
## Standardisation, integration, and optimisation of geodetic products

*Convener: Detlef Angermann*

| | |
|---|---|
| 14:00-14:15 | Updates from the GGOS Bureau of Products and Standards<br>*Detlef Angermann* |
| 14:15-14:30 | New strategy for ITRF Updates [online]<br>*Zuheir Altamimi* |
| 14:30-14:45 | Combination Centre for the International Height Reference Frame (IHRF)<br>*Georgios S. Vergos* |
| 14:45-15:00 | Status of the International Terrestrial Gravity Reference Frame (ITGRF)<br>*Hartmut Wziontek* |
| 15:00-15:15 | Definition of Essential Geodetic Variables (EGVs) [online]<br>*Thomas Gruber* |
| 15:00-15:30 | Discussion/Summing up |
| 15:30-16:00 | **Coffee Break** |
| 16:00-16:15 | Towards an updated reference level ellipsoid [online]<br>*Urs Marti* |
| 16:15-16:30 | Contributions to Earth system modelling<br>*Maik Thomas* |

# Updates from the GGOS Bureau of Products and Standards (BPS)

- BPS is chaired by the Technical University of Munich (TUM), further involved partners are GFZ (German Research Centre for Geosciences) and DLR (German Aerospace Centre, Oberpfaffenhofen)

  D. Angermann (Director), T. Gruber (Deputy Director), M. Gerstl (retired), R. Heinkelmann (GFZ), U. Hugentobler (TUM), L. Sánchez (DGFI-TUM), P. Steigenberger (DLR)

- **GGOS components associated to the BPS:**
  - Committee "**Contributions to Earth System Modelling (ESM)**" (Chair: M. Thomas, GFZ)
  - Committee "**Definition of Essential Geodetic Variables (EGVs)**" (Chair: T. Gruber, TUM)
  - Working Group **"Consolidation of a best estimate GRS based on the adopted $W_0$ of the IHRF"** (Chair: U. Marti, swisstopo)

- **Representatives associated to the BPS**
  - Representatives of the IAG Services and the IERS Conventions Centre
  - Representatives of external entities involved in standards and conventions (e.g., ISO, IAU Comm. A3 **"**Fundamental Standards")

# Representatives of IAG Services and other entities

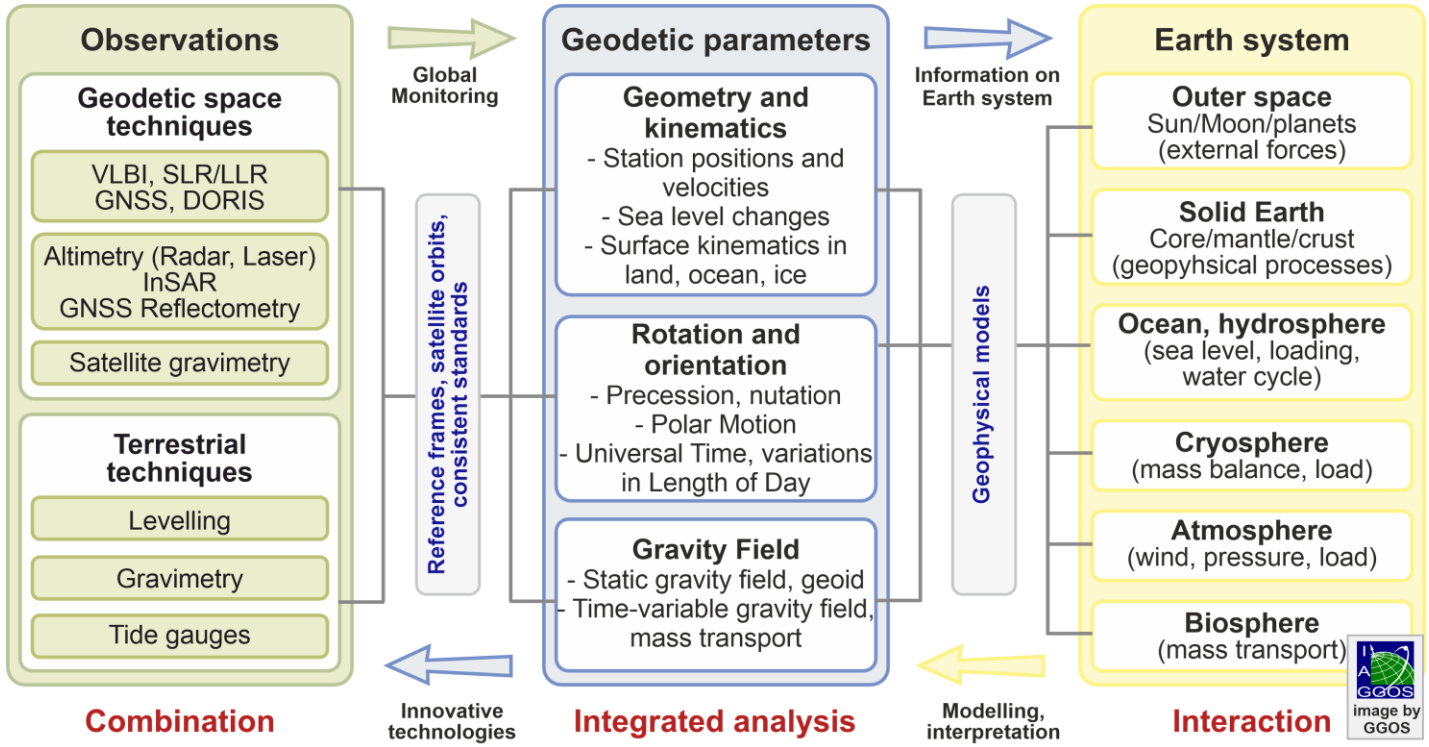
| | | |
|---|---|---|
| R. Heinkelmann, Germany | International Earth Rotation and Reference Systems Service (IERS) | geometry |
| N. Stamatakos, USA | International Earth Rotation and Reference Systems Service (IERS) | |
| U. Hugentobler, Germany | International GNSS Service (IGS) | |
| M. Bloßfeld, Germany | International Laser Ranging Service (ILRS) | |
| J. Gipson, USA | International VLBI Service for Geodesy and Astrometry (IVS) | |
| P. Štěpánek, Czech Republic | International DORIS Service (IDS) | |
| R. Barzaghi, Italy | International Gravity Field Service (IGFS) | gravity |
| S. Bonvalot, France | Bureau Gravimétrique International (BGI) | |
| M. Reguzzoni, Italy | International Service for the Geoid (ISG) | |
| E. S. Ince, Germany | International Center for Global Earth Models (ICGEM) | |
| K. M. Kelly, Germany | International Digital Elevation Model Service (IDEMS) | |
| H. Wzointek, Germany | International Geodynamics and Earth Tide Service (IGETS) | |
| J. Kusche, Germany | Representative of gravity community | |
| J. Ferrandiz, Spain | IAU Commission A3 Fundamental Standards | other entities |
| M. Craymer, Canada | Chair of Control Body for ISO Geodetic Registry Network | |
| L. Hothem, USA | Vice-Chair of Control Body for ISO Geodetic Registry Network | |
| S. Rózsa, Hungary | IAG Communication and Outreach Branch | |
| M. Sehnal, Austria | GGOS Coordinating Office | |

