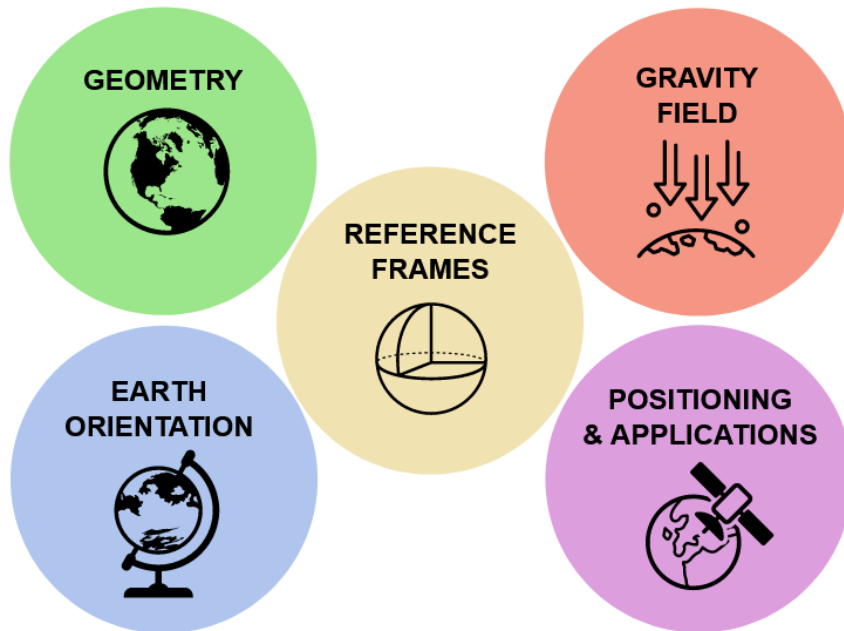


Some (personal) thoughts on the definition of EGVs

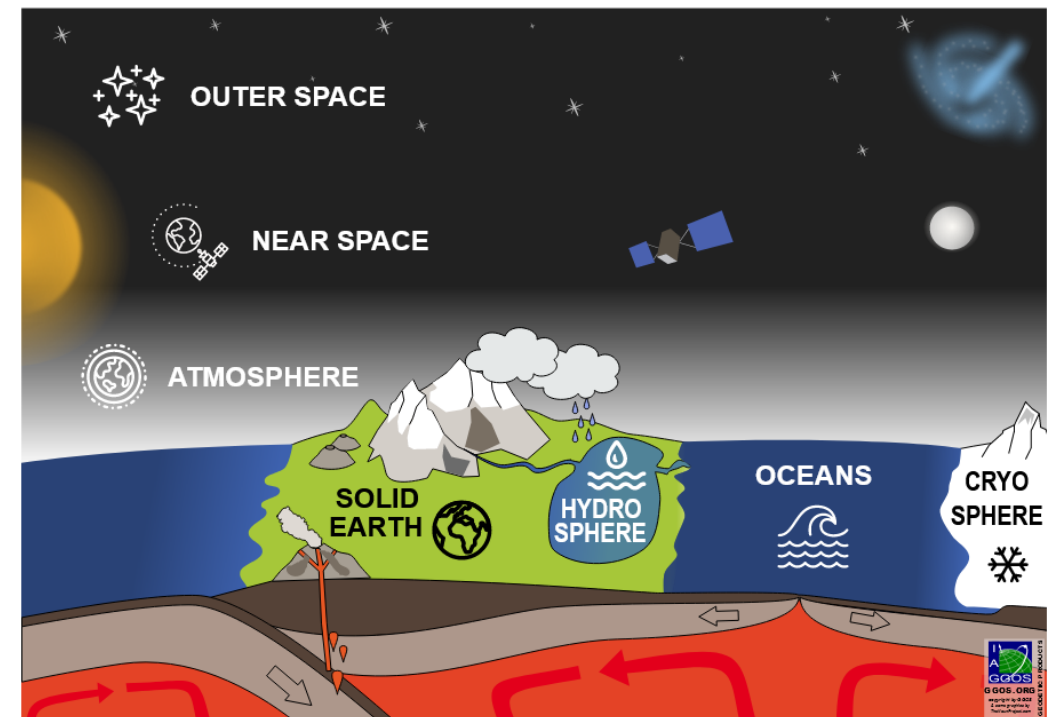
Thomas Gruber

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GEODETTIC THEMES



EARTH SYSTEM COMPONENTS & SPACE



What happened so far? - A short recap (1)

