

The Global Geodetic Observing System (GGOS): Integrating Geodetic Infrastructure, Science, and Services for Earth Monitoring

Laura Sánchez

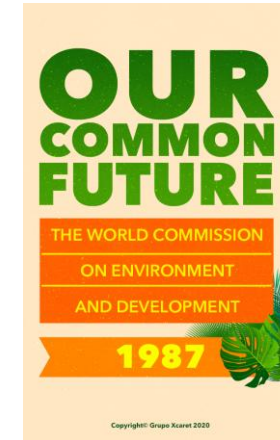
President of GGOS
Deutsches Geodätisches Forschungsinstitut,
Technische Universität München (DGFI-TUM)

20th General Assembly | Nordic Geodetic Commission
Vilnius, Lithuania | 14 – 17 September 2026



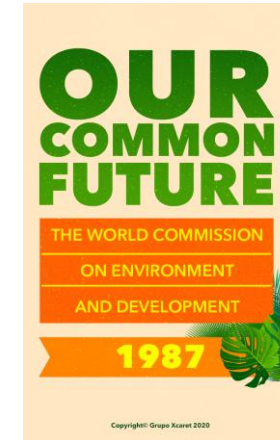
Genesis of the Global Observing Systems

- 1987 | “Sustainable development” as the mainstream international policy concept (the Brundtland Report)
- 1992 | UN Earth Summit in Rio de Janeiro: Political origin of modern Global Observing Systems – GOS (Agenda 21):
 - systematic monitoring of oceans, atmosphere, climate, and ecosystems
 - improved data sharing
 - capacity building in developing states
 - unified global observing networks



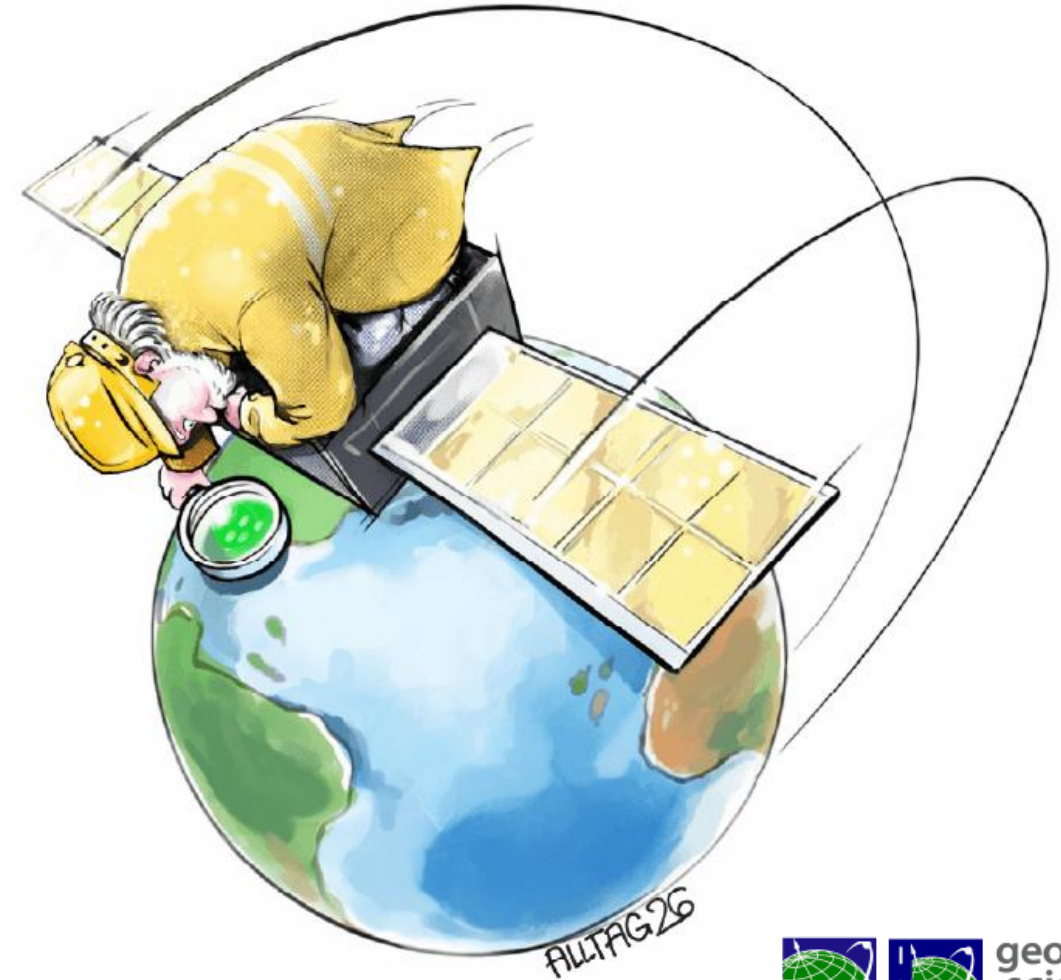
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- 1991 Global Ocean Observing System (GOOS)
- 1992 Global Climate Observing System (GCOS)
- 1995 First ideas for a Global Geodetic Observing System (GGOS) by the International Association of Geodesy (IAG)



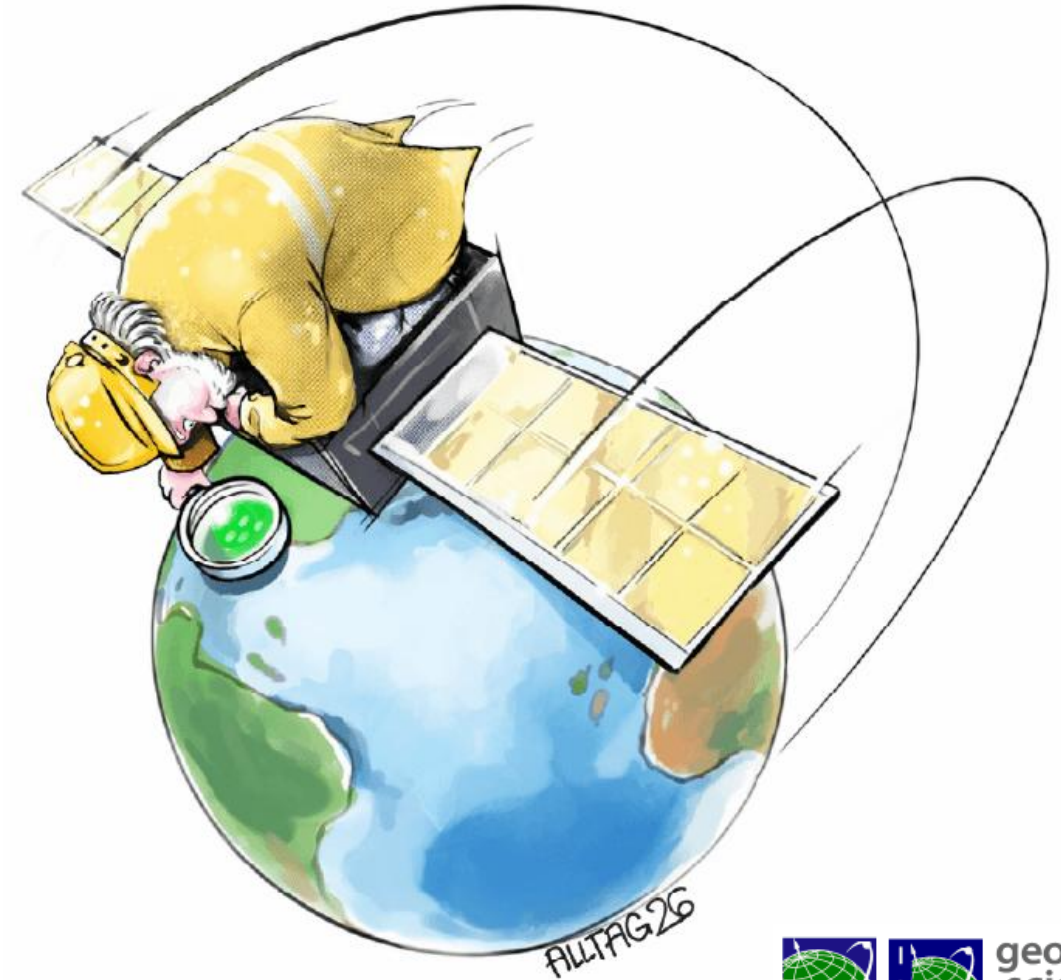
Global Observing Systems as collaboration hubs

- Goal: To develop an operational, stable, long-term observing infrastructure (not only infrastructure for short-term research).
- From the outset, these observing systems were designed to provide a common framework to coordinate Earth-monitoring efforts.



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- From the outset, these observing systems were designed to provide a common framework to coordinate Earth-monitoring efforts.
- They do not own instruments, launch satellites, operate stations or generate data independently.
- They depend on the infrastructure, data and expertise voluntarily shared by contributing countries and organisations.



Why an Observing System based on Geodesy?

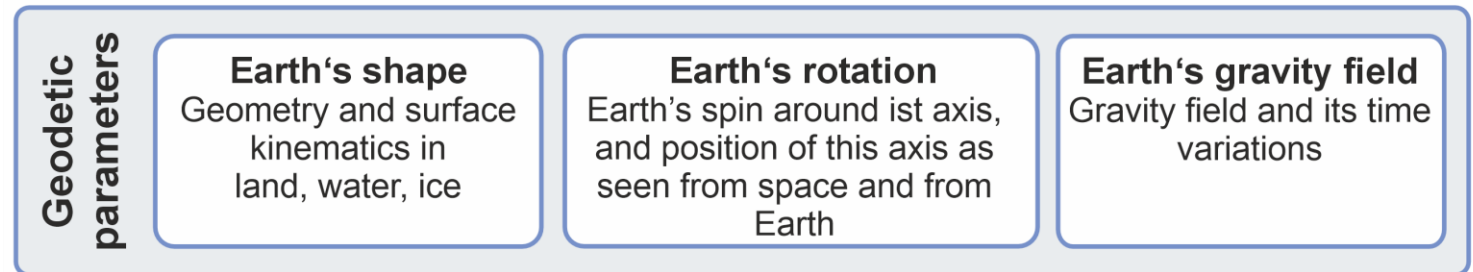


- Geodesy determines the shape, rotation and gravity field of the Earth as functions of time and space.
- These characteristics react, albeit in different ways, to changes within and between the Earth system components.