# Introduction and objectives

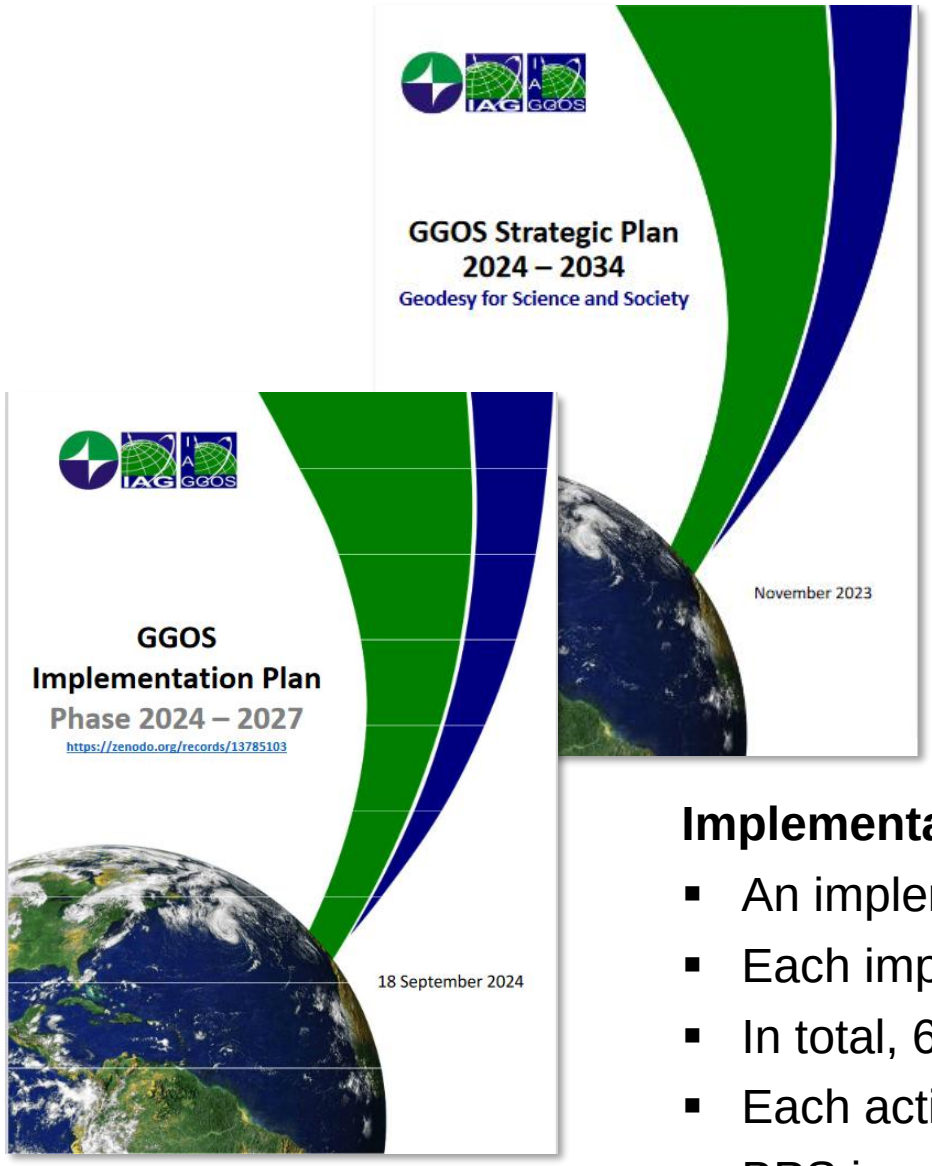
The BPS supports GGOS in its key goal to obtain consistent geodetic products describing the geometry, rotation and gravity field of the Earth. Fundamental requirements are reliable reference frames as well as common standards, conventions and models for the data analysis and product generation.