GGOS Days 2017:

- R. Gross: “Definition of Essential Geodetic Variables and **gap analysis**”

GGOS Days 2018: New BPS entity: “**Committee on Essential Geodetic Variables (EGVs)**”

- R. Gross: “Essential Geodetic Variables”:
 - Committee shall create **list of EGVs, assign requirements** to them, etc.
- T. Gruber: “Essential Geodetic (Gravimetric) Variables – Some initial Thoughts”:
 - **What is an essential** geodetic (gravimetric) variable (EGrV)?
 - Who is the **target group**? Is it geodesy, Earth sciences in general, all applications?
 - Geodesy is not well known. **Are EGV equivalent to ECV, EOv** or others?
 - Very draft idea: Define **different levels of EGrV's**: Level 1: Observables: Level 2: Geodetic Products; Level 3: Applications, probably strongly linked to ECV's, EOv's.

What happened so far? - A short recap (2)

IUGG 2019:

- R. Gross: “Essential Geodetic Variables”
 - Committee shall create **list of EGVs, assign requirements** to them, etc.
- R. Gross: “Essential Earth Rotation Variables”
 - 5 parameters: GGOS accuracy requirements met, but resolution and latency not.
- M. Rothacher: “Identification of EGV’s for Earth’s Geometry”
 - **Criteria for Essential Variables**: Relevance, Feasibility, Cost Effectiveness, Sustainability
 - What is the **right level for EGV’s**? Should be at L2 or L3 to be relevant and understandable.
 - **Classification Options**: Geodetic pillars or Earth system domain?
 - **Essential for what?** For geodesy or for monitoring the Earth system
 - Define **real geometrical and physical quantities** not like “Glaciers”, “Ground Water”

What happened so far? - A short recap (3)

IUGG 2019 (Cont.):

- T. Gruber: “Essential Gravimetric Variables – Identification and Initial Assessment”
 - **Link** between ECV’s, EOVS and E’GrV’s
 - **EGrV Levels**: From L0 to L3
 - Initial Assessment of **EGrV requirements** (resolution and accuracy)

GGOS Days 2019:

- R. Gross: “Essential Geodetic Variables”

GGOS Days 2021:

- R. Gross: “Definition of Essential Geodetic Variables (EGVs)”

GGOS Days 2022:

- R. Gross: “Definition of Essential Geodetic Variables (EGVs)”
 - **Identify target audience** (internal and external)
 - **Create list** of EGV’s

What happened so far? - A short recap (4)

IUGG 2023:

- R. Gross: “Defining Essential Geodetic Variables: Status & Plans”
 - **Identify target audience** (internal and external)
 - **Create list** of EGV’s
- T. Gruber: “Geodetic Requirements for Next Generation Gravity Field Missions in the Context of Essential Geodetic Variables”
 - **Identify a basic set of EGV’s** (either classified by geodetic pillars or by applications).
 - **Define criteria** to become an EGV: Relevance, Feasibility, Cost effectiveness, Sustainability, others.
 - Define the **right level for EGV’s**: Should it be at Level 2 or 3 to be relevant? Should lower level variables be considered?
 - Identification of **requirements for EGV’s**: Driven by applications? Driven by geodetic techniques?

What are the main questions to be answered now?

1. What is an essential variable?

- To whom are variables essential (target group)?
- For what are variables essential? For geodesy or for monitoring the Earth system?
- What are the criteria to declare a variable as essential?

2. What is the right level for an essential variable?

- Is the level equivalent to ECV, EOV?
- Should it be at level 2 or 3 or even lower to be relevant?

3. What variables provided by geodesy are essential?

- What are these variables?
- What are the requirements for these variables?

1. What is an Essential Variable?

To whom are variables essential (target group)?

- **Global society** (people, administration, decision makers, science, etc.)

For what are variables essential? For geodesy or for monitoring the Earth system?

- “Observed variables that are crucial (essential) to characterizing the geodetic properties of the Earth and that are key to sustainable geodetic observations.” (R. Gross)
- The **Earth as a whole** with regional and local refinements

What are the criteria to declare a variable as essential (adapted from ECV/EOV criteria)?

