GGOS: The Global Observing System of the International Association of Geodesy

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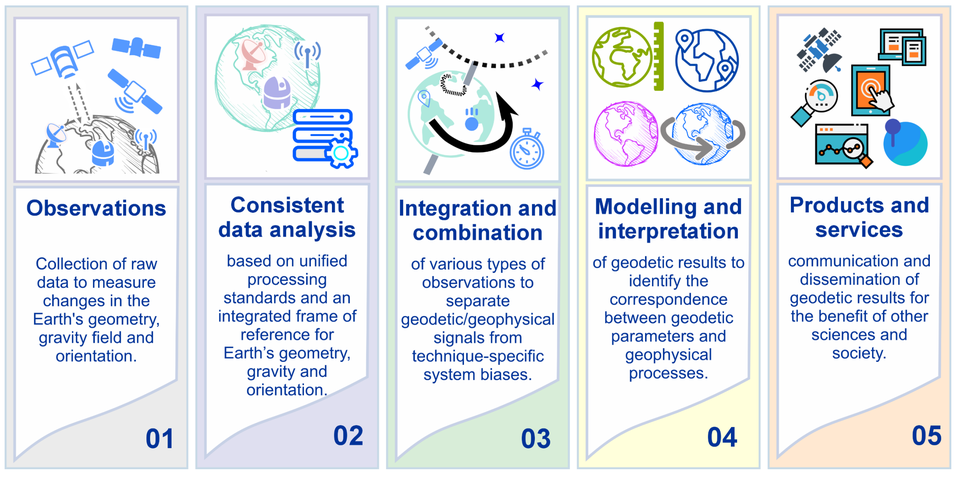
Observing the Earth with Geodesy

A Global Observing System consists of numerous individual terrestrial and space-based observing networks/sensors that collect data essential for monitoring specific characteristics of the Earth. The **Global Geodetic Observing System (GGOS)** observes the time-varying size, shape, rotation and gravity field of the Earth with respect to precise and long-term stable geodetic reference frames.



From geodetic observations to Earth system modelling. *The IAG established GGOS with the vision of using geodetic data and products to serve science and society far beyond the traditional task of measuring and mapping the Earth's surface. The basic principle is to move from the provision of basic geodetic products (station coordinates, geoid, Earth orientation parameters) to a level of consistent modelling and interpretation of Earth system processes and interactions, and to ensure an integrated observing system rather than a flood of individual technic-dependent products.*

Organisational elements facing specific building blocks of GGOS

The **GGOS Bureau of Networks and Observations (BNO)** focuses on the global geodetic infrastructure.

It assesses the status of the existing infrastructure and advocates its modernisation, expansion and maintenance, carries out simulation studies to optimise the observing networks, and provides a forum for the exchange of information on satellite missions relevant to geodesy. The coordination and implementation of the GGOS co-located station network (with geometric and gravimetric techniques) is a major focus of the Bureau.

The **GGOS Bureau of Products and Standards (BPS)** focuses on standardisation, integration and optimisation of geodetic products.

It keeps track of the adopted geodetic standards and conventions in all IAG Components and proposes actions to address inconsistencies or gaps. It promotes and identifies (new) geodetic products that could meet emerging science and societal needs. To this end, it is working towards the definition of Essential Geodetic Variables (EGVs), see below.

The **GGOS Coordinating Office (GGOS-CO)** is responsible for outreach, communication and external relations.

It also hosts activities related to the use of DOIs in geodetic data and works on the implementation of the GGOS Portal as a unique and comprehensive platform for the availability of geodetic data and products. This is essential for the communication and dissemination of geodetic results so that other sciences and communities recognise the monitoring of the Earth system by geodesy.

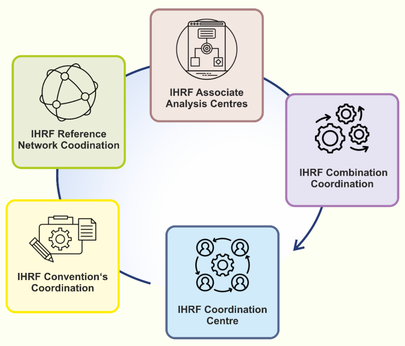
GGOS Affiliates are national or regional geodesy-related organisations that enable greater collaboration across regions, communities and new technologies.

Current GGOS Affiliates are GGOS Japan, GGOS D-A-CH (Germany, Austria, Switzerland) and GGOS IberAtlantic (Spain and Portugal). A GGOS Affiliate for Africa is in the start-up phase.

GGOS Focus Areas: Incubators of new themes and integrated research

The GGOS Focus Areas (FAs) address broader issues that require the convergence of different IAG components to solve. They are interdisciplinary, designed to address gaps and required future geodetic products, and are incubators for new research topics. They illustrate the GGOS principles of overarching collaboration across the IAG, integrated analysis across geodesy and generation of new products.

FA Unified Height System



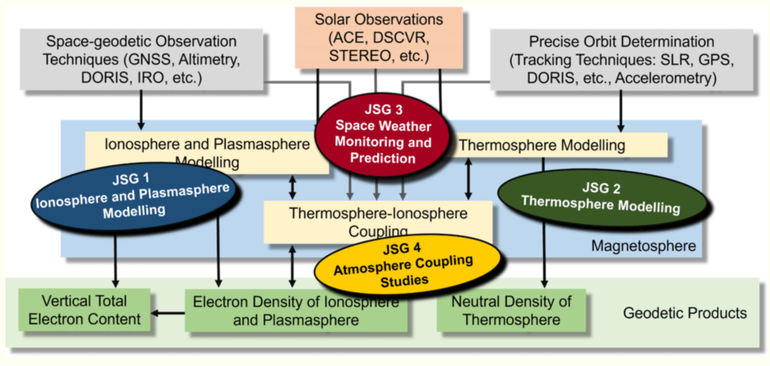
Components of the IHRF Coordination Centre

