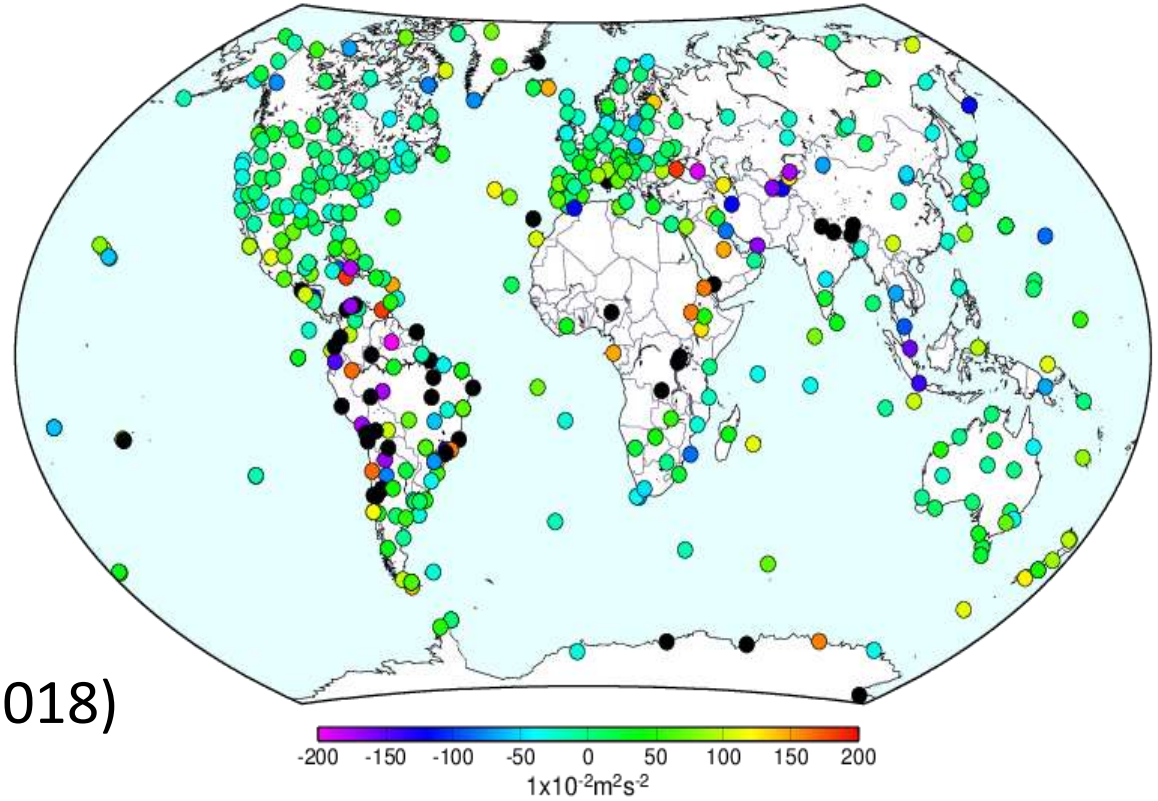
2.6 Gravity and Mass Transport in the Earth System

WG: Relativistic Geodesy: Towards a New Geodetic Technique

Challenges of geodesy to gravity field models

- Establishment of the International Gravity Reference Frame (IGRF);
- Support regional gravity field determinations;
- Release a conventional global gravity field model (GGM).

Differences of potential values W_P of EGM2008 (Pavlis et al. 2008) and EIGEN6C4 (Förste et al. 2014), both n=2190. Discrepancies up to ±20 cm (maximum differences, particularly in South America come up to ± 2 m) (Sánchez 2018)



Commission 3 “Earth Rotation and Geodynamics”

3.1 Earth Tides and Geodynamics

- New International Geodynamics and Earth Tide Service (IGETS)

3.2 Crustal Deformation

- SC3.2 dissolved; new SC3.2 Volcano Geodesy (joint with IAVCEI)