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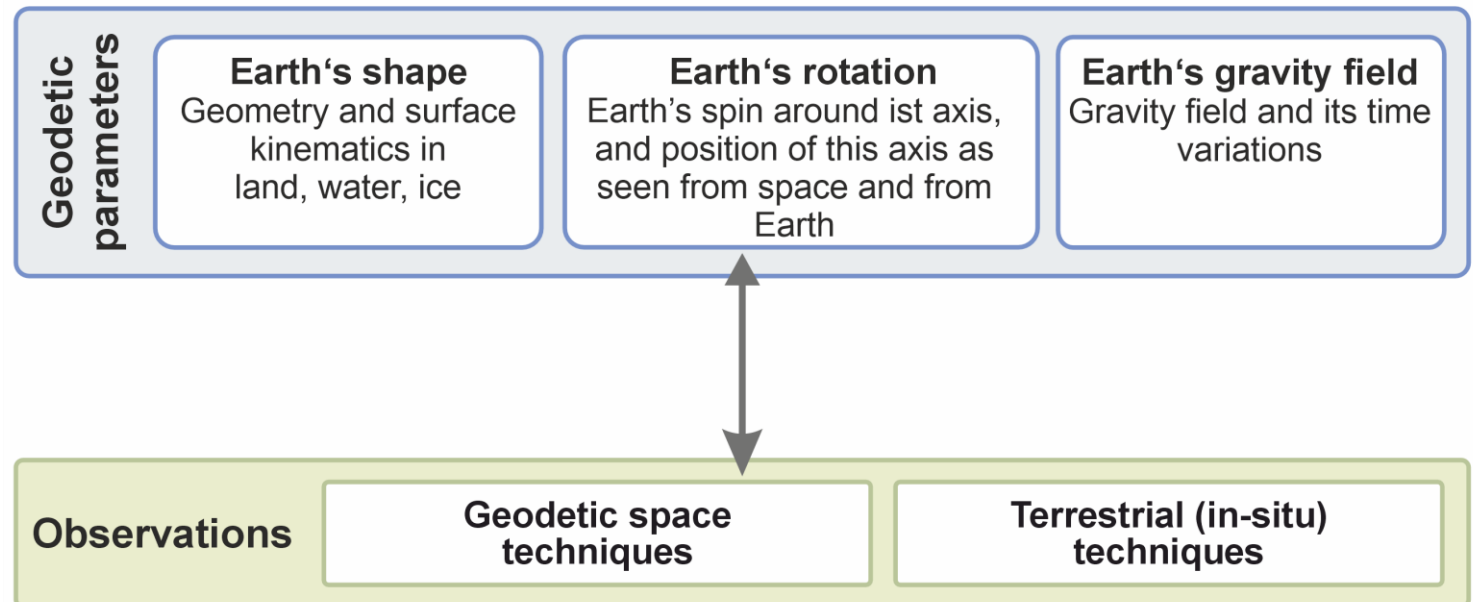
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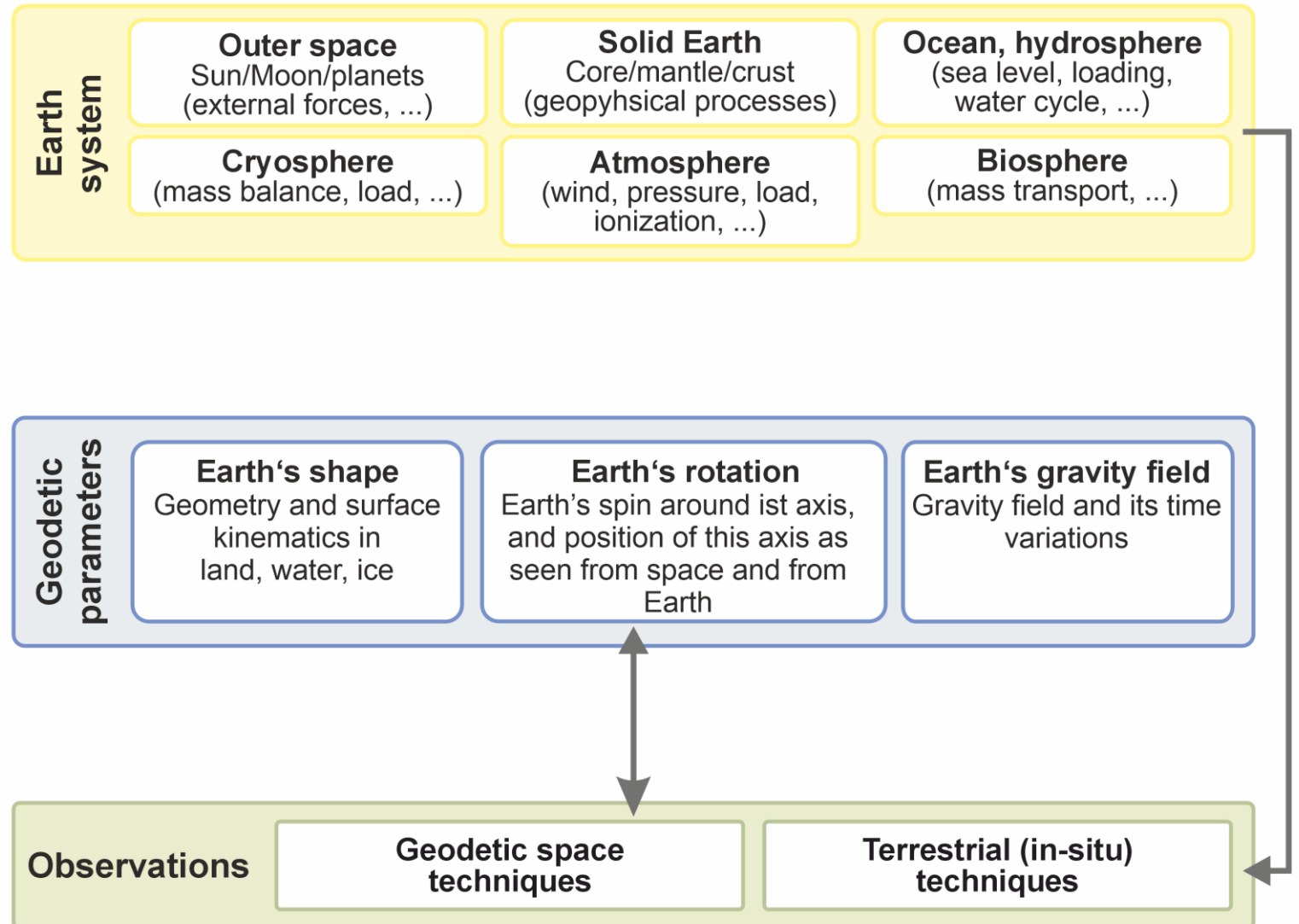


