WORKING WEEK 2025
AND Locate25
THE NATIONAL GEOSPATIAL CONFERENCE
FIG Geospatial Council of Australia
Collaboration, Innovation and Resilience: Championing a Digital Generation
Brisbane, Australia 6–10 April

Enhancing Global Geodetic Observations for Sustainable Development

Anna Riddell, Laura Sanchez, Detlef Angermann, José Rodríguez, Martin Sehnal, Richard Gross, Allison Craddock, José M. Ferrándiz, Claudia Tocho, Basara Miyahara, Georgios Vergos

IUGG

IAGGOS Global Geodetic Observing System

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PLATINUM SPONSORS Australian Government CHCNAV esri THE SCIENCE OF WHERE Leica Geosystems Meter Surveyors Australia

Abstract

- The Global Geodetic Observing System (GGOS) represents the international geodetic community's response to the critical need for continuous monitoring of changes in the Earth system. Organized under the umbrella of the International Association of Geodesy (IAG), GGOS plays a vital role in Earth observation by providing the reference frames essential for all position-dependent observations. These reference frames form the foundation for most Earth observations and are crucial for measuring changes in the Earth's shape, size, gravity field, and rotation over time and space.
- GGOS is built upon the Scientific Services of the IAG and their products, which are derived from the operational monitoring of the Earth using both space- and ground-based geodetic techniques. A key objective of GGOS is to create an integrated framework that transitions from providing technique-specific products to delivering combined, integrated products. This approach ensures consistent modelling and interpretation of Earth system processes and interactions, contributing significantly to a coherent Earth observation system.
- This system is essential for enhancing our understanding of global change and its impacts on the environment and society. Achieving this goal requires strong international and multidisciplinary cooperation, focusing on generating and sharing standardised and consistent geodetic data and products. GGOS also aims to identify emerging scientific and societal needs that can be addressed by new geodetic techniques, services and products. Additionally, GGOS strives to enhance the visibility of geodesy by improving the accessibility of geodetic observations, information, and products to a wide range of users.
- This presentation will provide an overview of the latest achievements of GGOS, highlight ongoing initiatives, and discuss future directions for enhancing global geodetic observations. By leveraging the power of geodesy, GGOS aims to contribute to a more resilient and sustainable world.

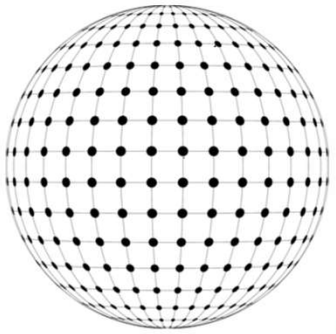
IUGG GGOS Global Geodetic Observing System

DRAFT Outline

- GGOS Intro and placement in IAG + relationship with other Geodesy bodies
- GGOS goals and objectives
- GGOS Strategy and high-level overview of implementation plan
- Progression of EGV's and support for Global Geodesy
- An example/case study of GGOS at work (Sea level change)

Geodesy

- Determination of Earth's size, shape, gravity field and orientation as functions of space and time.



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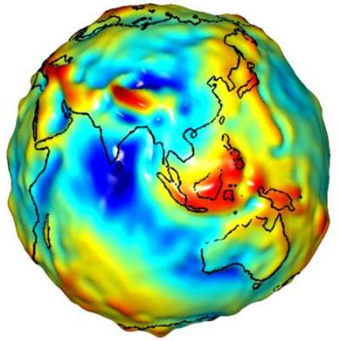

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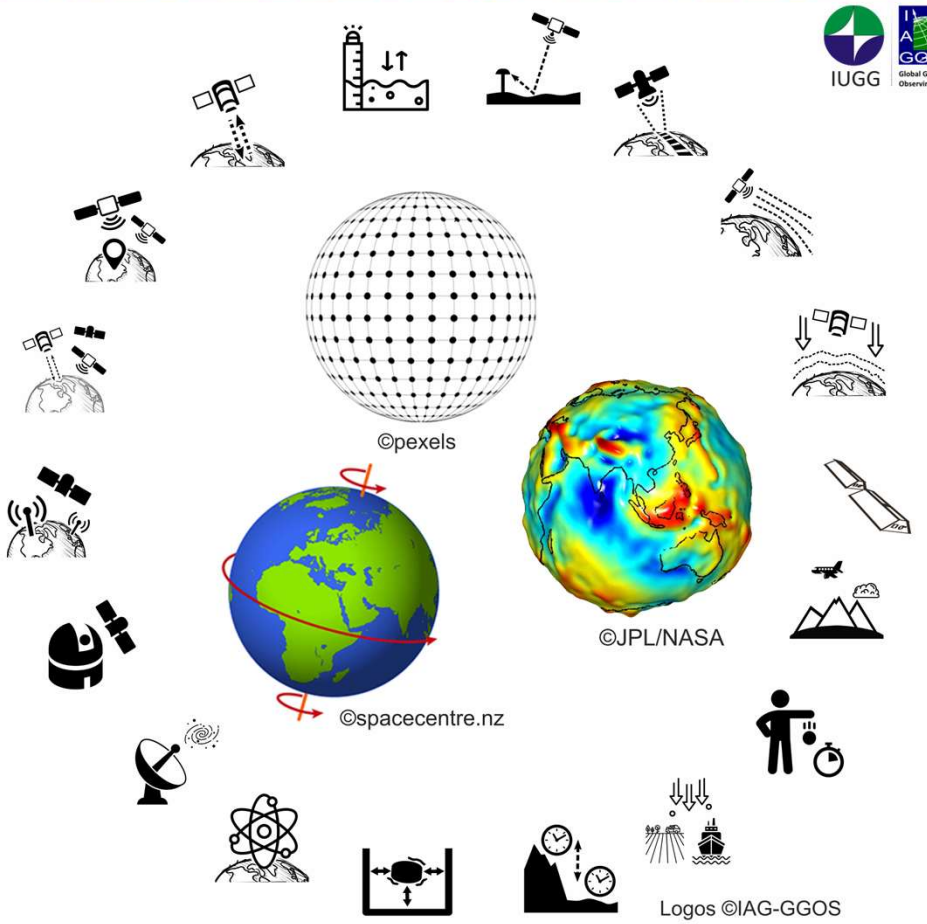
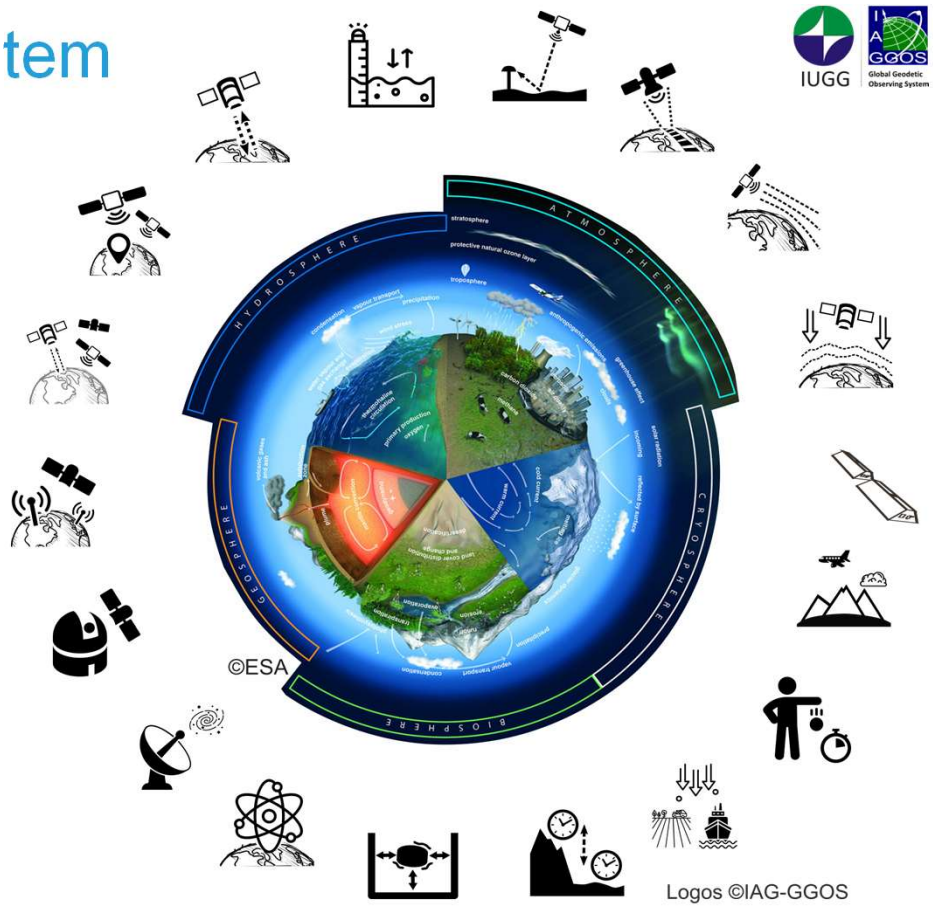
Geodetic techniques