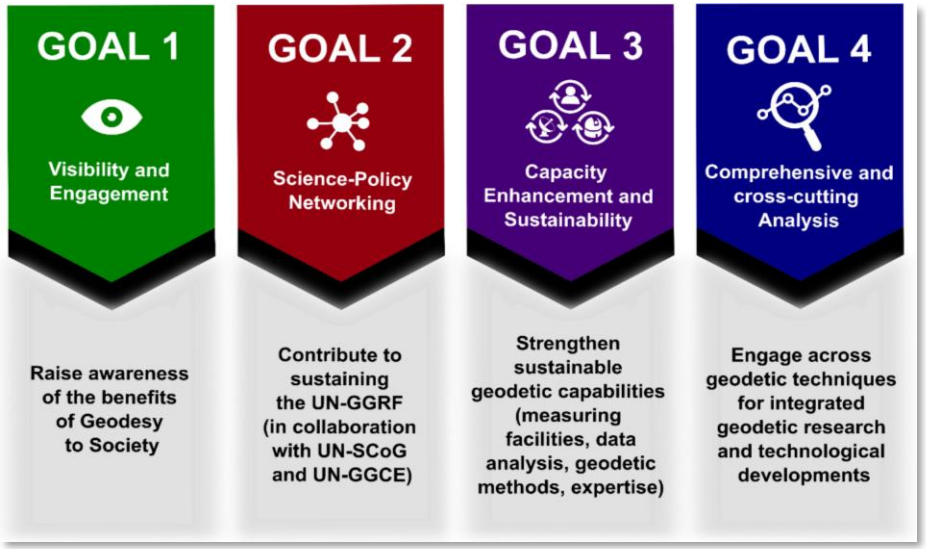
## Objectives of the BPS:

- contact & coordinating point for the homogenization of geodetic standards and products
- keep track of the adopted standards and conventions across all IAG components
- motivate the development of integrated geodetic products needed for Earth sciences and society
- raise awareness of geodetic products to improve the visibility of geodesy



# GGOS Strategic Plan and GGOS Implementation Plan




Each goal is completed by **four objectives** focused on


**Implementation Plan 2024 – 2027**

- An implementation action has been defined for all 16 objectives
- Each implementation action comprises several activites (SMART criteria)
- In total, 64 implementation activities have been defined
- Each activity is assigned to a GGOS component (One lead and contributors)
- BPS is responsible for 11 activities (and contributes to about 20 further activities)

# BPS activities (according to new GGOS Implementation Plan 2024 – 2027) – Part 1

| Activities (BPS lead) | 2024 | 2025 | 2026 | 2027 | Performance indicators |
|---|---|---|---|---|---|
| ***Standardisation, Integration and Optimisation*** | | | | | |
| **3.1.d** Identify **lack of geodetic products** that could be generated in the operational routine of the IAG Services and access their feasibility and usability. | | | | | **List of potential new products** from the IAG Services (operational routine), and pros and cons of creating and using these products. |
| **4.2.a** Promote a consistent and well-documented **data processing chain** that describes how the data are transformed into user-relevant information. | Continuous | | | | Liase with IAG Services, owners of geodetic space missions and other data providers to **promote accurate documentation** in their data analysis. |
| **4.2.b Update of the BPS inventory** of standards and products | | | | | Identification of **missing topics** (align with EGVs) |
| | | | | | **Publication** in a scientific journal or as part of the updated GGOS2020 book |
| **4.2.c Keep track of standards, constants and conventions** adopted by the IAG and collaborate with external stakeholders (IAU, ISO, CODATA, …) | | | | | Finalize **chapter 1 of IERS Conv**. (with IERS CC) |
| | | | | | Invited **BPS presentation** at IAU Comm. A3 Symp. |
| | Continuous | | | | **Interaction** with external stakeholders. |
| **4.2.d** Calculation of a **new reference level ellipsoid** based on current best estimates **(WG-GRS)** | Continous | | | | **Presentations** at international conferences and **scientific publication**; descriptive **manual for non-geodetic users** how to convert to new GRS. |
| **4.2.e Updated geophysical models** for the generation of consistent geodetic products **(C-ESM)** | Continuous | | | | **Presentations** at international conferences and **publication** in scientific journals. |