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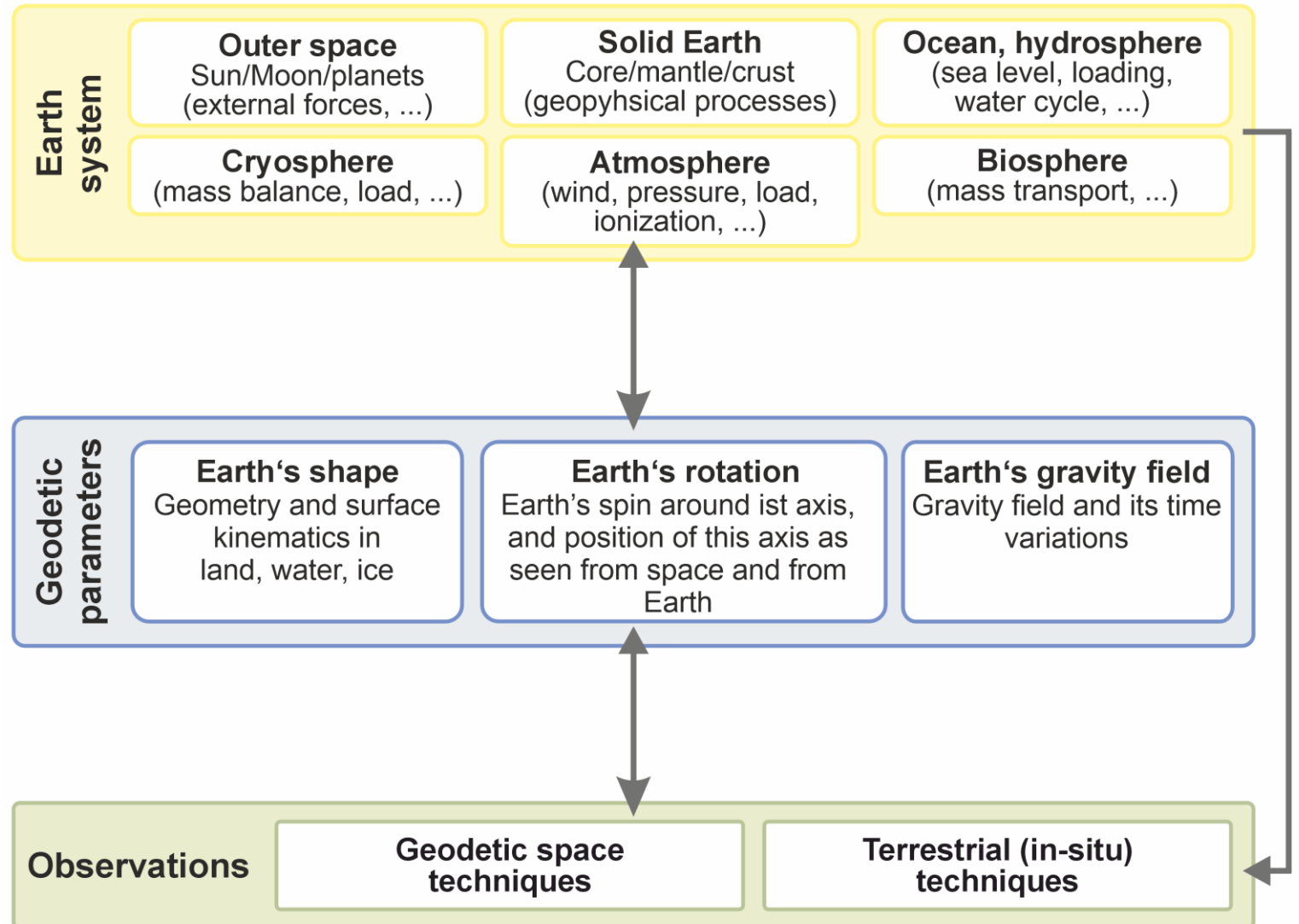
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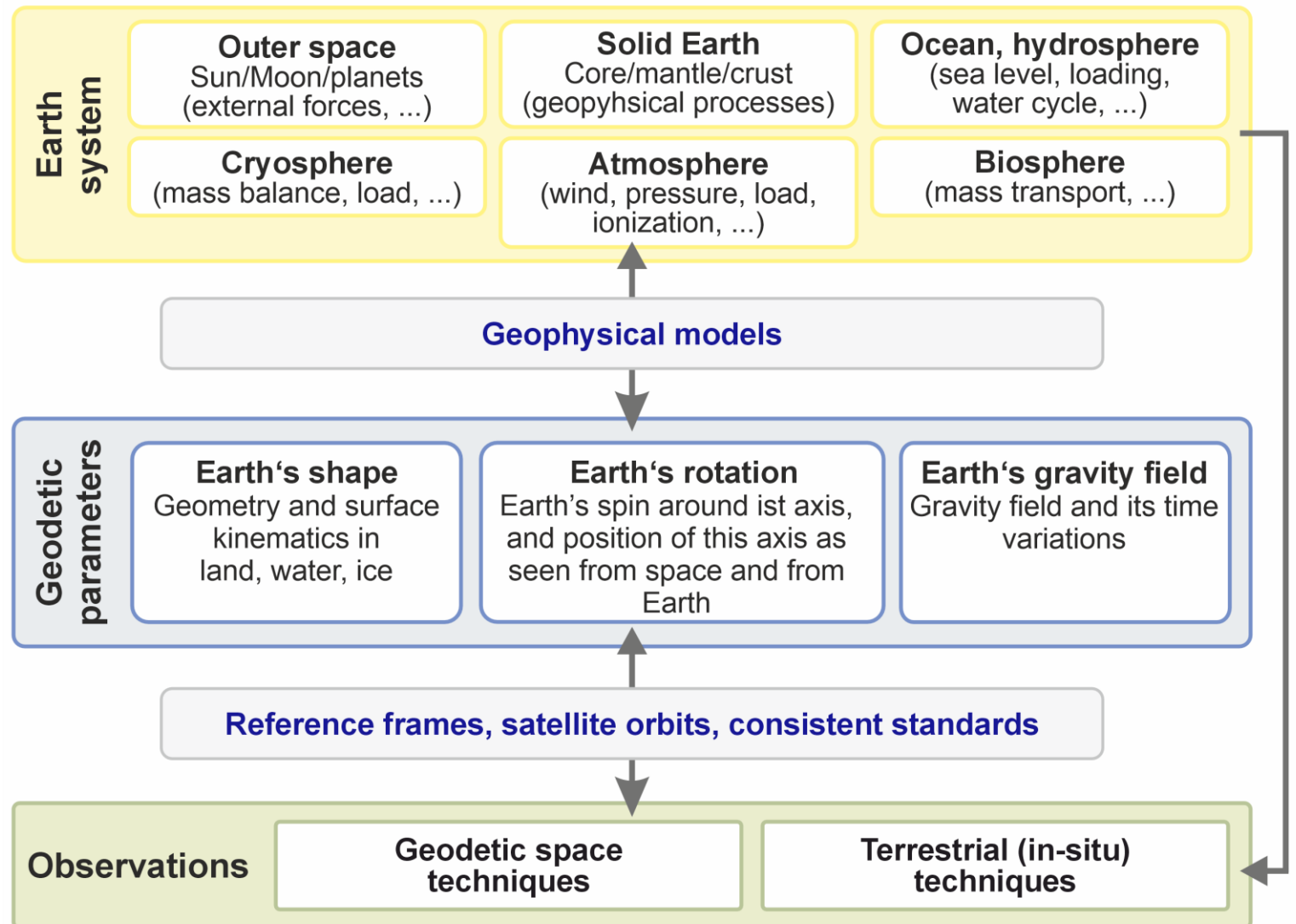
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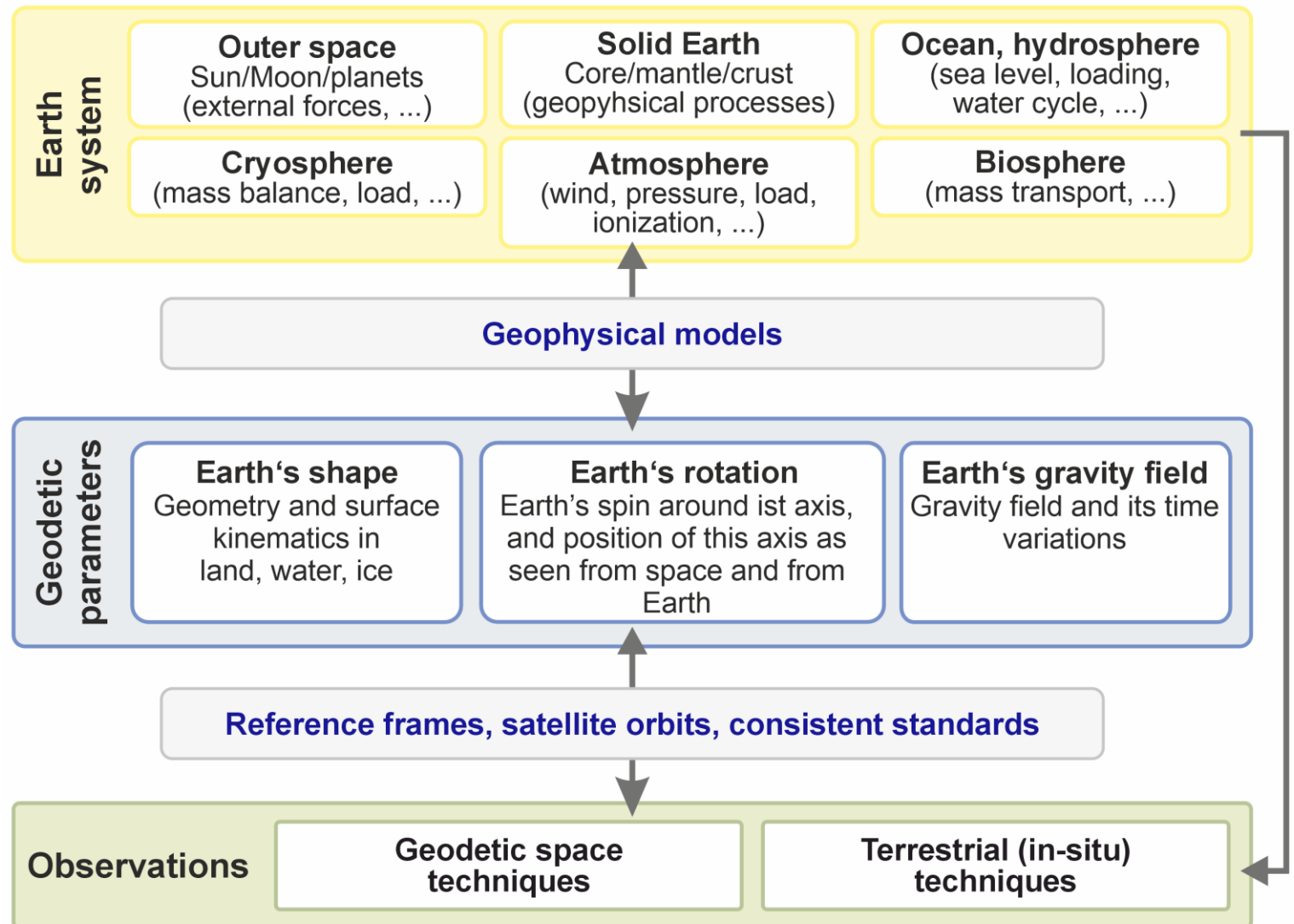
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- Geodesy determines the **shape, rotation and gravity field of the Earth** as functions of time and space.
 - These characteristics react, albeit in different ways, to changes within and between the Earth system components.
- *The Earth is changing, and geodesy provides the measurements and reference needed to monitor those changes.*



Why under the umbrella of the International Association of Geodesy (IAG)?



IAG is a global organisation that **advances geodesy**.