- Relevance: The variable is critical for characterizing the **Earth system** (T. Gruber)
- Feasibility: Observing or deriving the variable on a global scale is feasible
- Cost effectiveness: Generating and archiving is affordable (technology)
- **Sustainability** (M. Rothacher): Variable available over decades

1. What is an Essential Variable?

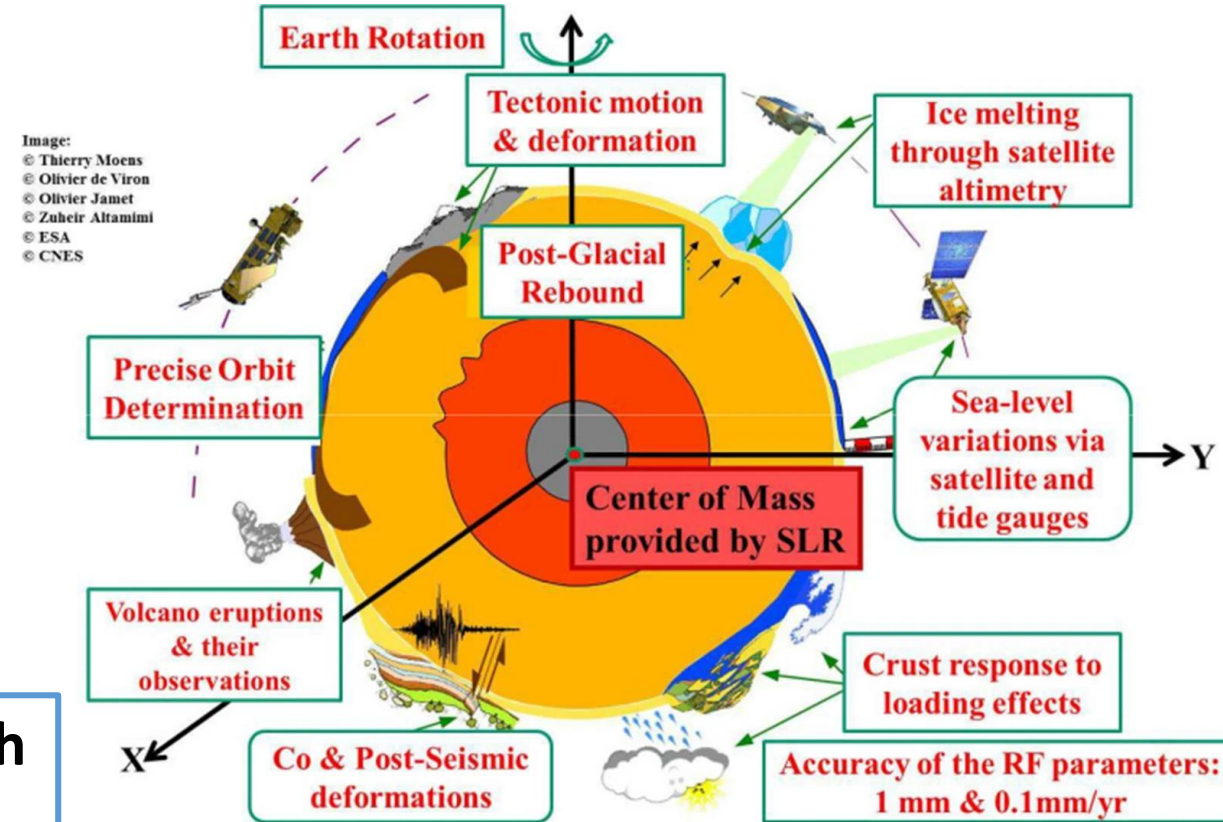
Example GENESIS Mission

“The GENESIS mission's primary goal is a significant improvement of the **International Terrestrial Reference Frame (ITRF)**. The ITRF is recognized to be the metrological foundation for all space- and ground-based observations in Earth Science and Navigation, and therefore this mission will potentially have a major impact in a large number of GNSS and Earth Observation applications”

→ **Geodetic Product: ITRF**

→ **Essential Variable: Geometric Shape of Earth**

- Land: Tectonic, Seismic, Volcanos, Loading, Deformations, Inland Water Level, ...
- Cryosphere: Ice Sheets, Glaciers
- Ocean: Sea Level, Sea State



© Delva, P., Altamimi, Z., Blazquez, A. et al. GENESIS: co-location of geodetic techniques in space. Earth Planets Space 75, 5 (2023). <https://doi.org/10.1186/s40623-022-01752-w>