# BPS activities (according to new GGOS Implementation Plan 2024 – 2027) – Part 2

| Activities (BPS lead) | 2024 | 2025 | 2026 | 2027 | Performance indicators |
|---|---|---|---|---|---|
| ***GGOS Requirements and Essential Geodetic Variables (EGVs)*** | | | | | |
| **1.2.a Definition and classification of EGVs** | | | | | A **white paper** on EGVs. |
| **1.2.b** Communicate the **contribution of geodesy to ECVs and EOVs** and their interaction with EGVs | | | | | Publication in a popular science magazine of a broad geoscience journal. |
| **2.4.b** Describe EGVs as a measure for the **availability and quality** of geodetic infrastructure | | | | | **Outreach package** on the topic. |
| **4.3.b** Establish a **first catalogue of EGVs** with **requirements** for accuracy, stability, latency, and temporal and spatial resolution. | | | | | **Definition of requirements** for the EGVs. |
| | | | | | **Fact sheets** for EGVs. |
| ***Communication, Education and Outreach*** | | | | | |
| **4.4.c Description of products** for GGOS website | | | | | New/updated **product descriptions** |
| ***Further BPS activities (contributions to GGOS Coordinating Office and collaboration with UN-GGCE)*** | | | | | |
| **GGOS outreach activities** (e.g. GGOS films, articles, brochures, geodesy cartoons, fact sheets) | Continous | | | | See Activities of GGOS Coordinating Office |
| **Collaboration with UN-GGCE** on the mapping of the global geodesy supply chain and outreach | | Continous | | | See UN-GGCE Implementation Plan |

# BPS inventory of standards and conventions

- Inventory of standards and conventions used for the generation of IAG products
- Published in the Geodesist‘s Handbooks 2016 and 2020
- Key elements of the document:
  - General introduction (Sect. 1 and 2)
  - Evaluation of numerical standards
  - Product-based review (CRF, TRF, EOP, GNSS Orbits, Gravity and Heights)
  - Assessment of the status, gap analysis and recommendations to improve consistency of geodetic products
- Preparation of an updated version of the BPS inventory
  - Shortening of general parts (avoid duplications)
  - Identification of missing topics regarding standards and products
  - Consider other products (e.g., atmosphere products, sea level, ice melting, terrestrial water storage, …)
  - Merge with definition of EGVs
- Publication of the updated document (scientific journal or as part of updated GGOS2020 book)

**Contents**



*Angermann D., Gruber T., Gerstl M., Heinkelmann R., Hugentobler U., Sánchez L., Steigenberger P. (2020):* ***GGOS Bureau of Products and Standards: Inventory of standards and conventions used for the generation of IAG products****. The Geodesist‘s Handbook 2020, Eds: Poutanen M., Rózsa S., Journal of Geodesy, https://doi.org/10.1007/s00190-020-01434-z.*

# Essential Geodetic Variables (EGVs)

**White Paper:**
**Definition of Essential Geodetic Variables (EGV):**
**Contribution of Geodesy to Earth Observation**

Authors:
Thomas Gruber[1], Detlef Angermann[2], Laura Sánchez[3]

Draft Version: 4.0 (01.08.2024)