Origins:

- 1862 | **Central European Arc Measurement**: Determine anomalies in Earth's curvature in Central Europe
- 1864 | First Conference of Representatives in Berlin: **Permanent Commission and Central Bureau** with Triennial meetings of General Conferences (**considered a forerunner of IAG and IUGG General Assemblies**)
- 1886 | Creation of the **International Geodetic Association**
- 1919 | Incorporated into the **International Union of Geodesy and Geophysics**
- 1946 | Renamed to **International Association of Geodesy**



<https://geodesy.science/>

Measuring the Earth with Geodesy



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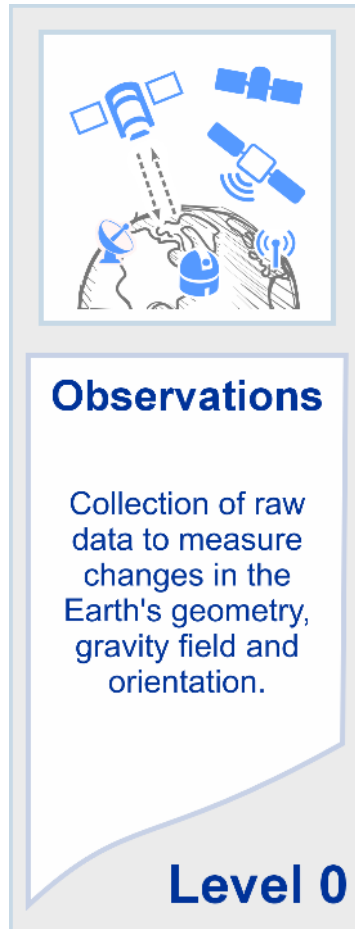
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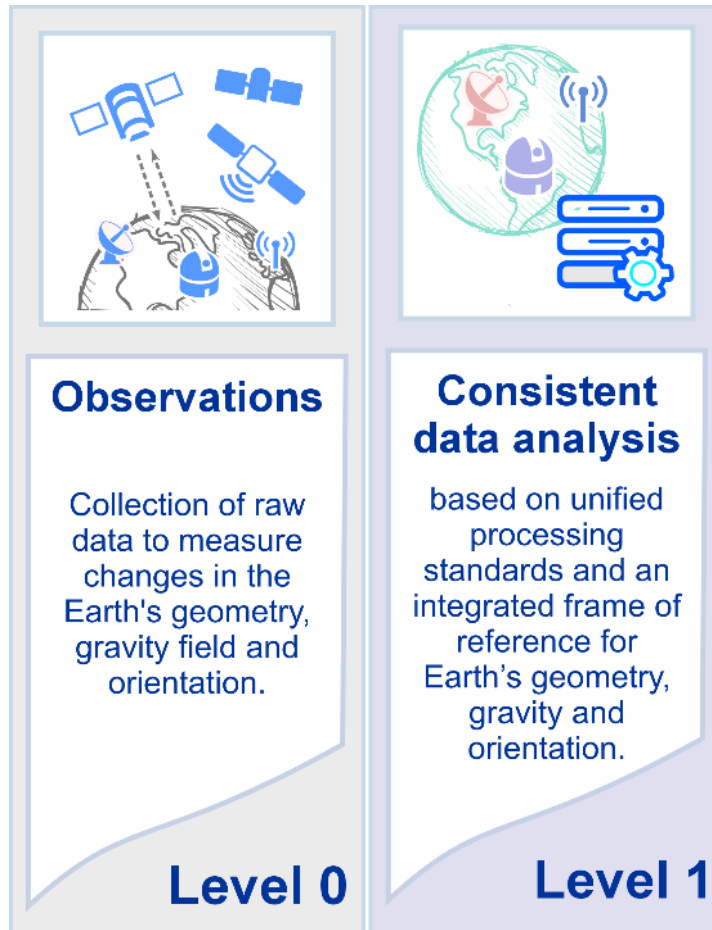
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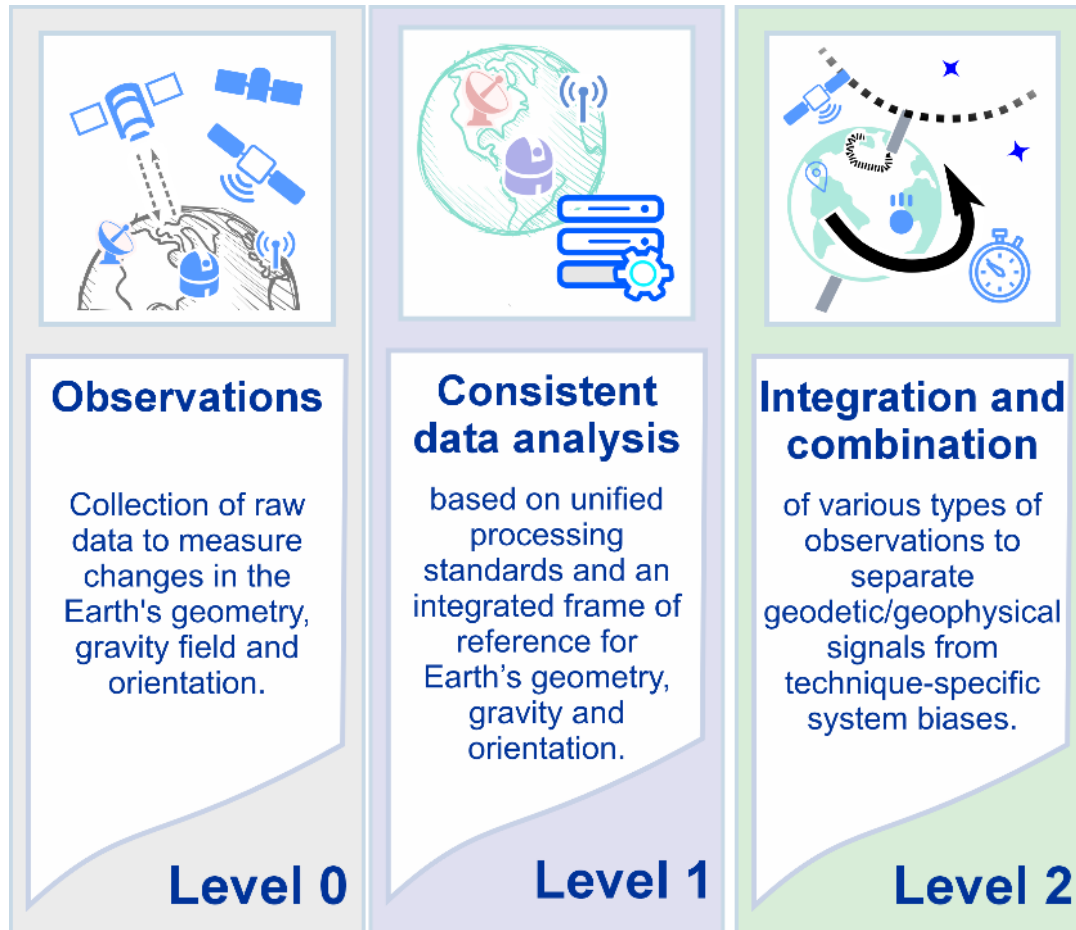
From geodetic observations to Earth System monitoring