- Various sensors and instruments on the ground (land and oceans), in air and in space.
- Space techniques dominate global and regional observations.
- Terrestrial techniques are mainly needed for interpolation in space and time, and for recording specific local features.



Geodetic observation of the Earth system

- Changes in the Earth's size, shape, gravity field and orientation are inherently related to the Earth's dynamics and the transport of mass and energy throughout the Earth system.
- Any change within the system affects any geodetic observation.
- In order to achieve its primary goals, geodesy is necessarily involved in the detection and analysis of the signals emitted by the Earth system.



Observations

Collection of raw data to measure changes in the Earth's geometry, gravity field and orientation.

Level 0

Consistent data analysis

based on unified processing standards and an integrated frame of reference for Earth's geometry, gravity and orientation.

Level 1

Integration and combination

of various types of observations to separate geodetic/geophysical signals from technique-specific system biases.

Level 2

Modelling and interpretation

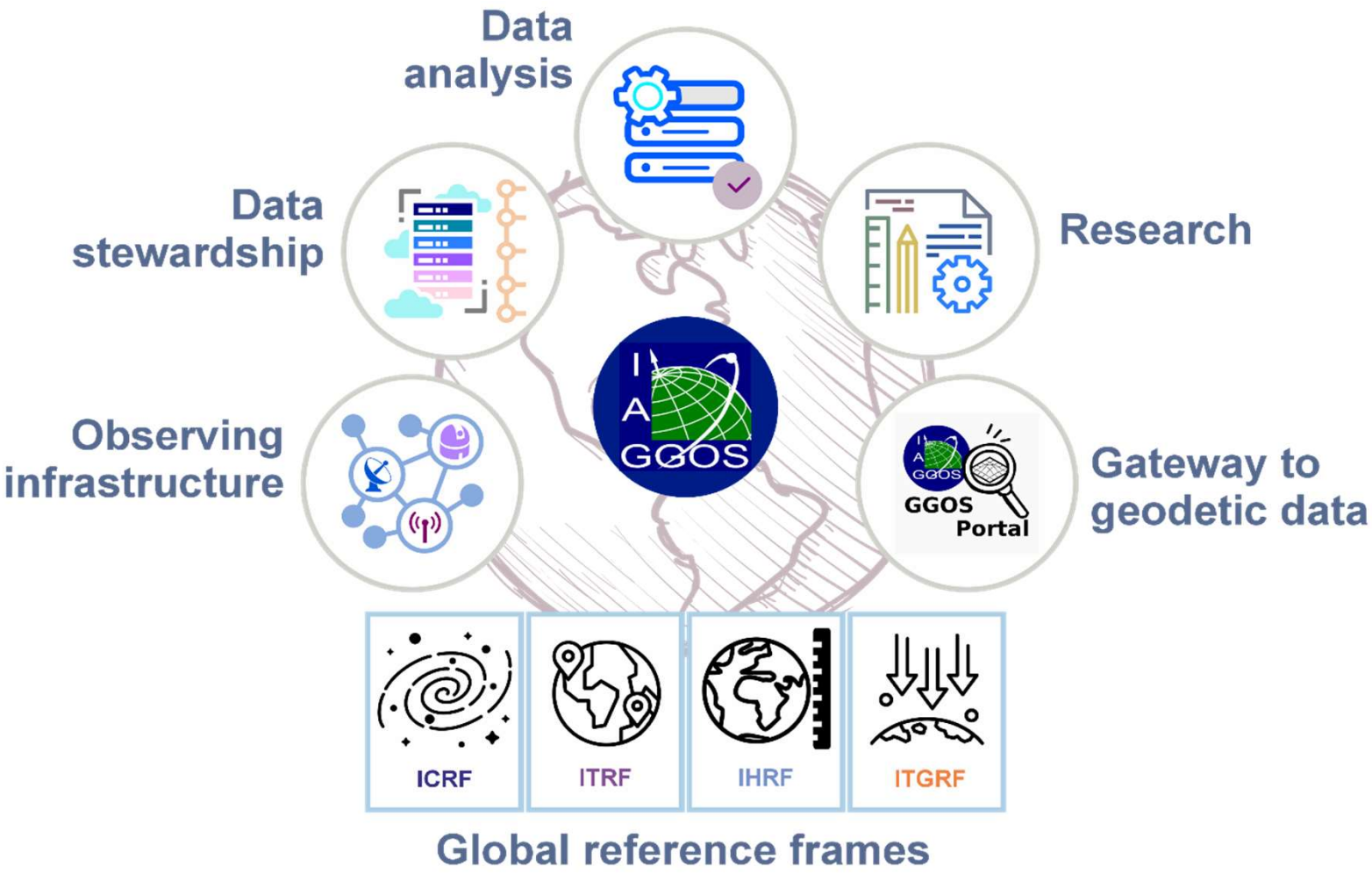
of geodetic results to identify the correspondence between geodetic parameters and geophysical processes.