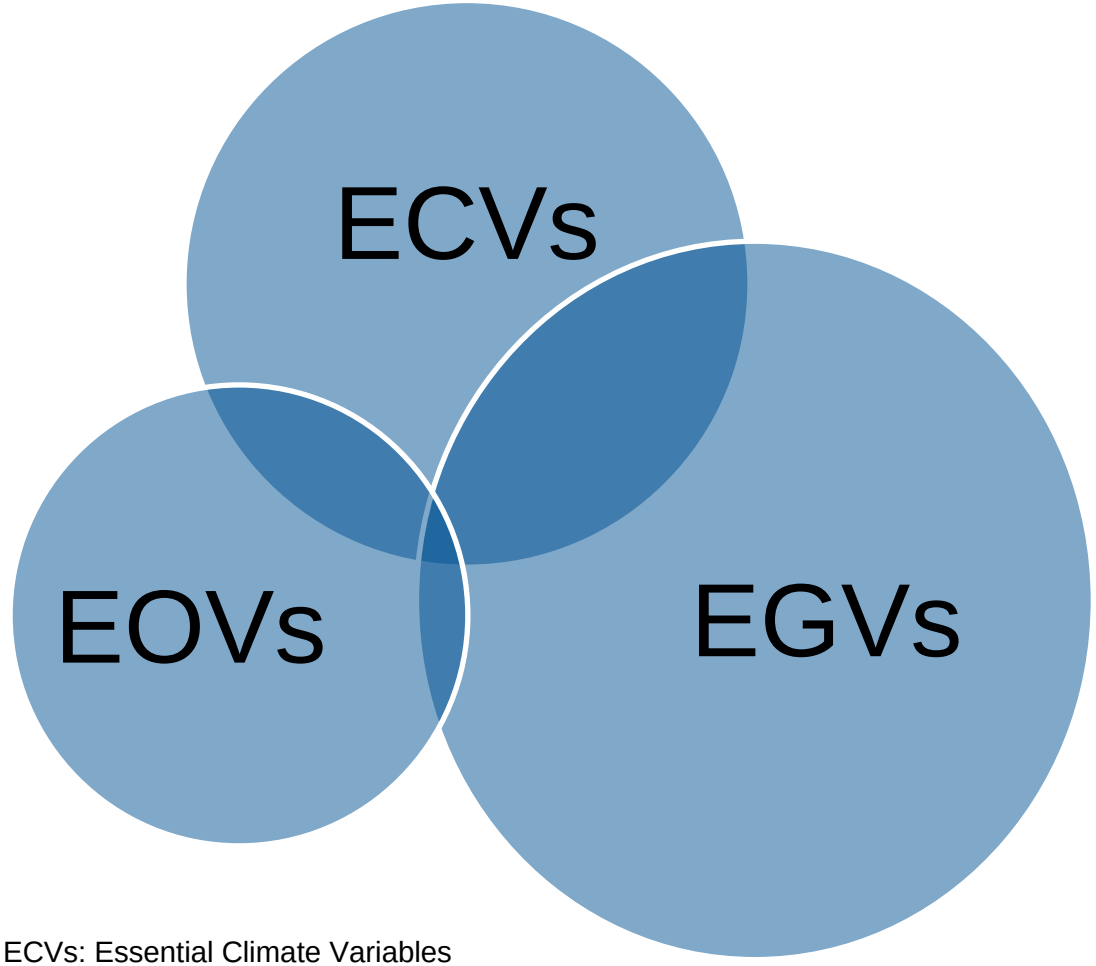
[1] Chair of the GGOS Committee „Definition of Essential Geodetic Variables“, Technical University Munich, Germany
[2] Director of the GGOS Bureau of Products and Standards, Technical University Munich, Germany
[3] GGOS President, Technical University Munich, Germany

=> Presentation on EGVs by Thomas Gruber

**Status and next steps:**

- April 2024: Release of a White Paper for the concept of the definition and classification of EGVs
- May/June 2024: Review by the GGOS Science Panel
- August 2024: Updated version of the White Paper including feedback from GGOS Science Panel
- October 2024: Review by the GGOS Governing Board
- Revision of the document; IAG Executive Committee will be asked for review
- Definition of requirements, needs assessment and gap analysis, generation of fact sheets

# EGVs – Overlap with ECVs and EOVs




ECVs: Essential Climate Variables
EOVs: Essential Ocean Variables
GCOS: Global Climate Observing System
GOOS: Global Ocean Observing System

**Some facts and planned activities:**

- 18 EGVs (53 geodetic products) have been defined
- 6 EGVs are defined as ECVs (sea surface, sea level, sea ice, ice sheets, glaciers, terrestrial water storage, atmosphere)
- 2 EGVs are defined as EOVs (sea surface, sea level)
- Communicate the contribution of geodesy to ECVs and EOVs; interaction with GCOS, GOOS and GEO
- Policy briefs for EGVs (in collaboration with UN-GGCE)
- Fact sheets for EGVs
- Promote EGVs (jointly with IAG and UN-GGCE)

# Product descriptions at GGOS website (ggos.org)

### Reference Frames


Height Reference Frame


Celestial Reference Frame


Gravity Reference Frame


Terrestrial Reference Frame

### Positioning & Applications


Thermosphere


Ionosphere


Lower Neutral Atmosphere


Atmospheric Products


GNSS Satellite Orbits and Clocks

### Geometry


Surface Deformation Models


Ocean Topography Models


Sea Level Change


Digital Elevation Model


Ice Sheets & Glaciers – Variations


Station Positions & Variations


Tide Gauge Records


Sea Surface Heights

### Earth Orientation


Earth Orientation Parameters

### Gravity Field


Global Gravity Field – Models


Gravity Field – Temporal Variations


Terrestrial Gravity Data


Regional / Local Geoid Models


Ice Sheets & Glaciers – Variations


Height Systems

**Some facts and planned activities**:

- 23 product descriptions are available at the GGOS website
- EGV definition: 18 EGVs and 53 geodetic products
- Update product descriptions and generate new descriptions
- Fact sheets for EGVs