3.3 Earth Rotation and Geophysical Fluids

- Global mass transport, Earth rotation and low-degree gravity change

3.4 Cryospheric Deformations

- Glacial Isostatic Adjustment (GIA) research

3.5 Tectonics and Earthquake Geodesy

- Joint Sub-commission planned with IASPEI

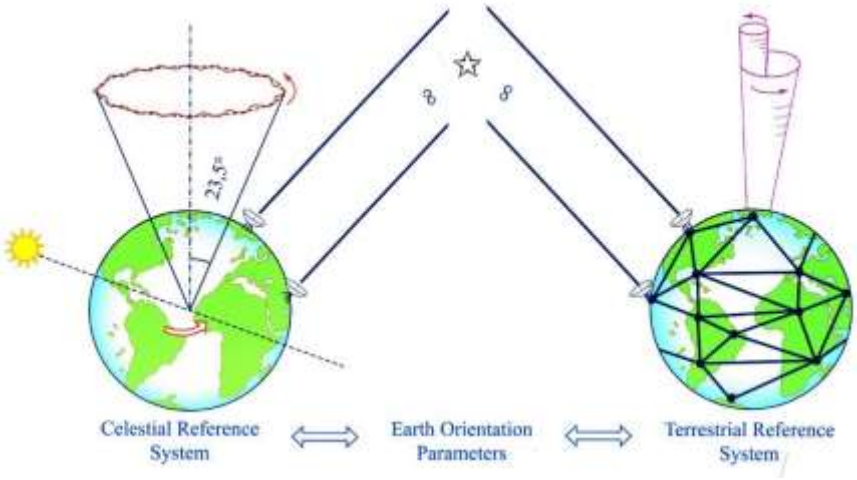
JSG1 : Intercomparison of Gravity and Height Changes

JWG1: Theory of Earth Rotation and Validation

JWG2: Constraining Vertical Land Motion of Tide Gauges

Challenges of geodesy to rotation & geodynamics

- Prove consistency of the ICRF3 (released by IAU 2018) with ITRF;
- Effects of mass displacements (atmosphere, hydrosphere and solid Earth on Earth rotation;



- For geodynamics research, establish joint (Sub-)commissions with
  - IAHS (hydrosphere)
  - IAPSO (oceans)
  - IASPEI (seismology, approved and under construction)
  - IAVCEI (volcanology, approved and under construction)

Commission 4 "Positioning and Applications"

4.1 Emerging positioning technologies and GNSS augmentation

- Multi-sensor systems
- 3D point cloud monitoring
- Indoor positioning and navigation
- Robust positioning for urban trafic

4.2 Geo-spatial mapping and geodetic engineering

- Mobile mapping technologies
- Mobile health monitoring
- Geodesy in mining engineering
- Building information modelling

4.3 Atmosphere remote sensing

- Iono-atmosphere coupling
- Multi-dimens. Ionosphere
- Ionosphere scintillations
- Real-time iono-/atmosph. monitoring
- Impact on GNSS-positioning
- Troposphere tomography

4.4 Multi-constellation GNSS

- Integrity monitoring for PPP

WG1: Biases in multi-GNSS data processing

WG2: Integer ambiguity resolution for multi-GNSS PPP and PPP-RTK

Challenges of geodesy to positioning & applications

- Real-time multi-sensor positioning in engineering;
- Improve ionosphere models (scintillations, multi-dimensional);
- Study troposphere-ionosphere coupling;
- Develop troposphere topography.

Inter-Commission Committee on Theory

Joint Study Groups with Commissions / Services

10: High-rate GNSS
11: Multi-resolution aspects of potential field theory
12: Methods for recovery of high-resolution gravity field models
13: Integral equations of potential theory for continuation and transformation of classical and new gravitational observables
14: Fusion of multi-technique satellite geodetic data
15: Regional geoid/quasi-geoid modelling for sub-centimetre occur.
16: Earth's inner structure from geodetic and geophysical sources
17: Multi-GNSS theory and algorithms
18: High resolution harmonic analysis & synthesis of potential fields
19: Time series analysis in geodesy
20: Space weather and ionosphere
21: Geophysical modelling of time variations in deformation & gravity
22: Definition of next generation terrestrial reference frames

IAG Services on Geometry

IERS: International Earth Rotation and Reference Systems' Service

IGS: International GNSS Service

ILRS: International Laser Ranging Service

IVS: International Service for Geodesy and Astrometry

IDS: International DORIS

All the techniques' Services compute epoch station coordinates (weekly, monthly, session-wise) and provide them as free or loosely constrained networks to the ITRF processing centres of the IERS.