Level 3

Products and services

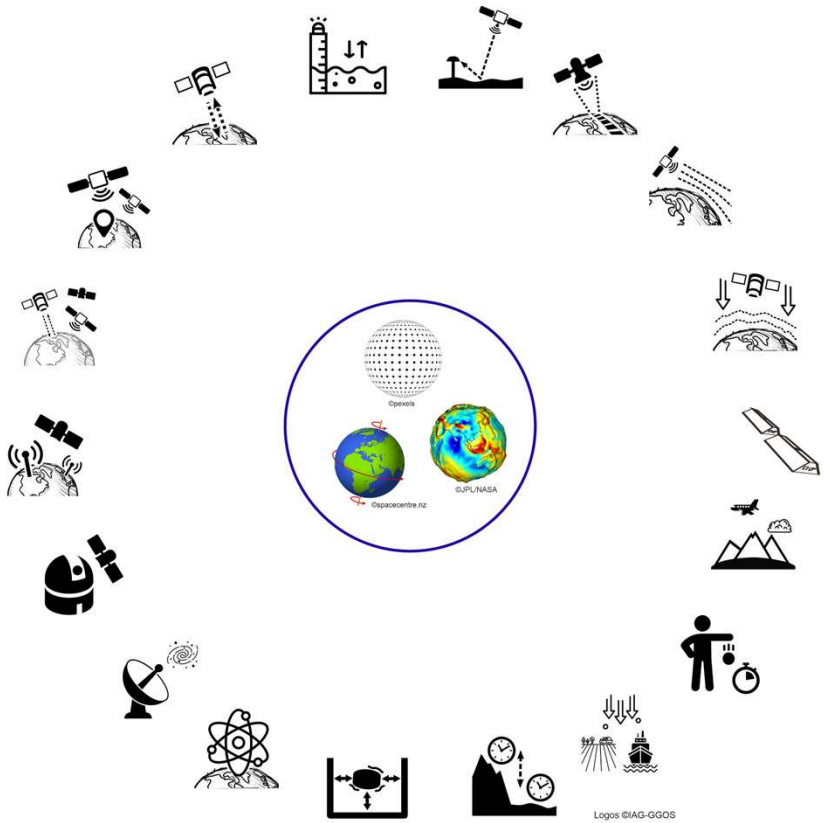
communication and dissemination of geodetic results for the benefit of other sciences and society.

Level 4


Data analysis
Data stewardship
Research
Observing infrastructure
Gateway to geodetic data
GGOS Portal
ICRF
ITRF
IHRF
ITGRF
Global reference frames

The International Association of Geodesy (IAG)

- IAG is the organisation responsible for the advancement of geodesy.
- 160 years of geodetic excellence based on strong international voluntary cooperation based on best efforts.



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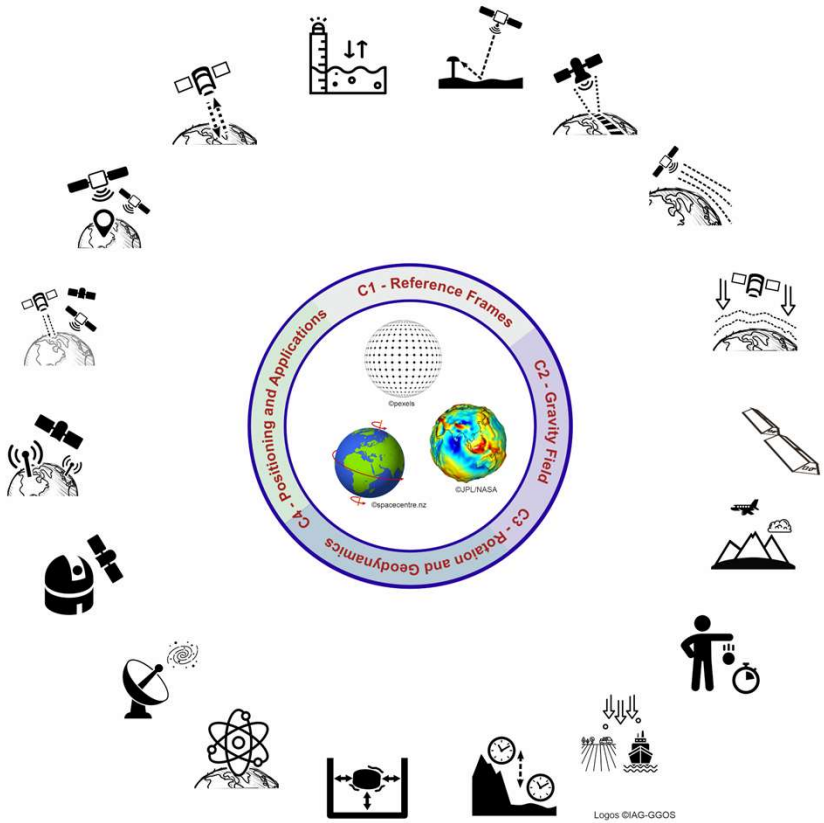
- The **IAG Commissions**, Inter-Commission Committees and Projects address key scientific issues.



IUGG IAG GGOS Global Geodetic Observing System

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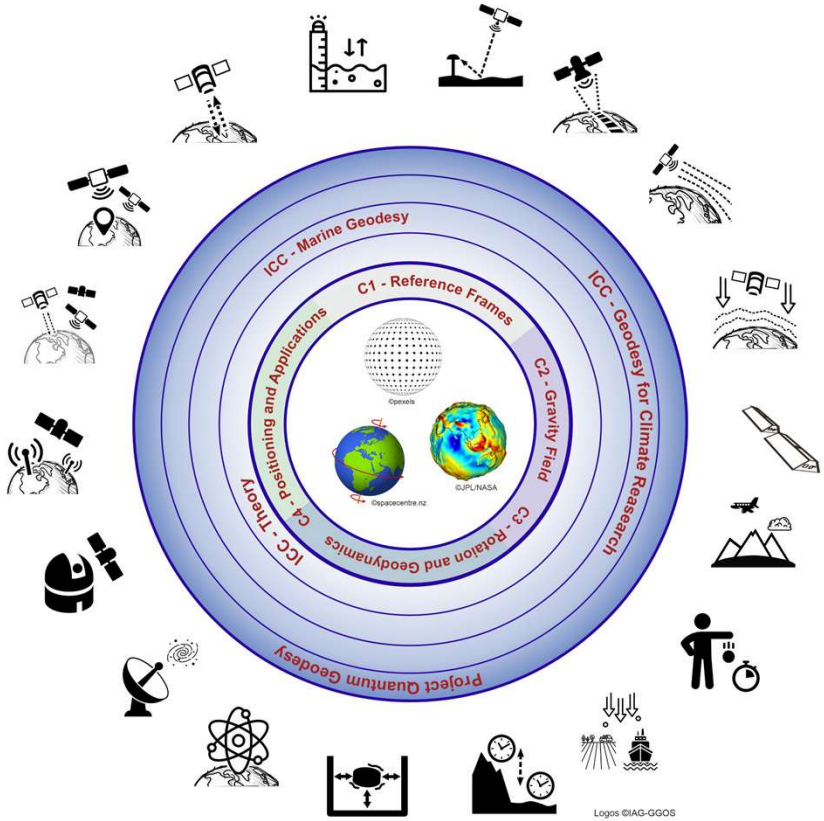
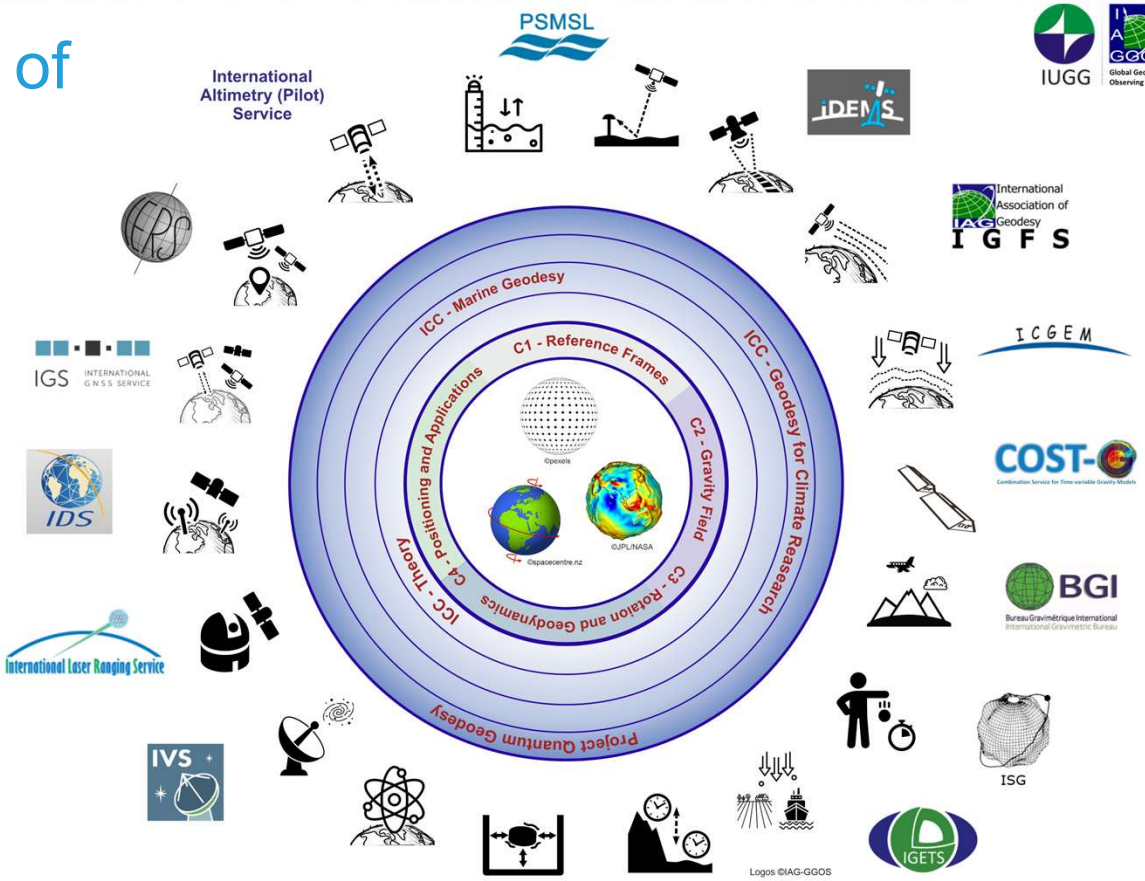