# Fact sheets – Example for an ECV: Sea Level


## Sea Level

Sea Level is one of the primary indicators of global climate change. Change in the global mean sea level provides a measure of the net change in ocean mass due to melting of glaciers and ice sheets, and net change in ocean volume due to thermal expansion. Sea level observations characterize inter-seasonal variability such as ENSO. On the regional scales, changes in sea level can be far larger than the globally averaged value due to changes in temperature, salinity and circulation. Along many continental margins vertical land displacement associated with crustal adjustments to past and current land ice melt also cause regional variations in apparent sea level independent of the ocean. Coastal sea level change is a major driver of societal impacts.

| | |
|---|---|
| Domain: | Ocean |
| Subdomain: | Physical |
| Scientific Area: | Physical Properties |
| ECV Steward: | Peter Oke |
| Products: | Regional Mean Sea Level; Global Mean Sea Level |

### Sea Level Rise Map and Global Trend

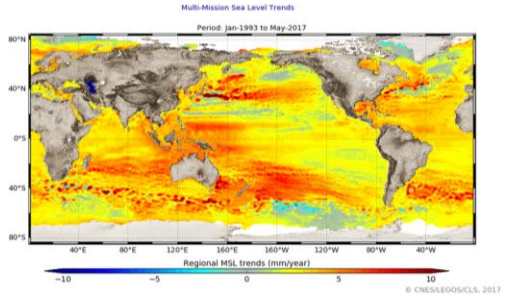



*Figure 1: Combined map of regional patterns of observed sea level (in mm/year). This map can be obtained using gridded, multi-mission Ssalto/Duacs data since 1993, which enable the local slopes to be estimated with a very high resolution (1/4 of a degree on a Cartesian projection). Isolated variations in MSL are thus revealed, mainly in the major ocean currents and ENSO events (Credits EU Copernicus Marine Service, CLS, Cnes, Legos).*

Source: https://www.aviso.altimetry.fr/en/data/products/ocean-indicators-produc…

### ECV Products and Requirements

*These products and requirements reflect the Implementation Plan 2022 (GCOS-244).*

*The requirements are found in the complete 2022 ECVs Requirements document as well: ECV Sea Level.*

| Products | | | Regional Mean Sea Level | | Global Mean Sea Level |
|---|---|---|---|---|---|
| | (*) | Unit | Values | Unit | Values |
| Horizontal Resolution | G | km | 10 | km | 10 |
| | B | | | | |
| | T | | 100 | | 100 |
| Vertical Resolution | G | | - | | - |
| | B | | - | | - |
| | T | | - | | - |
| Temporal Resolution | G | d | 1 | d | 1 |
| | B | | | | |
| | T | | 7 | | 30 |
| Timeliness | G | month | 1 | d | 30 |
| | B | | | | |
| | T | | 12 | | 365 |
| Required Measurement Uncertainty (2-sigma) | G | mm | | mm | |
| | B | | | | |
| | T | | 10 | | 2-4 |
| Stability | G | $mm\ yr^{-1}$ | 0.3 | $mm\ yr^{-1}$ | <0.03 |
| | B | | | | <0.1 |
| | T | | <0.1 | | <0.3 |

(*) **Goal (G)**: an ideal requirement above which further improvements are not necessary. **Breakthrough (B):** an intermediate level between threshold and goal which, if achieved, would result in a significant improvement for the targeted application. The breakthrough value may also indicate the level at which specified uses within climate monitoring become possible. It may be appropriate to have different breakthrough values for different uses. **Threshold (T)**: the minimum requirement to be met to ensure that data are useful

### Data Sources

*This list provides sources for openly accessible data sets with worldwide coverage for which metadata is available. It is curated by the respective GCOS ECV Steward(s). The list does not claim to be complete. Anyone with a suitable dataset who wishes it to be added to this list should contact the GCOS Secretariat.*