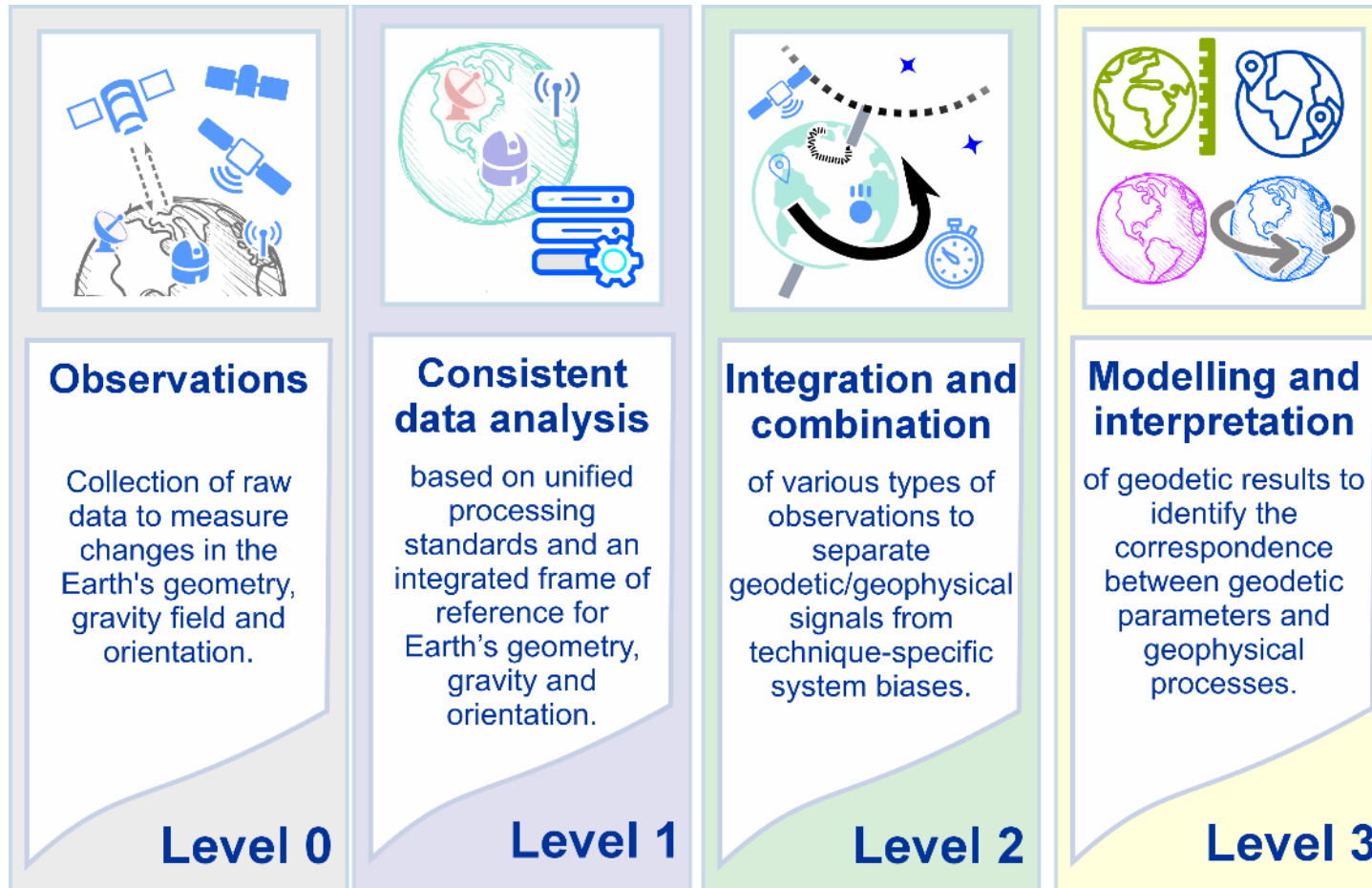
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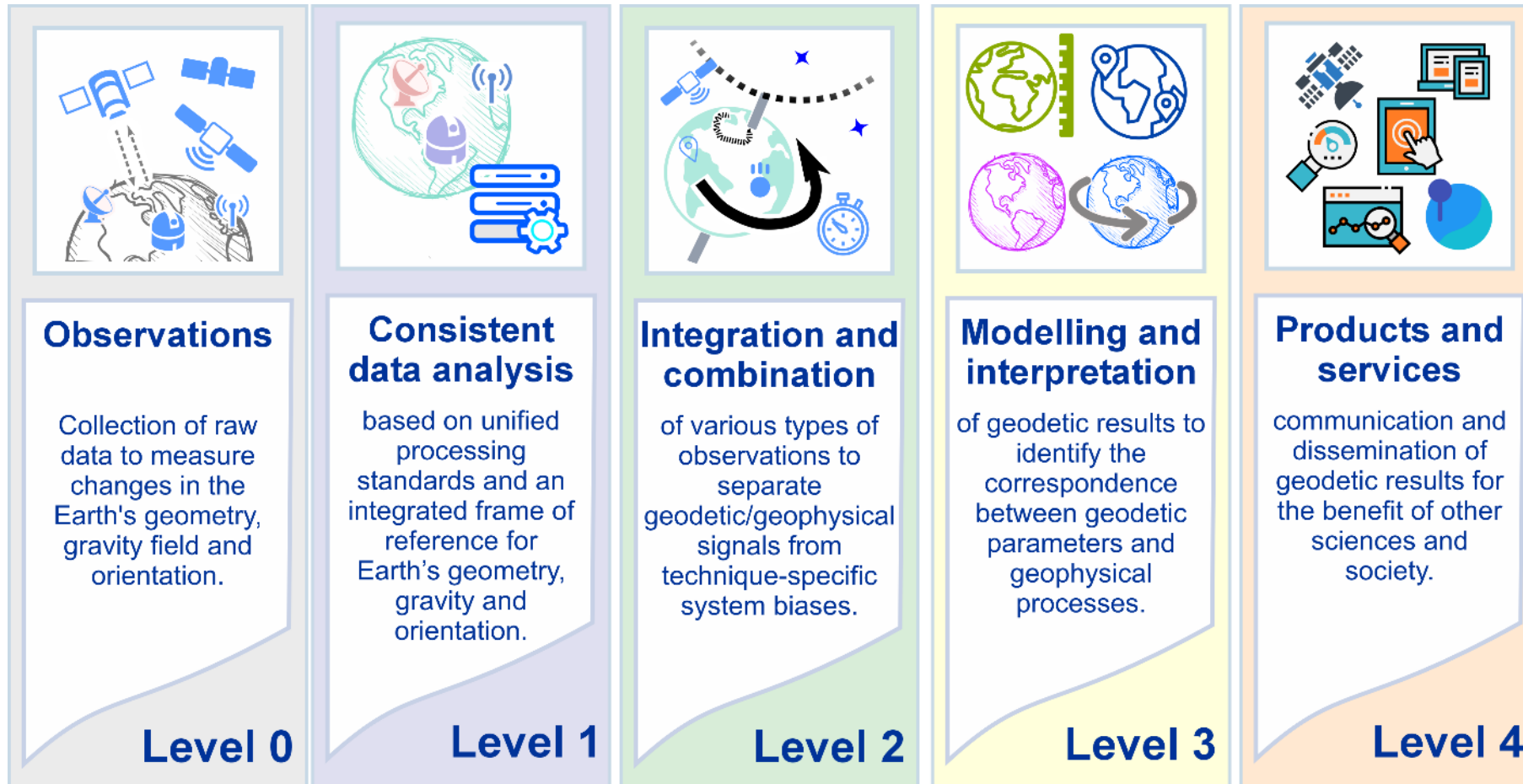
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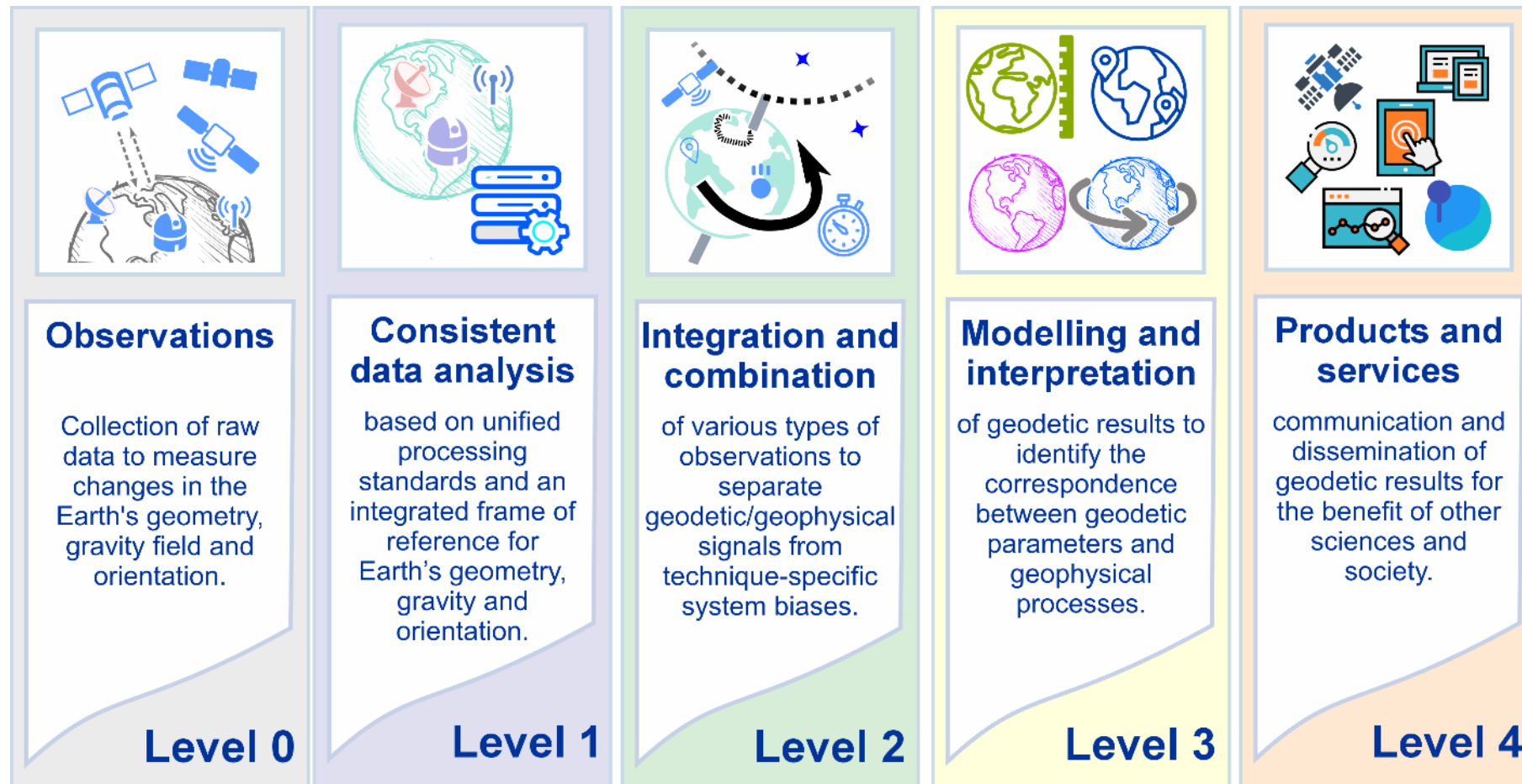
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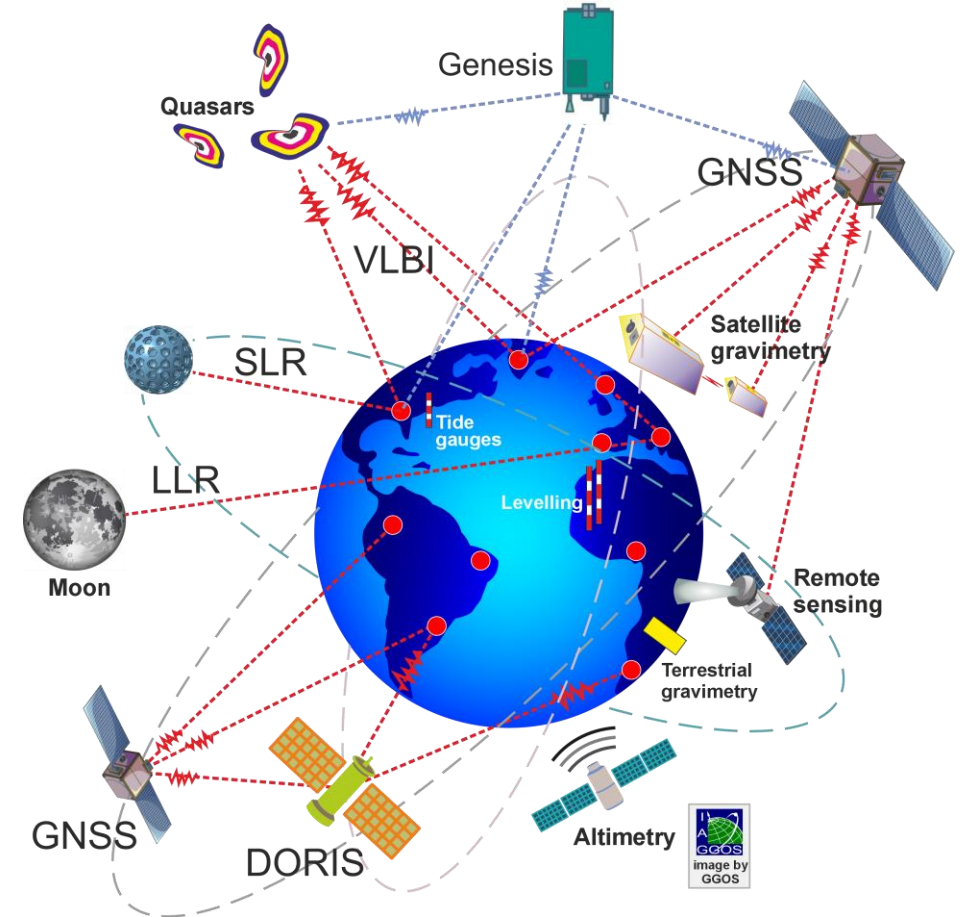
From geodetic observations to Earth System monitoring



→ *The driving challenge of GGOS is to bring together the infrastructure, science, and services needed for reliable geodetic Earth system monitoring.*

The role of GGOS

- Bring together the various geodetic observation techniques, services and analysis methods to ensure that the same standards, conventions, models and parameters are used in all data analysis and modelling of Earth system processes
- Combine geometric, gravimetric and Earth rotation observations in data analysis and assimilation, and jointly estimate and model all necessary parameters representing the different elements of the Earth system



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- Identify scientific and societal needs that can be addressed by (new) geodetic products and define the accuracy, time and space resolution, and consistency requirements of these products
- Identify service gaps and develop strategies to fill them

Geodesy Gets You There



Geodesy determines the exact position of GNSS receivers on Earth, keeping navigation precise and reliable. Without it, even the greatest explorers might have missed their destination.