The International Association of Geodesy (IAG)

- The **IAG Services** facilitate the global coordination of geodetic activities and ensure the generation of high accuracy and reliable geodetic products.
- The **IAG determines and provides the framework for monitoring and understanding the Earth system** as a whole, including its solid, fluid, and gaseous components.



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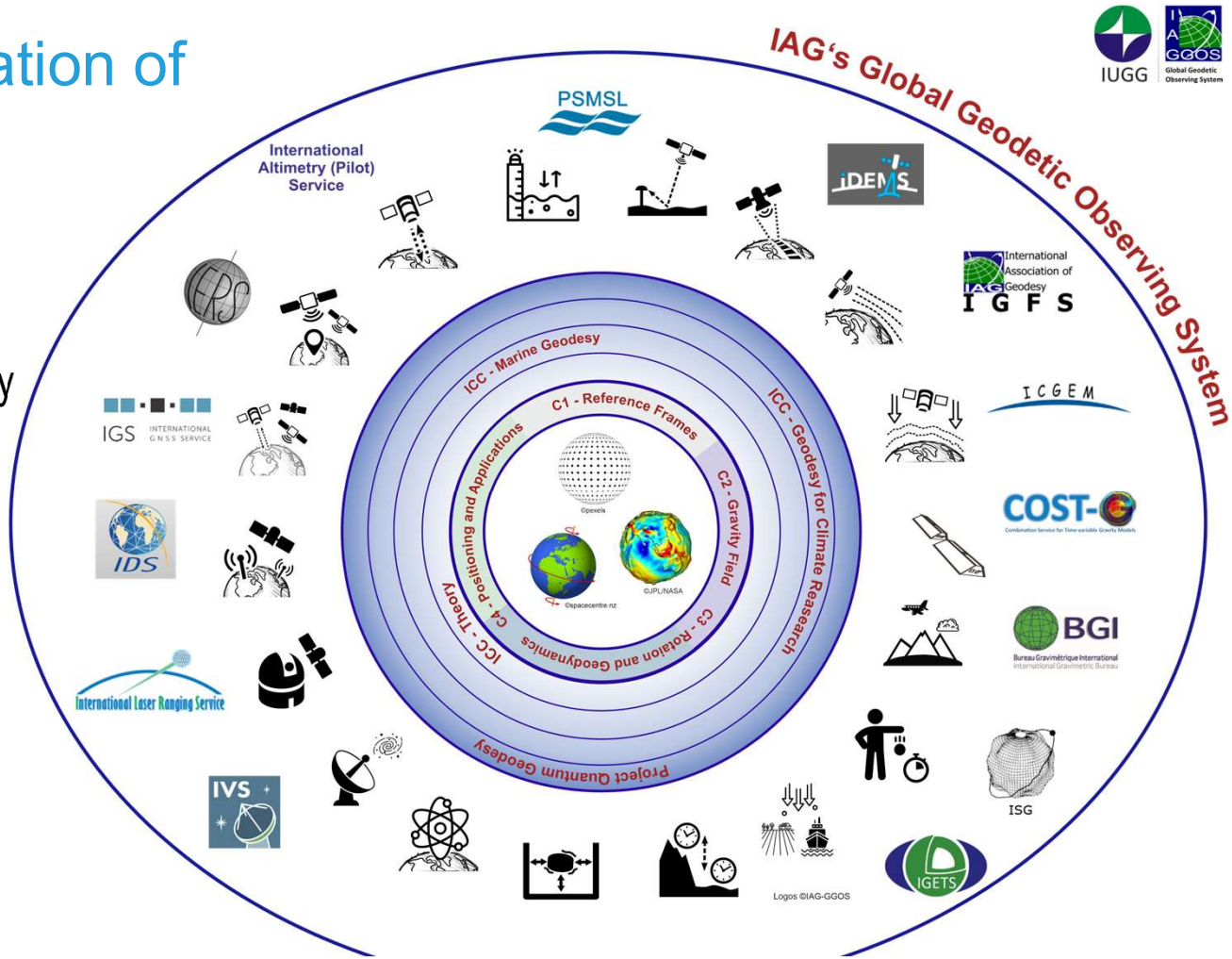
- The IAG determines and provides the framework for monitoring and understanding the Earth system as a whole, including its solid, fluid, and gaseous components.
- This framework is **GGOS**, the **Global Geodetic Observing System**.



Challenges

- Bring together the different geodetic observing 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 data assimilation, and jointly estimate and model all necessary parameters representing the different elements of the Earth system.
- Identify science and societal needs that can be addressed by (new) geodetic products and define the **requirements for accuracy, time resolution, and consistency of these products**.
- Identify **service gaps** and develop strategies to fill them.
- To promote and enhance the **visibility of geodesy** by improving the accessibility of geodetic observations, information and products to the widest range of users.