IAG Services on Gravimetry

IGFS: International Gravity Field Service

BGI: Bureau Gravimetrique International

ICGEM: International Centre for Global Earth Models

IDEMS: International Digital Elevation Model Service

IGETS: International Geodynamics and Earth Tide Service

ISG: International Service for the Geoid

COST-G: Combination Service for Time-variable Gravity field sol's

Comprehensive Services

BIPM: Bureau International des Poids et Mesures

- Time Department -

PSMSL: Permanent Service of Mean Sea Level

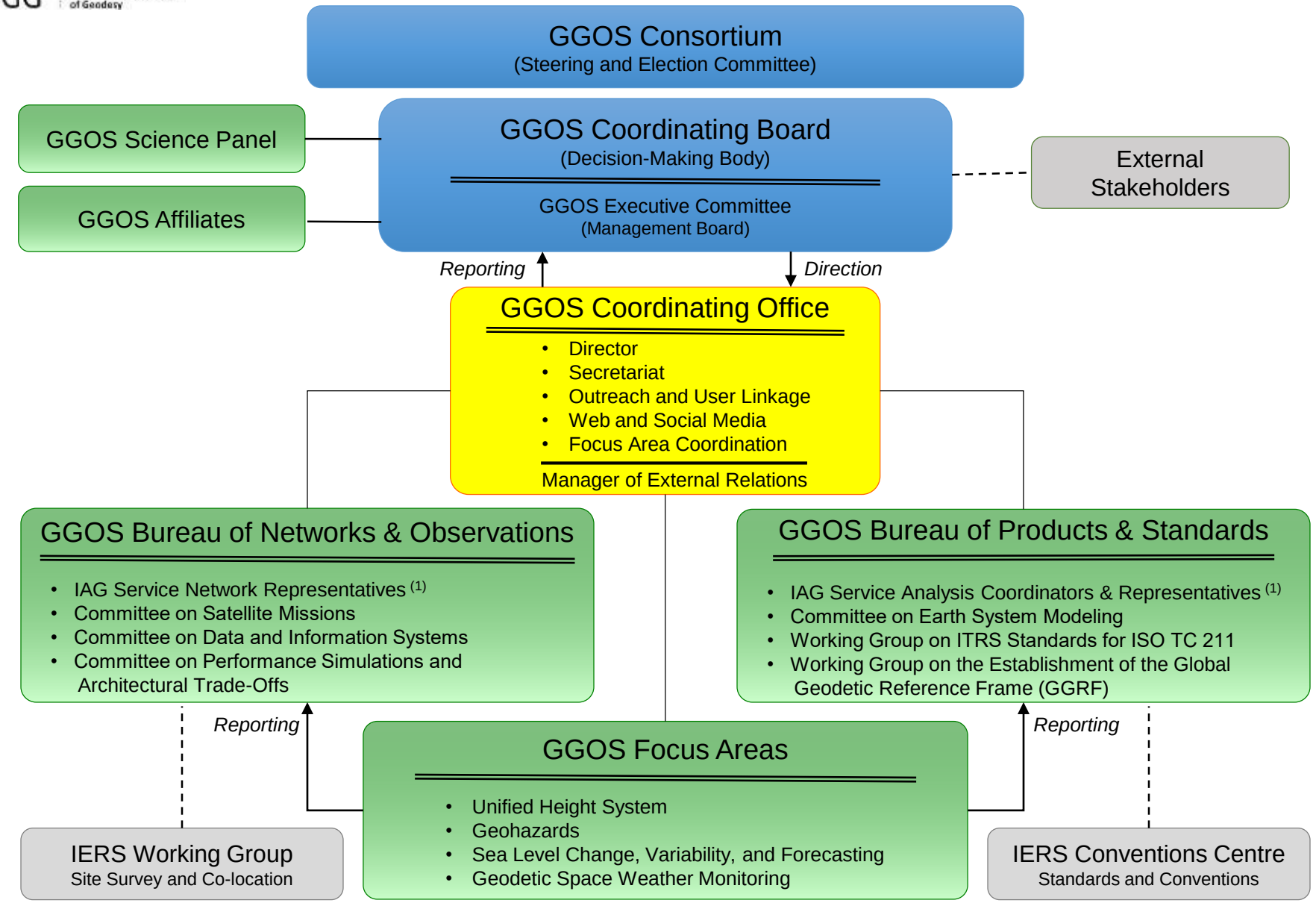
- Sea level at tide gauges

All the Services have a general structure including
- Central Bureau coordinating all internal affairs,
- Analysis Centres generating the Services‘ products.

All the Services are working on a voluntary basis, unpaid by IAG or other international organisations.