The role of GGOS

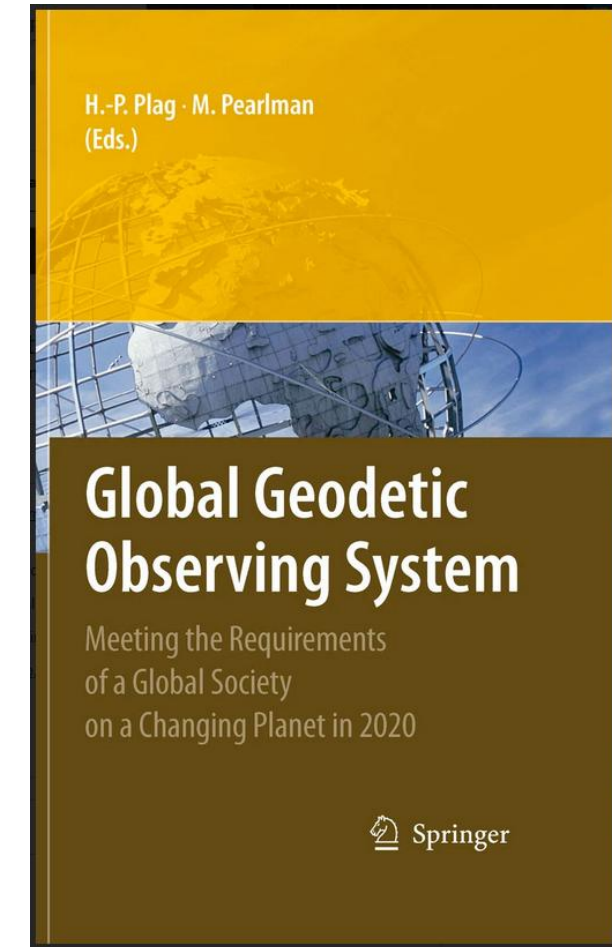
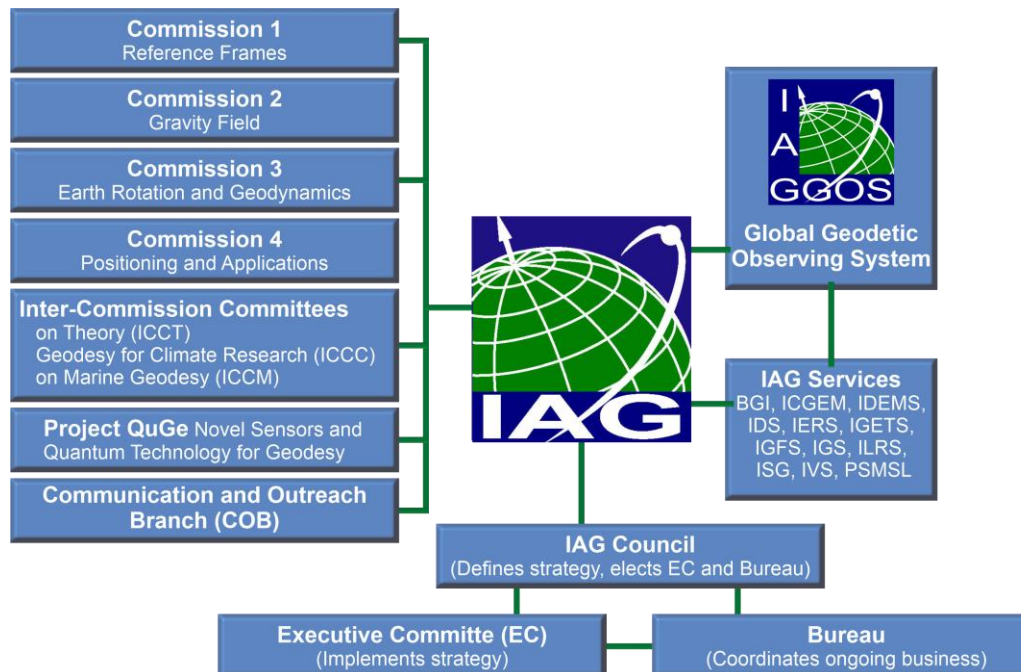
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- Identify scientific and societal needs that can be addressed by (new) geodetic products and define the accuracy, time and space resolution, and consistency requirements of these products
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- Promote and enhance the visibility of geodesy by improving the accessibility of geodetic observations, information and products to the widest range of users



The Evolution of GGOS (1/4)

1995–2007 | From an Idea to IAG Component: Building the concept

- 1998: Idea of an integrated global geodetic observing system widely discussed in Munich
- 2001: GGOS proposed as an IAG Project
- 2003: GGOS approved by IAG and endorsed by IUGG
- **2007: GGOS becomes a formal component of IAG**

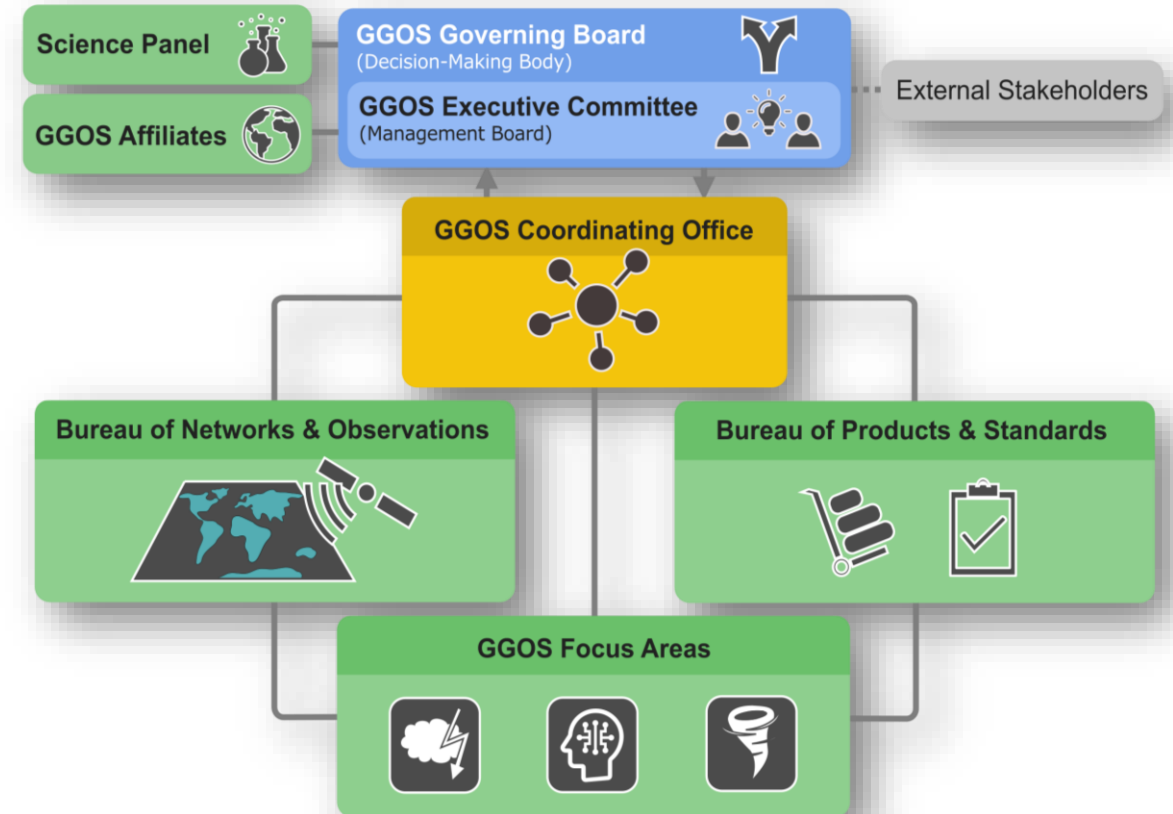


The Evolution of GGOS (2/4)

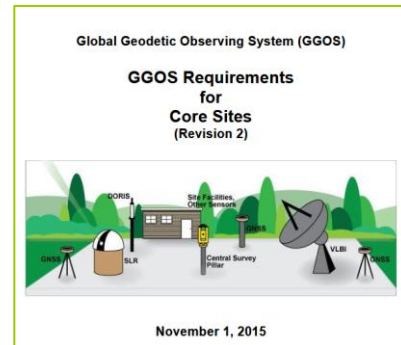


2009–2018 | Building the Global System: Integrating infrastructure and services

- GGOS Bureaus and Coordinating Office established
- Focus Areas introduced for integrated geodetic products (Unified Height System, Geohazards, AI4Geodesy, Space Weather)
- GGOS Affiliates established to broaden global participation (first GGOS Japan, now D-A-CH, IberAtlantic, Africa)
- **2015: UN Resolution on the Global Geodetic Reference Frame (GGRF)**
- **2018: First thoughts on Essential Geodetic Variables**