Implementing IAG's Global Geodetic Observing System

- The IAG decided to establish **an operational component** to deal with the day-to-day business of implementing, maintaining and ensuring the long-term availability of the observing system GGOS.
- This operational component (also called GGOS):
  - serve as a **clearinghouse** for geodetic information expertise,
  - provide an **integrating framework** for all IAG Components (Services, Commissions, Inter-Commission Committees and Projects), and
  - act as a **central interface** between science and society

pixtastock.com - 19188910

General Objectives of GGOS

- Provide a comprehensive global geodetic frame of reference (common, unified for geometry, gravity field and orientation/rotation)
- Contribute to the observation of the Earth system (quantification of its changes in space and time)
- Provide products and services for the benefit of other sciences and society

- Identify gaps in the **global geodetic infrastructure** and advocate for **modernisation, extension and maintenance** of the existing global geodetic infrastructure.
- Bring together the different geodetic observing 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 data assimilation, and jointly estimate and model all necessary parameters representing the different elements of the Earth system.
- Identify science and societal needs that can be addressed by (new) geodetic products and define the **requirements for accuracy, time resolution, and consistency of these products**.
- To promote and enhance the **visibility of geodesy** by improving the accessibility of geodetic observations, information and products to the widest range of users.

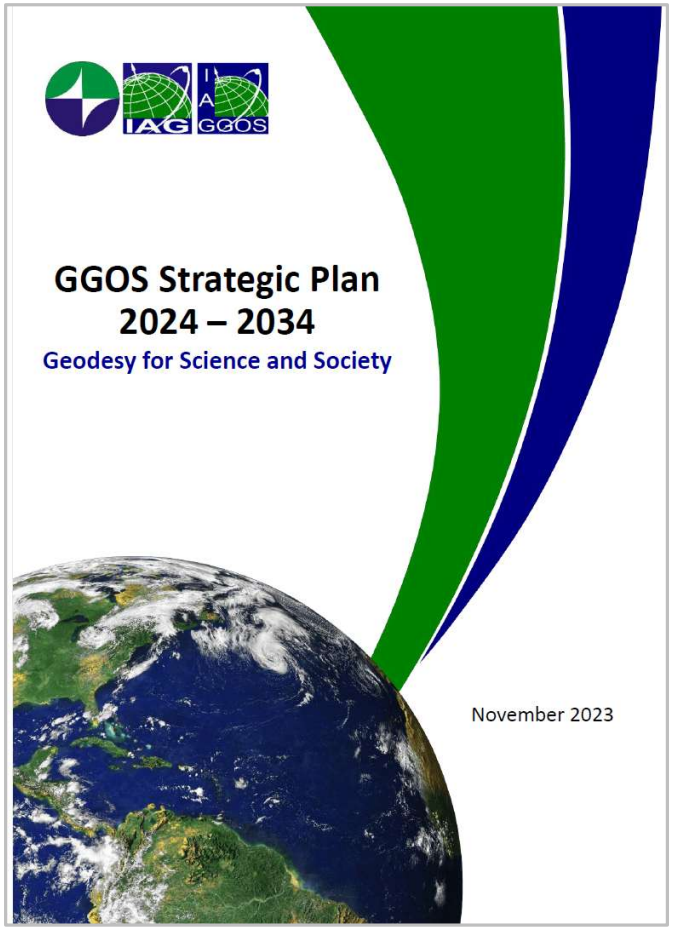
GGOS Strategic Plan 2024 – 2034

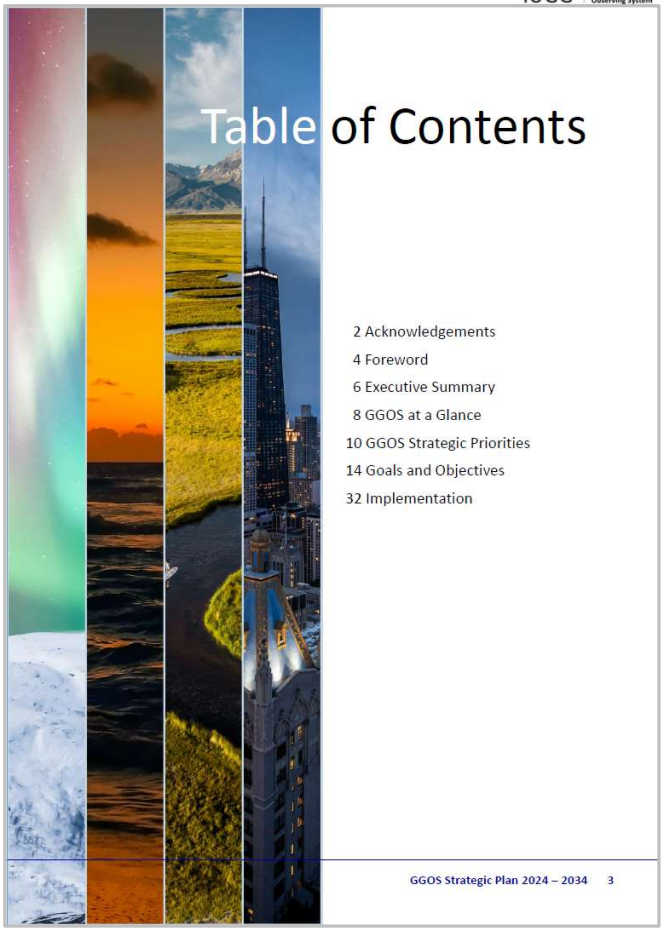
- Community survey in 2022 (about 70 colleagues from 32 countries).
- Completed in November 2023.
- Approved by the GGOS Governing Board on 28 January 2024.
- Published on 1 February 2024.

GGOS Strategic Plan 2024-2034

Sánchez, Laura[1]; Miyahara, Basara[2]; Craddock, Allison[3]; Sehnal, Martin[4]; Angermann, Detlef[1]; Gross, Richard[5]; Schuh, Harald[6]

DOI 10.5281/zenodo.10571157





GGOS Strategic Plan 2024 – 2034

- To advocate for geodesy in major global frameworks such as the Global Earth Observation System of Systems (GEOSS), the United Nations Sustainable Development Goals, and the Sendai Framework for Disaster Risk Reduction.

- To contribute to the sustainability of the United Nations Global Geodetic Reference Frame (UN-GGRF) through collaboration with key entities such as the UN Sub-Committee on Geodesy (SCoG) and the UN Global Geodetic Centre of Excellence (UN-GGCE) – scientific advice/evidence for policy development.

- To promote modernisation, extension, and maintenance of geodetic resources, while fostering capacity enhancement and knowledge sharing within the geodetic community, in particular developing countries and early carrier scientists.

- To provide a comprehensive platform for geodetic analysis and information-sharing, making geodetic data and resources accessible to all – GGOS Portal, FAIR and TRUST principles.

GGOS Implementation Plan, phase 2024 – 2027

- The proposed implementation actions follow the SMART criteria: Specific, Measurable, Achievable, Relevant, Time-bound.
- An assessment of progress will take place each year (preferably at the GGOS Days)
- First draft completed in June 2024.
- Reviewed by the GGOS Executive Committee in July 2024.
- Reviewed by the GGOS Governing Board in August 2024.
- Approved by the GGOS Governing Board and published on 18 September 2024.