**In Situ**

- GLOSS - Global Sea-Level Observing System

http://www.gloss-sealevel.org/data/

**Satellite:**

- ECV Inventory by the CEOS/CGMS Working Group on Climate (WGclimate)

http://climatemonitoring.info/ecvinventory

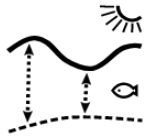
- Aviso

https://www.aviso.altimetry.fr/en/data/products/sea-surface-height-prod…

- JPL PODAAC

https://podaac.jpl.nasa.gov/OceanSurfaceTopography

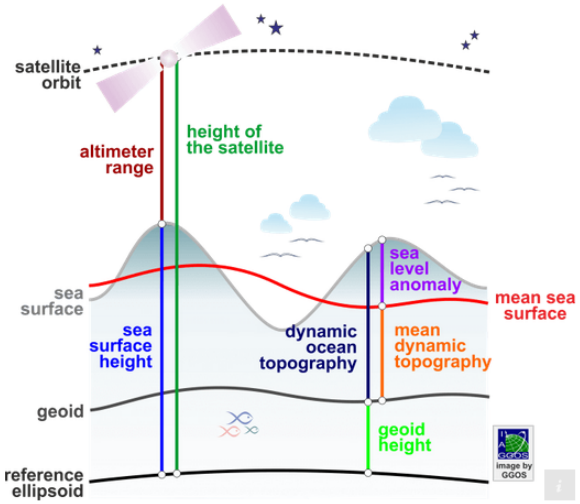
# Product description for Sea Surface Heights (ggos.org)



## Sea Surface Heights

### How can the height of oceans be observed?

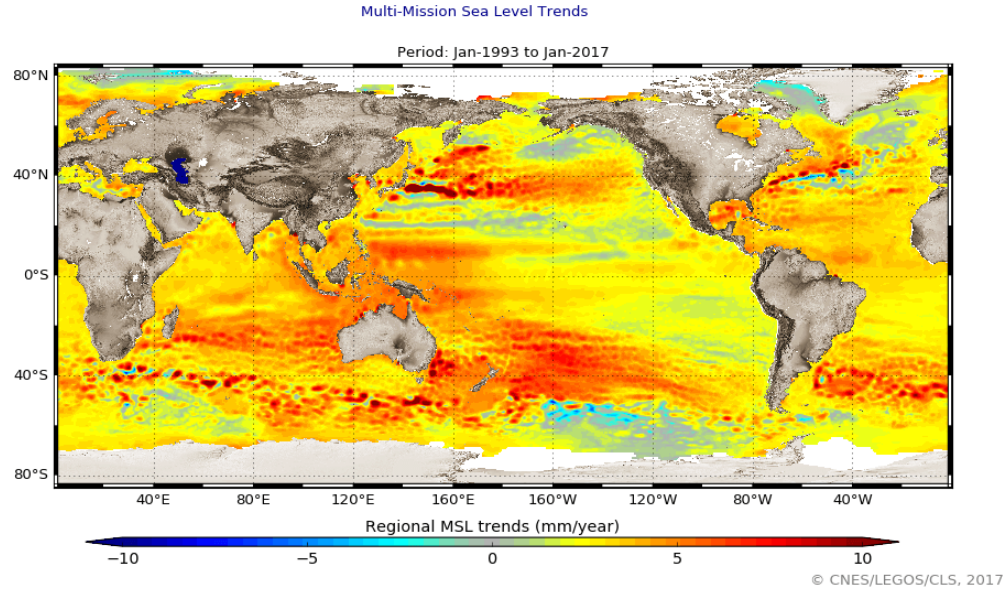
**Satellite altimetry** systems are designed to map the sea surface. These systems **measure the satellite-to-sea surface** round-trip travel time of radar or light pulses to determine the height of the satellite (altimetric range) above the instantaneous sea surface. The difference between the satellite altitude above a reference surface and the altimetric range provides the sea surface height with respect to the same reference surface. The range from the satellite to the sea surface is **corrected for various components** of the atmospheric refraction and to mitigate effects caused by instrumental biases and sea state induced systematics. A number of corrections due to different geophysical effects are also taken into account. **Different products are distinguished**:




Definition of various quantities related to sea-surface-heights

- + Sea Surface Height (SSH)
- + Mean Sea Surface (MSS)
- + Sea Level Anomalies (SLA)
- + Dynamic Ocean Topography (DOT)
- + Mean Dynamic Topography (MDT)
- + Mean Sea Level (MSL)
- + Global Mean Sea Level (GMSL)

Read More ...




## Selected Data Sources

**RADAR ALTIMETRY TUTORIAL AND TOOLBOX**
at the European Space Agency (ESA) and Centre National d'Etudes Spatiales (CNES)

**OCEAN SURFACE TOPOGRAPHY**
from Space at the US National Aeronautics and Space Administration (NASA)

**AVISO+ SATELLITE ALTIMETRY DATA**
at the Centre National d'Etudes Spatiales (CNES) and the Center for Topographic studies of the Ocean and Hydrosphere (CTOH)

**ALTIMETRIC AND OCEAN SURFACE TOPOGRAPHY DATA INFORMATION**
at the US National Aeronautics and Space Administration (NASA) and National Oceanic and Atmospheric Administration (NOAA)