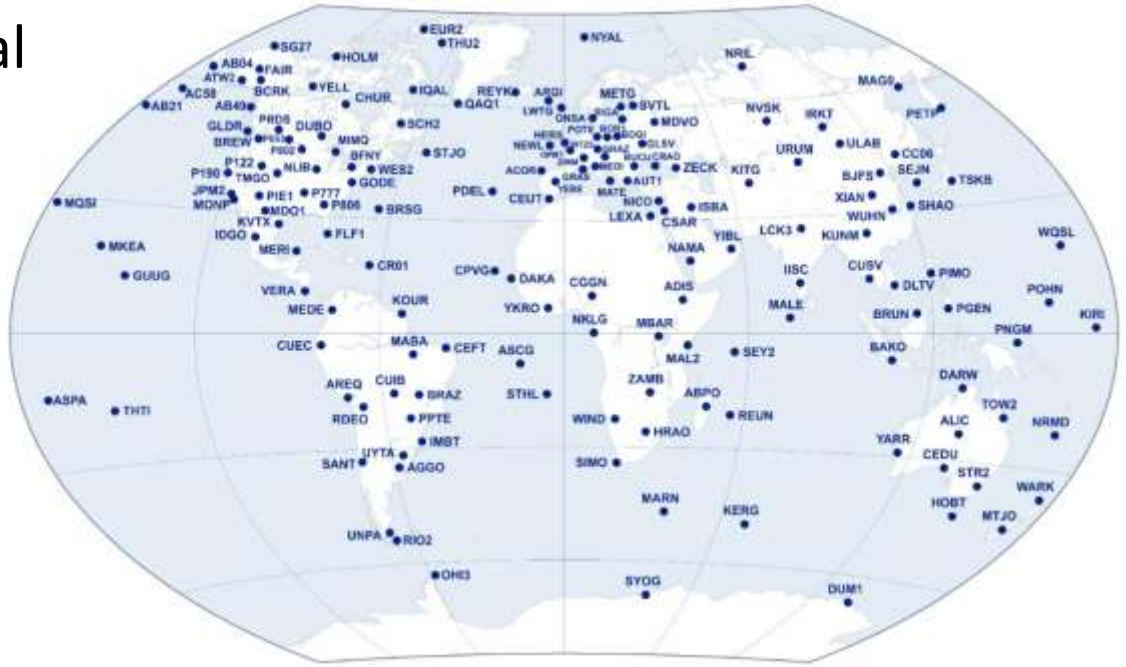
The Services are cooperating in the Global Geodetic Observing System (GGOS) to achieve consistency of products.

GGOS Structure



Challenges of geodesy to GGOS

- Develop a strategy to design, integrate and maintain the fundamental geodetic network of co-located instruments;
- Define the essential geodetic variables and provide fundamental geodetic parameters;
- Establish the International Height Reference Frame (IHRF) according to IAG Resolution 2, 2015;
- Improve the global interaction with GGOS by establishing regional and national alliances.



IHRF status April 2018 (Sánchez, L., 2018)

Cooperation with External Organisations

United Nations (UN)

- 2012: Initiative on the Global Geospatial Information Management (UN-GGIM)
- 2015: UN Resolution on the Global Geodetic Reference Frame (GGRF) approved
- 2015 – 2016: A Roadmap for the GGRF was developed
- 2016: At the UN-GGIM sixth session in New York on August 5, 2016, the UN Committee of Experts on the GGIM
  - endorsed the GGRF Roadmap and
- 2017: Decision to establish a permanent **Sub-Committee on Geodesy**.
- UN-GGIM Working Group on the GGRF: 32 Member States and 2 organisations:
  - International Association of Geodesy (IAG),
  - World Health Organisation (WHO)
- UN-GGIM Geospatial Societies (previously Joint Board of Geo-Information Societies (JBGIS) with GSDI, IAG, ICA, IEEE-GRSS, FIG, IGU, INIA, ISPRS)
- UN Office of Outer Space Affairs (UN-OOSA): Representatives to
  - Space-based Information for Disaster Management and Emergency Response (SPIDER)
  - International Committee on Global Navigation Satellite Systems (ICG)

Cooperation with External Organisations

COSPAR (ICSU Committee on Space Research)

- COSPAR Sub-commission B2: International Coordination of Space Techniques for Geodesy and Geodynamics (CSTG) is identical with IAG Commission 1

Group on Earth Observation (GEO)

- IAG represented by its GGOS (Global Geodetic Observing System) is a Participating Organisation of GEO

International Organisation for Standardisation (ISO)

- TC211 Geographic Information / Geomatics (2 representatives)
- Control Body for Geodetic Registry Network (2 representatives)

International Astronomical Union (IAU)

- Commission A2: Rotation of the Earth (representative)
- Joint Services and Working Groups:
  - International Earth Rotation and Reference Systems Service (IERS)
  - International VLBI Service for Geodesy and Astrometry (IVS)