GGOS Implementation Plan, Phase 2024 - 2027

Sánchez, Laura[1]; Sehnal, Martin[2]; Angermann, Detlef[1]; Rodríguez, José[3]

DOI 10.5281/zenodo.13785103

GGOS Implementation Plan, phase 2024 – 2027

IUGG GGOS Global Geodetic Observing System

Implementation activities related to geodetic information and expertise

- GGOS Requirements and Essential Geodetic Variables (EGVs) - 6 activities
- Focus Areas and Interdisciplinary Research - 8 activities
- Science-Policy Networking - 8 activities

Implementation activities related to Global Geodetic Infrastructure

- Simulations and documentation for fundamental stations - 7 activities
- Regional affiliates, GGOS Africa - 1 activity
- More satellites for reference frames - 2 activities

Implementation activities related to Standardisation, Integration and Optimisation

- Missing and new products - 2 activities
- Standards and metadata - 3 activities
- Updated geophysical models - 1 activity

Implementation activities related to Communication, Education and Outreach

- GGOS Portal and Internet Presence - 7 activities
- Networking with scholars, young people, early carrier scientists, and colleagues from developing countries - 10 activities
- Outreach and communication materials - 9 activities

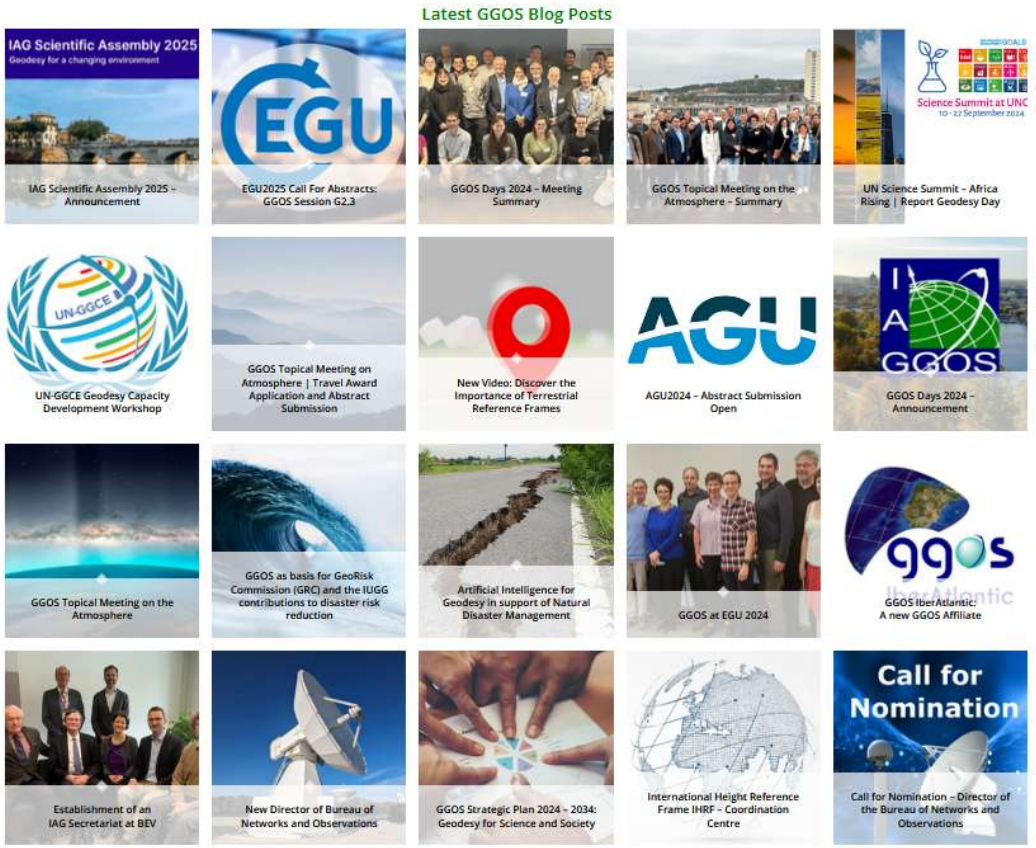
GGOS and the UN-GGCE

Cooperation on several activities:

- Outreach
- Consultations with the IAG Services
- Input for Needs Assessment and JDP
- Production of evidence for network design and priorities

Summary

- GGOS is the response of the international geodetic community, organised under the umbrella of the International Association of Geodesy (IAG),
- The operability and sustainability of GGOS is only possible with the contribution of all IAG components: Services, Commissions, Inter-Commission Committees, Projects.
- GGOS provides the interface between the scientific expertise of the IAG and society to demonstrate the fundamental value of geodesy and to facilitate access to geodetic data and products needed to detect, locate, understand and warn of changes in terrestrial ecosystems.
- More information at www.ggos.org



The most relevant SDGs related to the presentation and theme of this session

SUSTAINABLE DEVELOPMENT GOALS

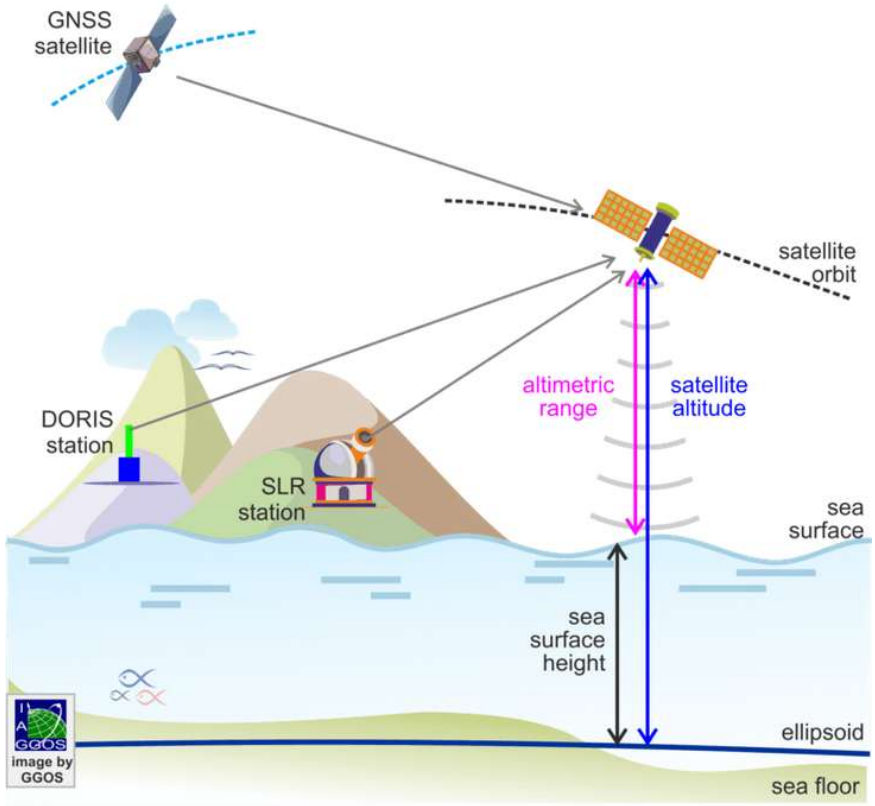
International Federation of Surveyors supports the Sustainable Development Goals

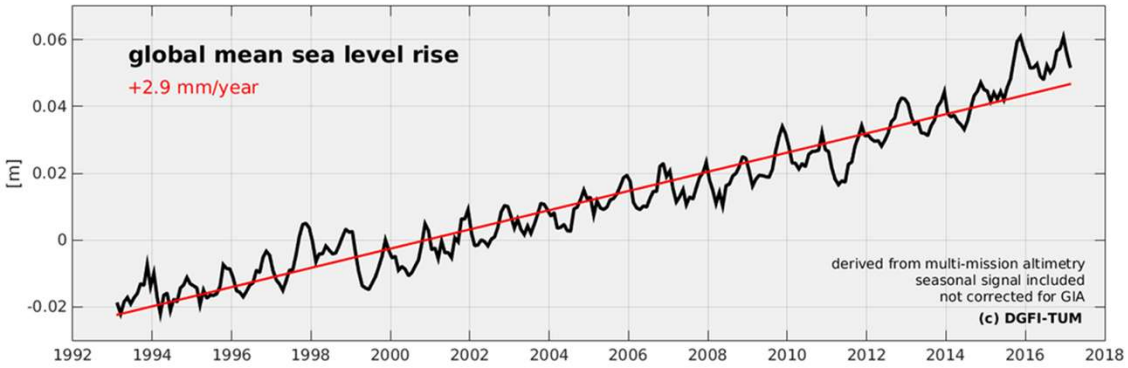
Global Geodetic Observing System (GGOS)