**COPERNICUS**
European Union's Earth Observation Programme Copernicus

# BPS contributions to GGOS outreach (supporting GGOS Coordinating Office)

## GGOS Website (www.ggos.org)

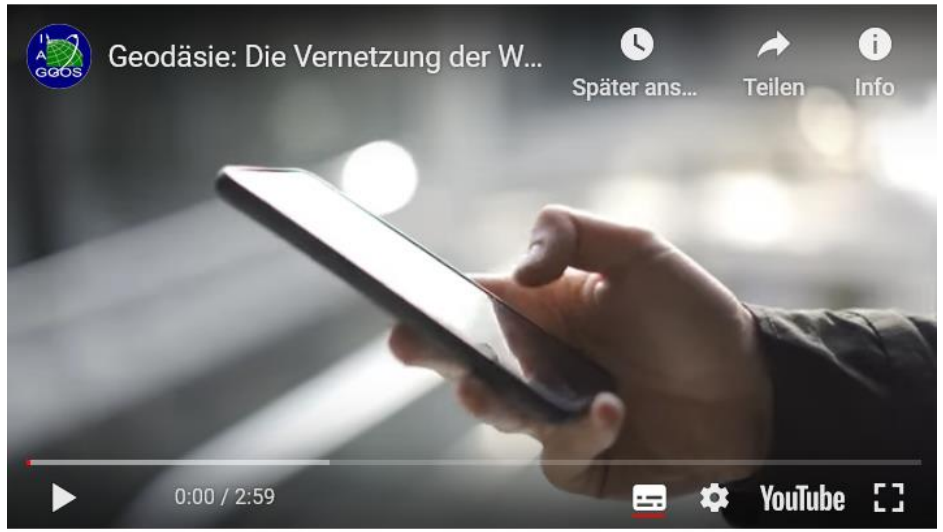
- About GGOS
- Information Portal
  - Observations, Services, Products
- Events, Blog, Social Media, …
- GGOS Cloud


GGOS Portal

## GGOS Videos

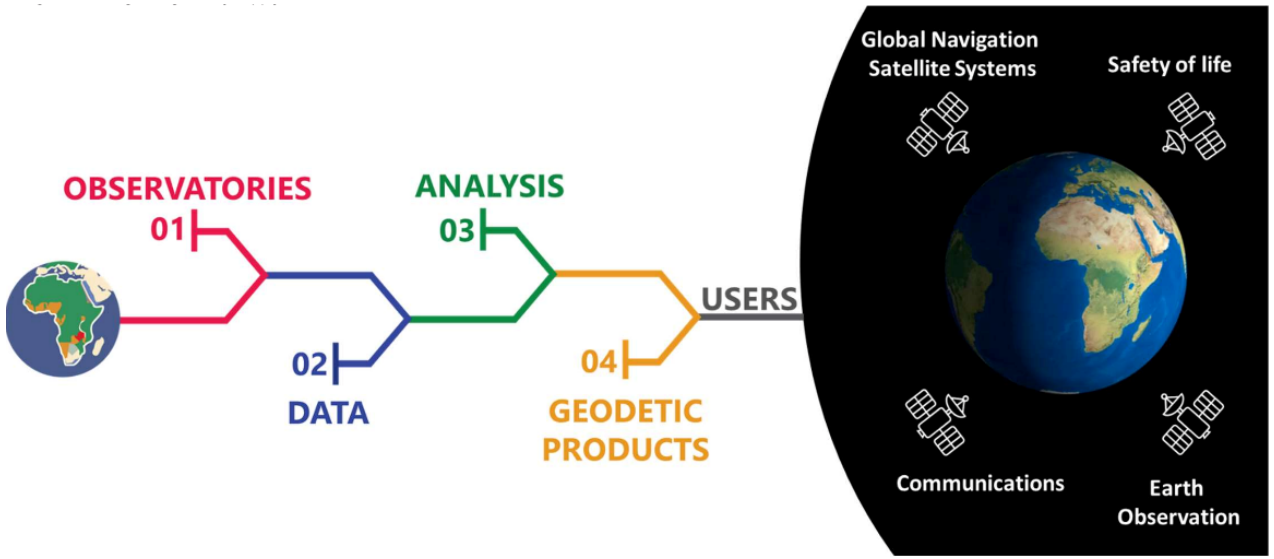
- Discover GGOS and Geodesy (14 languages)
- Terrestrial Reference Frames (12 languages)
- Short version of TRF video (jointly developed with the UN-GGCE)
- More videos about geodetic products will follow (e.g. Gravity Field and Heights)

Geodesy: Connecting the world through geodesy



# Collaboration with the UN-GGCE

Mapping of the Global Geodesy Supply Chain




Information gathering from IAG Services:

- Virtual meetings with IAG Services (UN-GGCE, with BNO and BPS, Feb-Apr 2024)
- Status, needs, products, users, and costs related to the global geodesy supply chain
- Five Focus areas: Evidence, Resources, Governance, Capacity Development, Awareness
- Input for UN-GGCE documents/reports


## Standardisation, integration, and optimisation of geodetic products

*Convener: Detlef Angermann*

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