International Hydrographic Organisation (IHO)

- Advisory Board on the Law of the Sea (ABLOS) (4 representatives)

IAG Publications

Publications

- **Journal of Geodesy** (monthly issues edited by Springer)

- **IAG Symposia Series** (latest volumes)
  - Vol. 147 International Symposium on Earth and Environmental Sciences for Future Generations (2018)
  - Vol. 148 International Symposium on Gravity, Geoid and Height Systems (2018)
  - Vol. 149 Joint IAG/IASPEI Scientific Assembly Kobe, Japan, 2017 (2019)

- **Geodesist's Handbook 2016** (https://link.springer.com/article/10.1007/s00190-016-0948-z)
  - IAG history, statutes, bylaws, rules, membership
  - Report of the General Assembly 2015
  - Structure and program descriptions 2015-2019
  - General information

IAG Reports, Position Papers, Outreach

IAG Reports

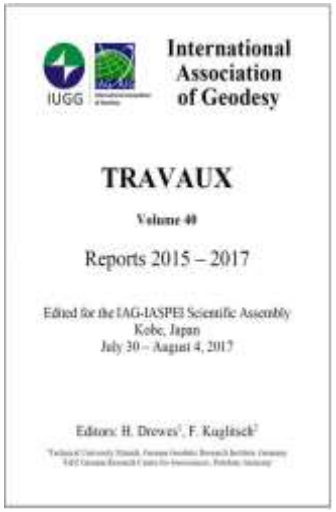
- **IAG Report 2015-2017** (Travaux de l'AIG Vol. 40)

  https://iag.dgfi.tum.de/en/iag-publications-position-papers/iag-reports-2017-online/

  - Activity reports of all IAG components and sub-components

- **Annual and quadrennial reports** (ibid.)

- **Monthly Newsletters** (http://www.iag-aig.org/index.php?tpl=cat&id_c=44)



Position Paper on the UN Global Geodetic Reference Frame (GGRF)

Communication and Outreach Branch (COB)

- **IAG Outreach Homepage** (https://www.iag-aig.org)
- **IAG Office Homepage** (https://iag.dgfi.tum.de)

IAG/IUGG General Assembly
Montreal, Canada, July 8 - 19, 2019

6 IAG Symposia

G01 Reference systems and frames;
G02 Static gravity field and height systems;
G03 Time variable gravity field;
G04 Earth rotation and geodynamics;
G05 Multi-signal positioning, remote sensing and applications;
G06 Monitoring and understanding the dynamic Earth with geodetic observations.

8 Joint Symposia with other associations (led by IAG)

20 Joint Symposia with other associations (sponsored by IAG)
(led by IACS, IAGA, IAHS, IAMAS, IAPSO, IASPEI, IAVCEI)

9 Union Symposia (co-organized by IAG)
(led by IUGG or IUGG Commissions)

Conclusions

Most provoking challenges

- Reference Frames - Co- and post-seismic deformation models
- Gravity field - International Gravity Reference Frame (IGRF)
- Rotation & Geodyn. - Joint commissions with other associations
- Pos. & Applications - Atmosphere (iono- & troposphere) models
- Geodetic theory - Relativistic geodesy, new geodetic techniques
- GGOS - International Height Reference Frame (IHRS)
  - Essential geodetic variables
  - New GRS to replace GRS80
- Geometry Services - Reliable continuous ITRF
- Gravity Services - Recommended global gravity field model
- Combining Services - Adopt IAG resolutions (W_0)
  - Sea level variation model

Invitation to IAG Membership via IUGG

IUGG member countries from the Americas (1 unit = US$ 1975)

Regular members		**Associate members**
Argentina	Brazil	Bolivia
Canada	Chile	Peru
Colombia	Costa Rica	
Mexico	Nicaragua	
USA		

Invitation to SIRGAS countries and others to become members

Cuba	was member till	1996	Belize	Jamaica
Dominican Rep.	was member till	1971	Ecuador	Panama
Guatemala	was member till	2000	El Salvador	Paraguay
Haiti	was member till	1971	Guyana	Suriname
Uruguay	was member till	2000	Honduras	Trinidad & Tobago
Venezuela		2008		

To join IUGG including IAG visit www.iugg.org/join/index.php)

Invitation to IAG Membership via IUGG

All geodesists are invited to become an individual member (https://www.iag-aig.org or https://iag.dgfi.tum.de).
It is free of charge for all (undergraduate … PhD) students!

Thank you for your attention!
¡Gracias por su atención!