- **Role and Importance**: GGOS monitors Earth's changes, providing essential reference frames for position-dependent observations.
- **Integrated Framework**: GGOS combines products from space- and ground-based techniques for consistent Earth system modeling.
- **International Cooperation**: GGOS promotes global collaboration to share standardized geodetic data and address emerging needs.
- **Visibility and Future Directions**: GGOS improves access to geodetic data, highlighting achievements and future initiatives for a sustainable world

Importance of geodetic reference frames in the Earth system observation

Example: Satellite altimetry for the mean sea level determination





IPCC Report (2021):

Global sea level rise

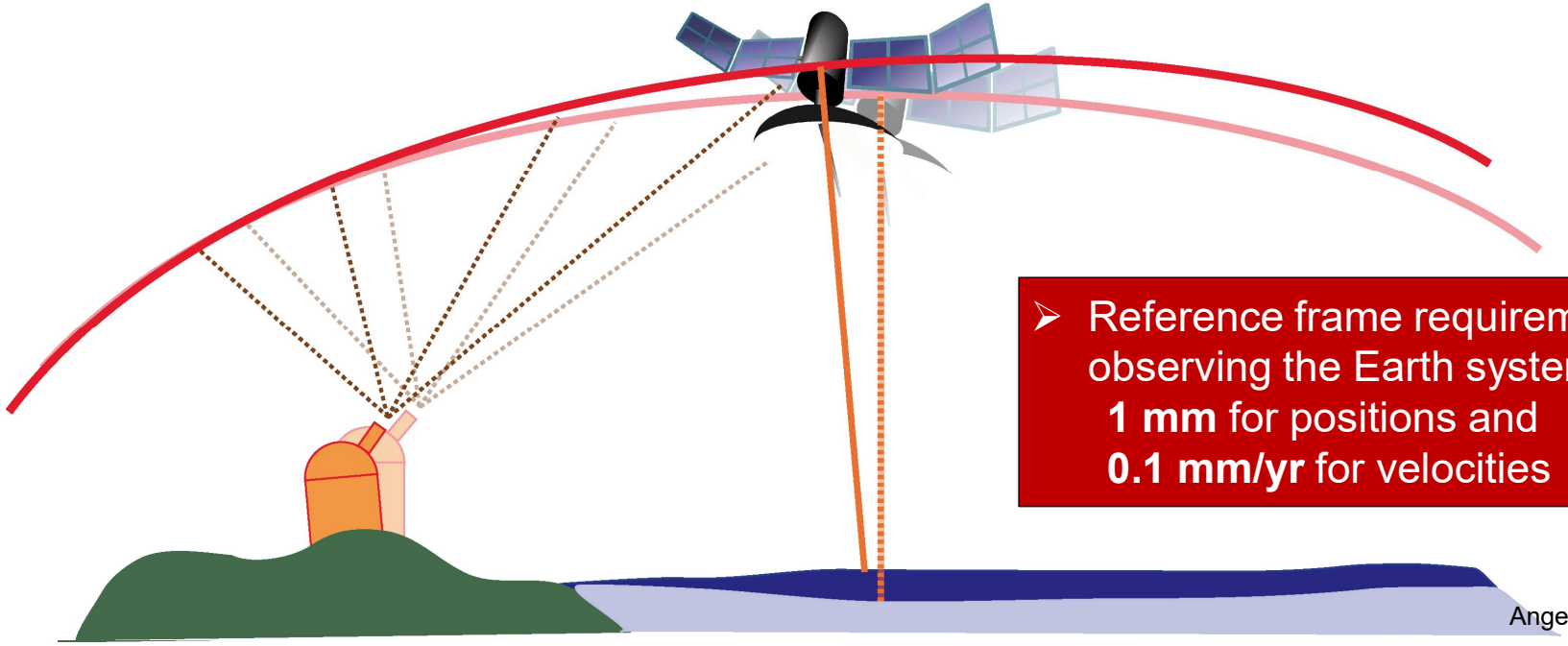
- 1,3 mm/yr (1901-1971)
- 1,9 mm/yr (1971-2006)
- 3,7 mm/yr (2006-2018)

Importance of geodetic reference frames in the Earth system observation

IUGG GGOS Global Geodetic Observing System

Example: Satellite altimetry for the mean sea level determination

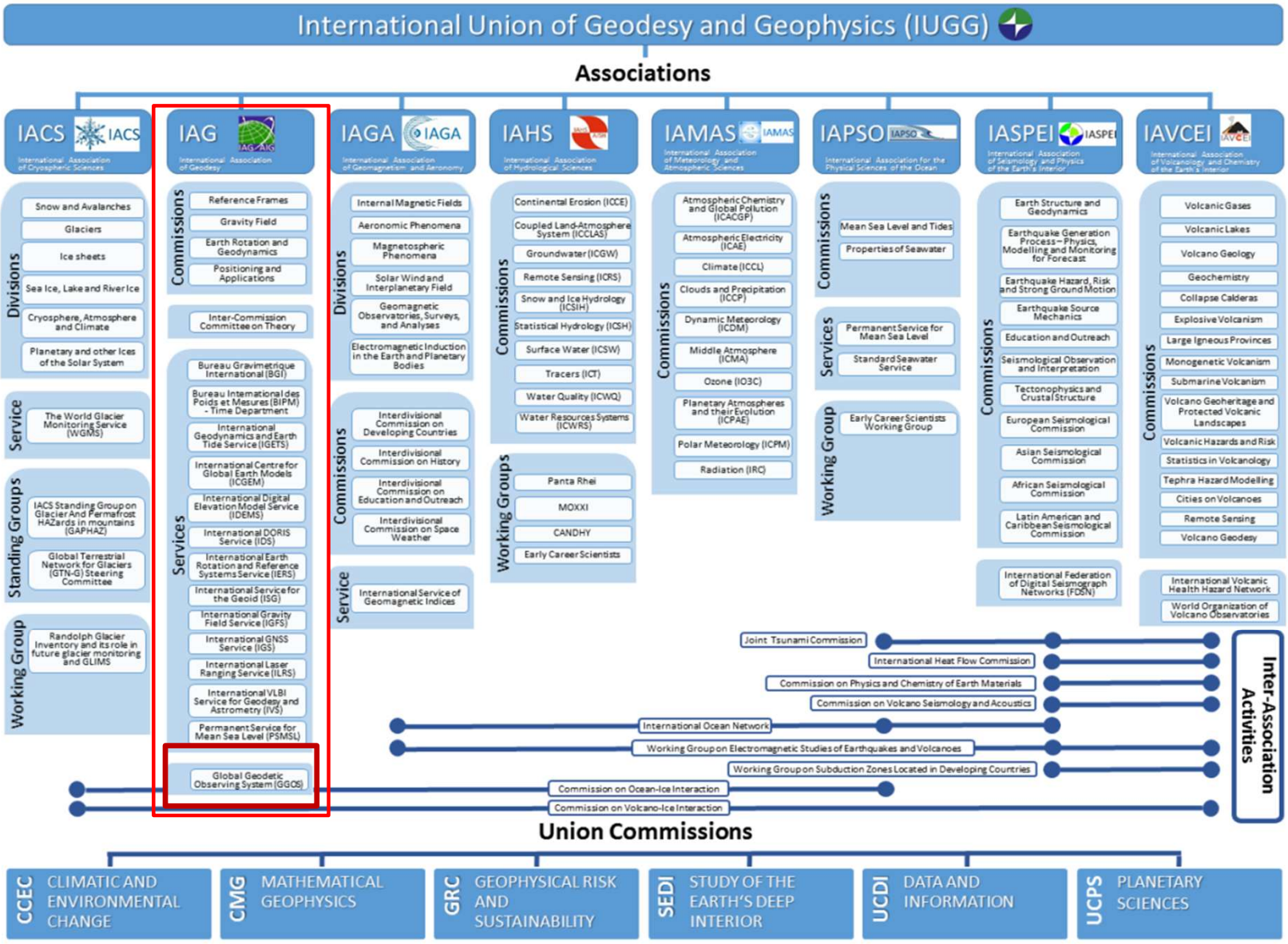
To detect millimetre-scale changes in the Earth system, the reliability of the reference frame needs to be an order of magnitude greater.