An example of the rationale behind the GGOS FAs is the FA Unified Height System. It was established to coordinate the efforts needed towards the establishment of a global standard for the precise determination of physical heights. During 12 years of continuous work, colleagues involved in this FA defined the International Height Reference System (IHRS), which was officially adopted by the IAG through a Resolution at the 2015 IUGG General Assembly, calculated the first solution for the realisation of the IHRS; the International Height Reference Frame (IHRF), and provided the basis for an operational infrastructure to ensure the long-term sustainability and reliability of the IHRS/IHRF. This operational infrastructure, called IHRF Coordination Centre, was approved by the IAG Executive Committee in December 2023 and is now operating under the umbrella of the International Gravity Field Service (IGFS). Having achieved its goals, this FA was closed during the IUGG 2023 General Assembly.

FA Geohazards Monitoring

This FA concentrates on the reliable use of GNSS techniques for Tsunami Early Warning Systems (GTEWS). Through close collaboration with the IUGG Commission on Geophysical Risk and Sustainability and the Geodesy4Sendai activity of the Group on Earth Observations (GEO), it leads the development, support and coordination of resources to assemble a GTEWS consortium. Outcomes of the FA have contributed to the 2019 Global Assessment Report on Disaster Risk Reduction (GAR) published by the UN Office for Disaster Risk Reduction. Efforts are currently underway to establish an enhanced GTEWS framework in Oceania.

FA Geodetic Space Weather Research (GSWR)



Objectives and structure of the GGOS FA GSWR

The objectives of this FA are (1) the development of improved models of the ionosphere, plasmasphere and thermosphere, (2) the investigation of the coupling processes between these atmospheric sub-components, and (3) a better understanding of space weather events and their possible monitoring by space missions and observing systems.

FA Artificial Intelligence for Geodesy (AI4G)

The FA-AI4G is making significant progress in the development and evaluation of improved geodetic products based on AI and machine learning in particular for GNSS remote sensing, gravity field and mass change, Earth orientation parameter prediction, and geodetic deformation monitoring.

GGOS strategy activities in progress

In a recent strategy survey, the international geodetic community provided their perceptions and expectations of GGOS. Based on this survey, GGOS has renewed its Strategic Plan and has designed the corresponding Implementation Plan. Central actions are:

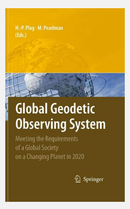
Definition of Essential Geodetic Variables (EGVs)

Domain	Subdomain	Essential Geodetic Variables (EGVs)
Global	Geometric/Physical	Global Reference Frames
	Geometric	Earth Orientation Parameters | Satellite Orbits
	Physical	Global Earth Gravity Field | Neutral Atmosphere and Ionosphere
Ocean	Geometric	Sea Surface | Sea Ice | Tide Gauge Records
	Physical	Sea Level
Land	Geometric	Land Geometry | Station Positions and Variations
	Physical	Terrestrial Water Storage
	Geometric/Physical	Ice Sheets | Glaciers | Inland Water Level
Land/ Ocean (for regional applications)	Geometric/Physical	Regional Reference Frames
	Physical	Land and Marine Gravity Data | Regional Gravity Field Model

to describe the contribution of geodesy to Earth observation using the same language as other global observing systems such as the Global Climate Observing System (GCOS) or the Global Ocean Observing System (GOOS). This will increase the visibility of geodesy and the usability of its products for the benefit of other sciences and society.

The present concept considers 18 EGVs based on 53 geodetic products. The EGVs are classified into the domains global (for the whole Earth), land and ocean. The sub-domain indicates whether the EGV relates to the geometry or the gravity field of the Earth. This concept has been endorsed by the GGOS Science Panel and is currently under review by the GGOS Governing Board.

Review and update of the requirements for GGOS



: The science rational behind GGOS, as well as its main goals and challenges were documented by the IAG science community in 2009 in The Global Geodetic Observing System Meeting the requirements of a global society on a changing planet in 2020 (Plag and Pearlman (eds.), 2009). Since then, great progress has been made in (new) technologies for the observations, data collection, analysis and distribution, and an increased accuracy of geodetic measurements and products has been achieved. It is necessary to update the requirements for GGOS to keep pace with these recent technological advances.

The implementation of the GGOS Portal

as a unique search and access point (one-stop-shop) for geodetic data and products. The IAG Services provide a variety of important and valuable geodetic data, information, and products that are increasingly relevant for Earth system research, geospatial data management, and sustainable development. However, it is currently difficult to have an overview of all available geodetic data and products, their quality, and fields of application. The GGOS Portal aims to provide a comprehensive description of geodetic products, associated metadata, and corresponding data sources.

Interaction with UN bodies related to geodesy

: The UN Resolution A/RES/69/266 "Global Geodetic Reference Frame for Sustainable Development" places the importance of geodesy at the centre of the political arena, not only from the point of view of a robust, modern and durable measurement infrastructure, but also of parallel research and development activities that ensure reliable, timely, long-range and globally accessible geodetic products. The UN initiative in geodesy continues to grow with the establishment of the Sub-Committee on Geodesy of the UN Committee of Experts on Global Geospatial Information Management (UN-GGIM) in 2017, and the UN Global Geodetic Centre of Excellence (UN-GGCE) in 2023. GGOS works closely with the UN-GGCE on outreach activities, contributed to the Global Geodesy Needs Assessment and supports the first Joint Global Geodesy Development Plan. A successful outcome of the UN-GGCE will mean an improved visibility of geodesy and increased availability of infrastructure resources for the GGOS.

More information at www.ggos.org and further reading *(selection)*