1. What is an Essential Variable?

Example MAGIC Mission

The MAGIC mission's primary goal is a significant **improvement of observing mass distribution and mass change in the Earth system**. The Earth gravity field is recognized to be the metrological foundation for observing spatial and temporal mass variations in the Earth system, and therefore this mission will potentially have a **major impact in a large number of Earth Observation applications**”

→ **Geodetic Product: Temporal Gravity Field**

→ **Essential Variable: Physical Shape of Earth (Geoid)**

- Hydrology: Ground Water, Soil Moisture, Water Cycle, ...
- Cryosphere: Ice Sheets, Glaciers, ...
- Ocean: Sea Level, Bottom Pressure, Ocean Circulation, ...
- Solid Earth: Geohazards, Geodynamics, Natural Resources, ...
- Geodesy: Heights, Height Systems, GNSS Levelling, ...



1. What is an Essential Variable?

My Thoughts

Shall we regard a geodetic product as an Essential Geodetic Variable (EGV)?

- I think in most cases the **geodetic products are not easy to understand** for society.
- See previous examples: ITRF or geoid are fundamental geodetic products, but hardly recognizable by non-geodesists.
- Proposal: **Define variables according to Earth system parameters** similar to ECV`s and EOVS. (e.g. sea level, ice sheets, ...)

Shall we use the term EGV at all?

- **Geodesy suffers from visibility** in society, therefore it might be difficult to promote them.
- Geodesy observes the **Earth system as a whole** with regional/local refinements.
- **Proposal:** Why not naming them as **Essential Earth System Variables (EEV`s or EESV`s)**?
- This is the most fundamental question we need to answer first!

2. What is the Right Level for an Essential Variable?

Is the level equivalent to ECV, EOV?

- Most ECV's and EOV's are defined at high data level (L3) not at observation level
- Example: Contribution of geodesy to a significant number of ECV's and EOV's

➤ Yes !

Land	Ocean Surface	Ocean Sub-Surface	Atmosphere Surface	Atmosphere Upper-air	Atmosph. Composition
River discharge	Temperature	Temperature	Temperature	Temperature	
Water use	Salinity	Salinity	Wind speed & dir.	Wind speed & dir.	
Ground water	Sea level		Water vapour	Water vapour	
Lakes	Sea state		Pressure		
Soil moisture	Sea ice		Precipitation	Lightning	
Snow cover	Surface Current	Sub-surface current	Surface radiation	Earth radiation	
Glaciers & ice caps	Ocean colour			Cloud properties	Cloud properties
Ice sheets	Carbon dioxide	Carbon dioxide			Carbon dioxide
Permafrost	Ocean acidity	Ocean acidity			
Land cover	Phytoplankton				
FAPAR	Stress	Oxygen			Methane
Leaf area index	Heat flux	Nutrients			Ozone
Biomass		Tracers			Aerosols properties
Soil carbon		Nitrous oxide			Greenhouse gas
Fire disturbance		Carbon isotopes			Precursors
Albedo		Organic carbon			

ECV
EOV
ECV & EOV

Link to Geodesy

2. What is the Right Level for an Essential Variable?

Should it be at level 2 or 3 or even lower to be relevant?

- Definition of Levels:
 - Level 0: Geodetic Standards
 - Level 1: Observations of different kind with different spatial and temporal coverage
 - Level 2: Models (regional & global), e.g. gravity field, ITRF
 - Level 3: Application variables (similar to ECV's and EOV's)
- Essential variables at Level 3 shall be defined first.
- Essential variables at level 2 might need to be considered if they address the Earth system as a whole.
- Level 1 variables could be used to measure the quality/robustness of the geodetic infrastructure used in a given region.