Inventory of Standards and Conventions	
GGOS Bureau of Products and Standards	
Inventory of Standards and Conventions used for the Generation of IAG Products	
D. Angermann ¹ , T. Gerdorf ² , M. Groll ³ , R. Heidebrecht ⁴ , U. Reipertshausen ⁵ , L. Scheller ⁶ , P. Schlegelberger ⁷	
Revision August 2020 © International Association of Geodesy 2020	
Contents	Preface and scope of the document
1. Introduction	1.1. Purpose and scope of the document
2. GGOS Bureau of Products and Standards	2.1. Mission and objectives
3. Tasks	3.1. Tasks
4. Staff and representation	4.1. Staff and representation
5. Evaluation of national standards	5.1. Evaluation of national standards
6. Policy and procedures	6.1. Policy and procedures
7. Field work and systems	7.1. Field work and systems
8. Product and services	8.1. Product and services
9. Technical reference systems and frames	9.1. Technical reference systems and frames
10. Earth Orientation Parameters (EOP)	10.1. Earth Orientation Parameters (EOP)
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12. Rights and responsibilities	12.1. Rights and responsibilities
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15. Bibliography	15.1. Bibliography

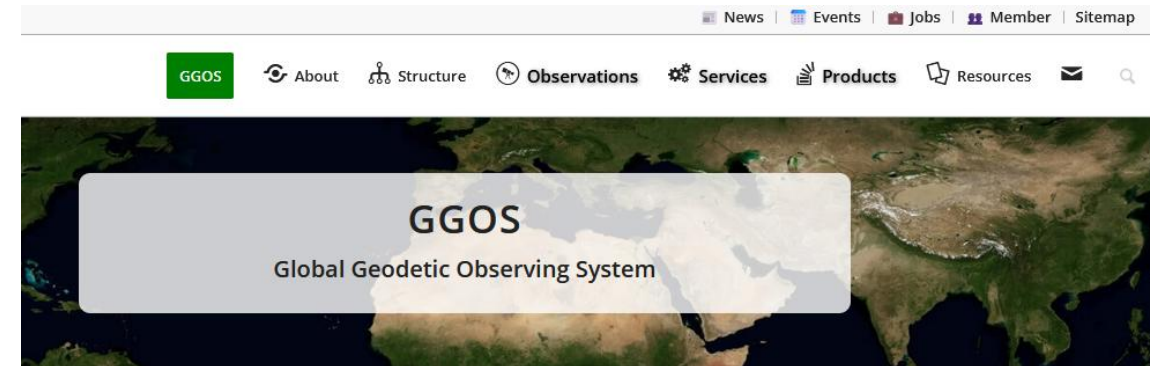
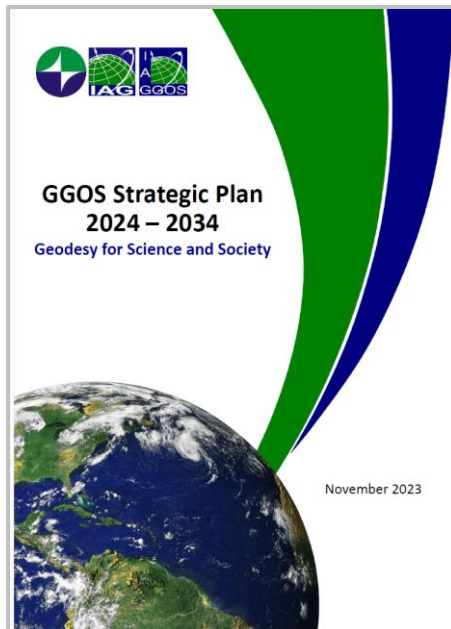


The Evolution of GGOS (3/4)



2019–2023 | Making Geodesy Visible: Connecting people, products and information

- New GGOS web presence
- Outreach, social media and networking
- Stronger links with GEO, CEOS and the UN, particularly with **UN-GGCE**
- **2023: new GGOS governance structure, new GGOS Strategic Plan (2024–2034) and Implementation Plan**



IAG + GGOS Geodesy

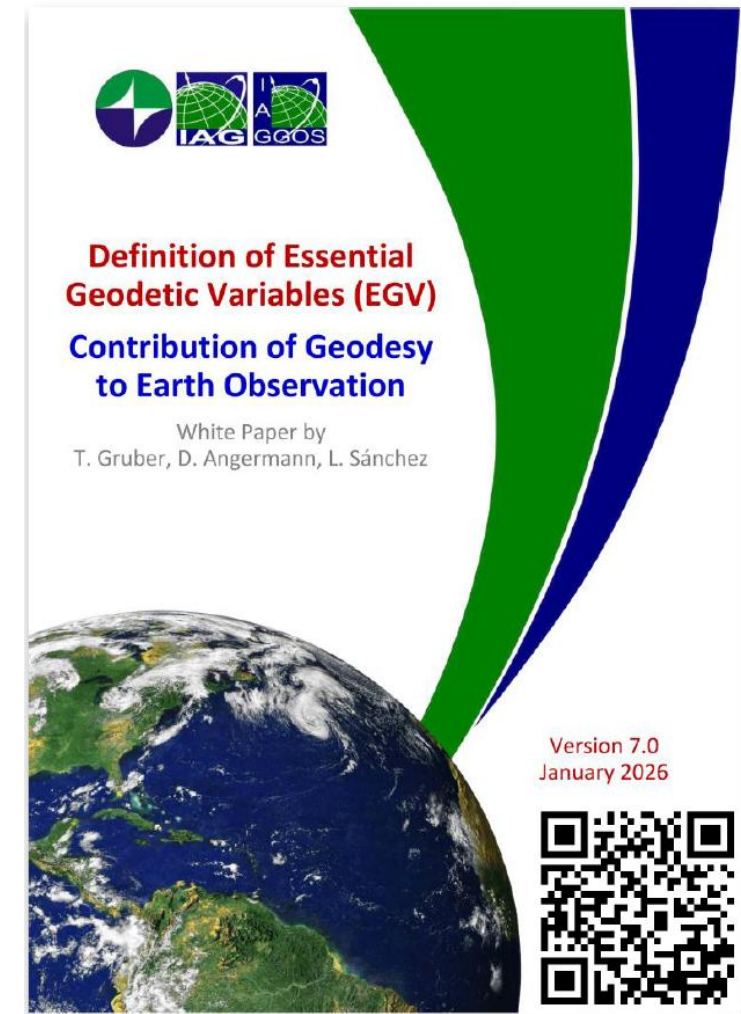
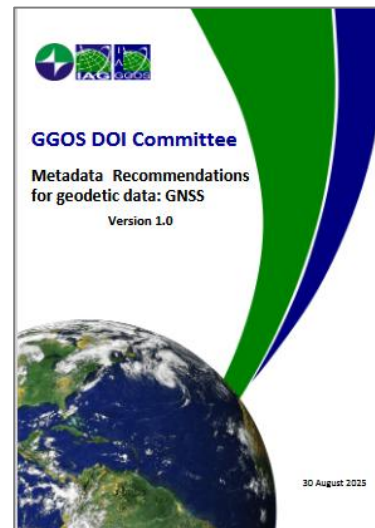


The Evolution of GGOS (4/4)



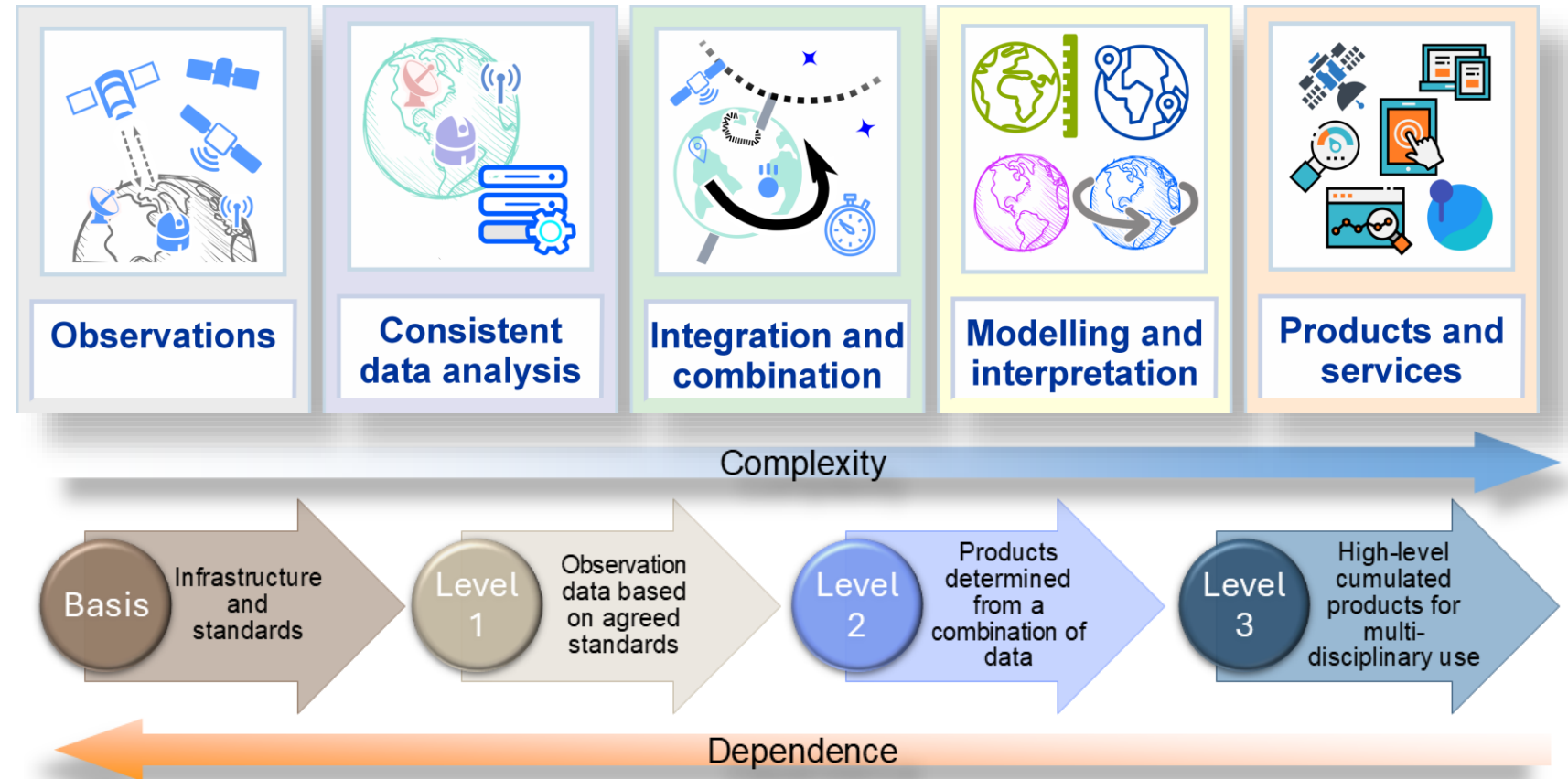
2023–... | Geodesy for Science and Society: From geodetic products to Essential Geodetic Variables (EGVs)

- Towards a GGOS Portal: **renewed effort to create a one-stop access point for geodetic data and products**
- Development of the **EGV concept and framework**
- EGVs become a central framework for **communicating geodesy's contribution to Earth Observation**:
 - **Internal**: setting requirements on infrastructure, data and products
 - **External**: promoting importance of geodesy to funding organisations, policy makers, etc.