- Reference frame requirements for observing the Earth system:
  1 mm for positions and
  0.1 mm/yr for velocities

Angermann et al. (2021)

STEP 1: SELECT HERE THE THREE MOST RELEVANT SDGs
STEP 2: COPY THE SDG INTO PREVIOUS SLIDE


International Union of Geodesy and Geophysics (IUGG)
Associations
IACS
International Association of Cryospheric Sciences
Divisions
Snow and Avalanches
Glaciers
Ice sheets
Sea Ice, Lake and River Ice
Cryosphere, Atmosphere and Climate
Planetary and other Ices of the Solar System
Service
The World Glacier Monitoring Service (WGMS)
Standing Groups
IACS Standing Group on Glacier And Permafrost HAZards in mountains (GAPHAZ)
Global Terrestrial Network for Glaciers (GTN-G) Steering Committee
Working Group
Randolph Glacier Inventory and its role in future glacier monitoring and GLIMS
IAG
International Association of Geodesy
Commissions
Reference Frames
Gravity Field
Earth Rotation and Geodynamics
Positioning and Applications
Inter-Commission Committee on Theory
Services
Bureau Gravimetrique International (BGI)
Bureau International des Poids et Mesures (BIPM) - Time Department
International Geodynamics and Earth Tide Service (IGETS)
International Centre for Global Earth Models (ICGEM)
International Digital Elevation Model Service (IDEMS)
International DORIS Service (IDS)
International Earth Rotation and Reference Systems Service (IERS)
International Service for the Geoid (ISG)
International Gravity Field Service (IGFS)
International GNSS Service (IGS)
International Laser Ranging Service (ILRS)
International VLBI Service for Geodesy and Astrometry (IVS)
Permanent Service for Mean Sea Level (PSMSL)
Global Geodetic Observing System (GGOS)
IAGA
International Association of Geomagnetism and Aeronomy
Divisions
Internal Magnetic Fields
Aeronomic Phenomena
Magnetospheric Phenomena
Solar Wind and Interplanetary Field
Geomagnetic Observatories, Surveys, and Analyses
Electromagnetic Induction in the Earth and Planetary Bodies
Commissions
Interdivisional Commission on Developing Countries
Interdivisional Commission on History
Interdivisional Commission on Education and Outreach
Interdivisional Commission on Space Weather
Service
International Service of Geomagnetic Indices
IAHS
International Association of Hydrological Sciences
Commissions
Continental Erosion (ICCE)
Coupled Land-Atmosphere System (ICCLAS)
Groundwater (ICGW)
Remote Sensing (ICRS)
Snow and Ice Hydrology (ICSIH)
Statistical Hydrology (ICSH)
Surface Water (ICSW)
Tracers (ICT)
Water Quality (ICWQ)
Water Resources Systems (ICWRS)
Working Groups
Panta Rhei
MOXXI
CANDHY
Early Career Scientists
IAMAS
International Association of Meteorology and Atmospheric Sciences
Commissions
Atmospheric Chemistry and Global Pollution (ICACGP)
Atmospheric Electricity (ICAE)
Climate (ICCL)
Clouds and Precipitation (ICCP)
Dynamic Meteorology (ICDM)
Middle Atmosphere (ICMA)
Ozone (IO3C)
Planetary Atmospheres and their Evolution (ICPAE)
Polar Meteorology (ICPM)
Radiation (IRC)
IAPSO
International Association for the Physical Sciences of the Ocean
Commissions
Mean Sea Level and Tides
Properties of Seawater
Services
Permanent Service for Mean Sea Level
Standard Seawater Service
Working Group
Early Career Scientists Working Group
IASPEI
International Association of Seismology and Physics of the Earth's Interior
Commissions
Earth Structure and Geodynamics
Earthquake Generation Process – Physics, Modelling and Monitoring for Forecast
Earthquake Hazard, Risk and Strong Ground Motion
Earthquake Source Mechanics
Education and Outreach
Seismological Observation and Interpretation
Tectonophysics and Crustal Structure
European Seismological Commission
Asian Seismological Commission
African Seismological Commission
Latin American and Caribbean Seismological Commission
International Federation of Digital Seismograph Networks (FDSN)
IAVCEI
International Association of Volcanology and Chemistry of the Earth's Interior
Commissions
Volcanic Gases
Volcanic Lakes
Volcano Geology
Geochemistry
Collapse Calderas
Explosive Volcanism
Large Igneous Provinces
Monogenetic Volcanism
Submarine Volcanism
Volcano Geoheritage and Protected Volcanic Landscapes
Volcanic Hazards and Risk
Statistics in Volcanology
Tephra Hazard Modelling
Cities on Volcanoes
Remote Sensing
Volcano Geodesy
International Volcanic Health Hazard Network
World Organization of Volcano Observatories
Inter-Association Activities
Joint Tsunami Commission
International Heat Flow Commission
Commission on Physics and Chemistry of Earth Materials
Commission on Volcano Seismology and Acoustics
International Ocean Network
Working Group on Electromagnetic Studies of Earthquakes and Volcanoes
Working Group on Subduction Zones Located in Developing Countries
Commission on Ocean-Ice Interaction
Commission on Volcano-Ice Interaction
Union Commissions
CCEC CLIMATIC AND ENVIRONMENTAL CHANGE
CMG MATHEMATICAL GEOPHYSICS
GRC GEOPHYSICAL RISK AND SUSTAINABILITY
SEDI STUDY OF THE EARTH'S DEEP INTERIOR
UCDI DATA AND INFORMATION
UCPS PLANETARY SCIENCES

IUGG

INTERNATIONAL ASSOCIATION OF GEODESY (IAG)

International organisation responsible for the advancement of geodesy.

Origins:

Central European Arc Measurement

- Established in 1862 by General Johann Jacob Baeyer of Prussia to determine anomalies in Earth's curvature in Central Europe

First Conference of Representatives held in 1864 in Berlin

- Created a Permanent Commission and Central Bureau with Triennial meetings of General Conferences
- Considered forerunner of IAG and IUGG General Assemblies

International Geodetic Association

- Established at General Conference of 1886 in Berlin
- Incorporated into International Union of Geodesy and Geophysics (established in 1919 by International Research Council)
- Renamed to International Association of Geodesy in 1946

IAG Organisational Structure