Definition of Essential Geodetic Variables (EGVs)

- Essential variables are parameters that, if changed, directly alters the fundamental behaviour or outcome of a system.
- **Essential Geodetic Variables:** Minimum set of parameters needed to observe, model, and understand the Earth's shape, rotation, and gravity field as functions of time and space.



Criteria and classification of EGVs

21 EGVs, based on **59 geodetic products**

Criteria: relevance, feasibility, cost effectiveness, **sustainability, consistency and interoperability**

Domains: Global, Land, Ocean, Land/Ocean (coasts)

Infrastructure and standards



Geodetic Infrastructure



Standards and Conventions

Observation data based on agreed standards



Geodetic Observations

Products determined from a combination of data



Station Positions and Variations



Satellite Orbits



Land and Marine Gravity Data



Sea Water Level Records

High-level cumulated products for multi-disciplinary use



Earth Orientation Parameters



Atmosphere Parameters



Land Geometry



Ice Sheets



Sea Surface



Global Ref. Frames



Regional Ref. Frames



Inland Water Level



Glaciers



Sea Level



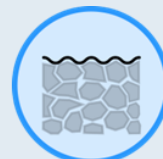
Global Earth Gravity Field



Reg. Gravity Field Model



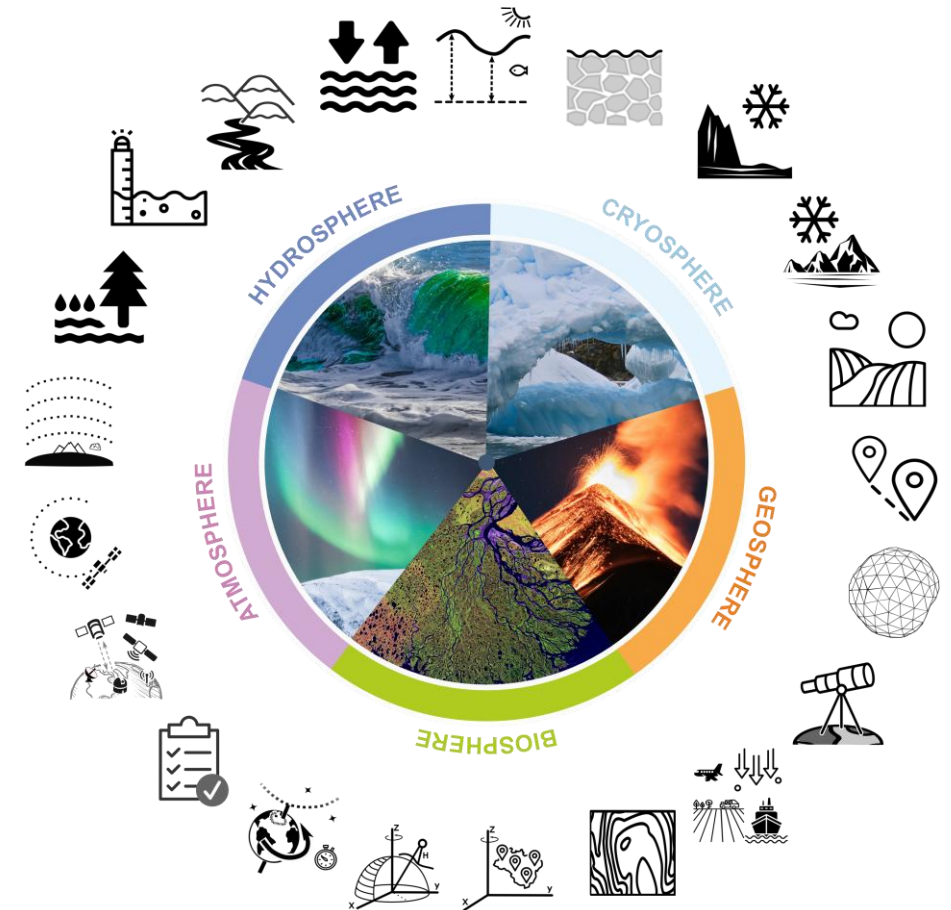
Terrestrial Water Storage



Sea Ice

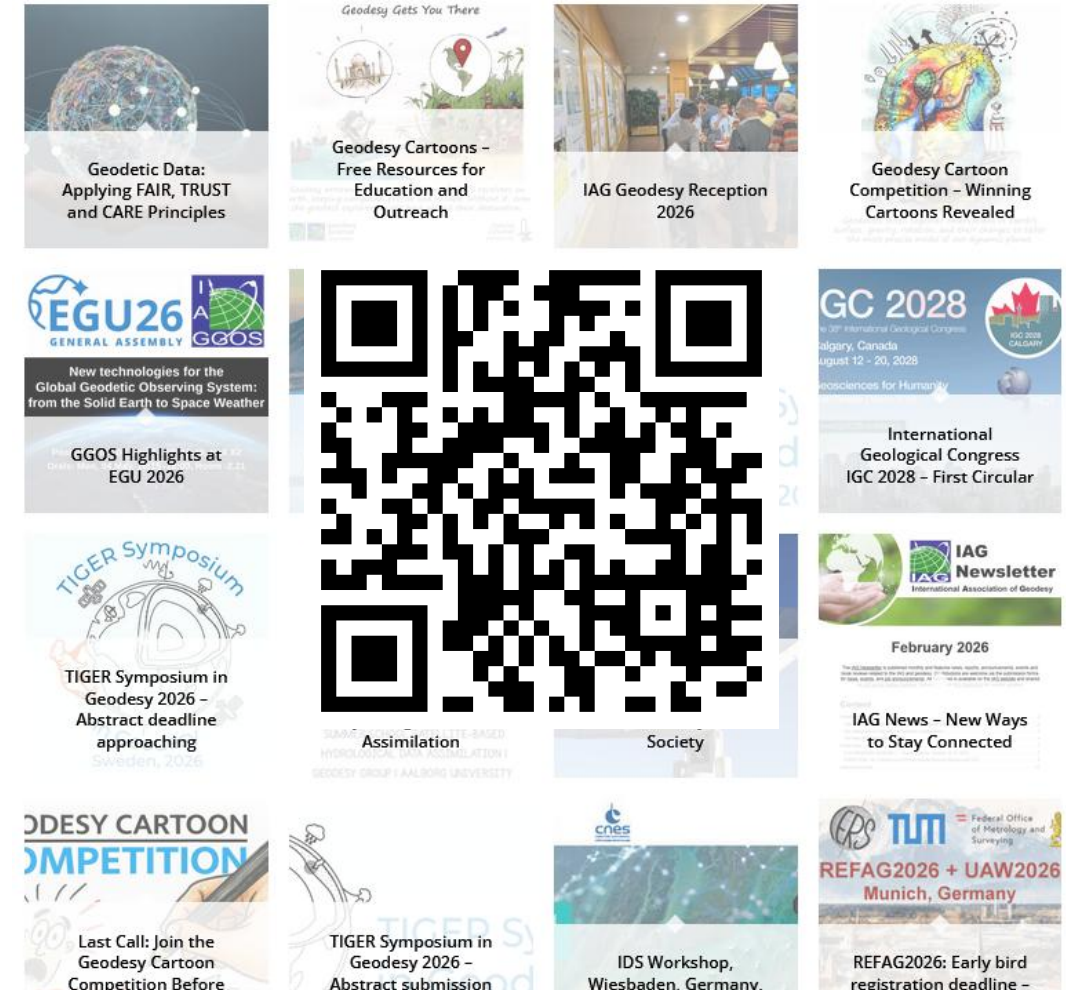
Implementation progress

- EGV concept already reviewed by
 - GGOS Science Panel
 - GGOS Governing Board
 - IAG Executive Committee
 - UN Global Geodetic Centre of Excellence (UN-GGC)
- EGVs are a central component of
 - the GGOS Strategic Plan
 - the UN-GGCE 1st Joint Development Plan for Global Geodesy
- **Characterisation of geodetic products:** in terms of *uncertainty, spatial and temporal resolution, timeliness, reliability, data sources*.
- **ESA EGV-Pilot: Translating the GGOS/IAG Essential Geodetic Variables into an ESA-relevant framework** as geodetic foundation for future Earth Observation and Earth system science missions.



Take-home message

- Through GGOS, IAG communicates and provides the contribution of geodesy to Earth system monitoring.
- The operation and sustainability of GGOS depend on the contributions of all IAG components: Services, Commissions, Inter-Commission Committees, and Projects.
- GGOS serves as interface between IAG's scientific expertise and society, facilitating access to the geodetic data and products needed to detect, locate, understand, and warn of changes in the Earth system.
- More information at <https://geodesy.science/ggos/>
- Follow us



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