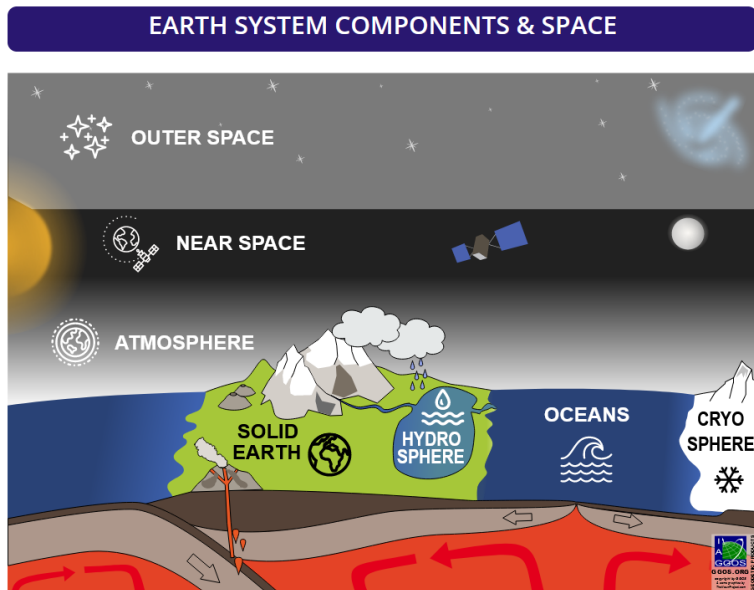
3. What Variables Provided by Geodesy are Essential?

What are these variables?

- Geodetic products contributing to Essential Variables shall be identified (see [GGOS Products Classification](#) by Earth System Components and Space):
- Example: Essential Variable = [Land Deformation](#)

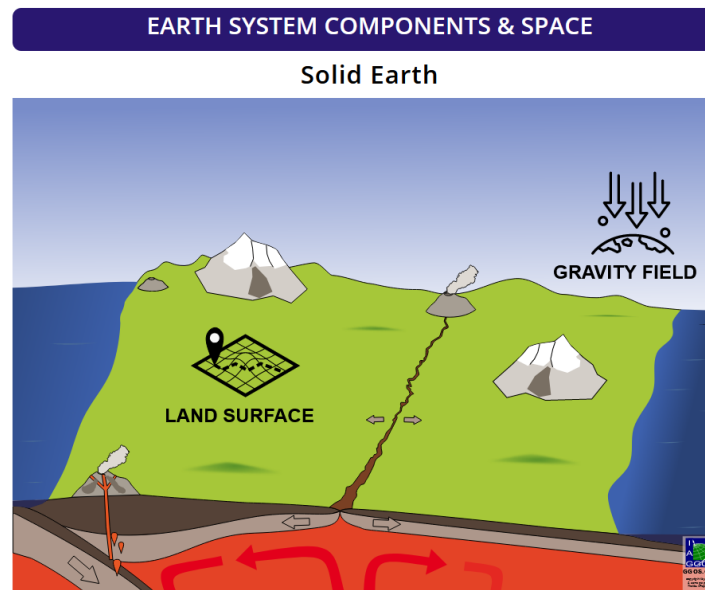
Select Domain: Solid Earth

Geodetic Products



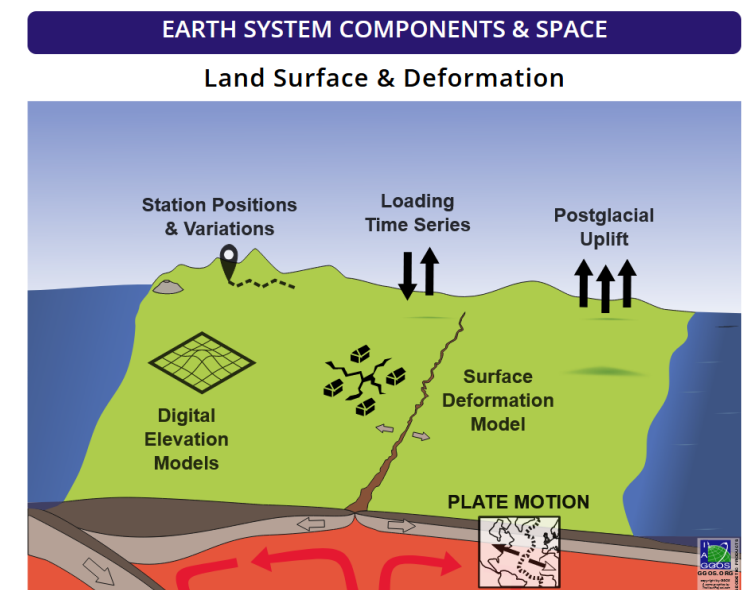
Select Subdomain: Land Surface

Geodetic Products



Select Product:
Surface Deformation Model

Geodetic Products



3. What Variables Provided by Geodesy are Essential?

What are these variables?

- A **classification scheme** shall be developed for each essential variable, see example:
- A **matrix** shall be developed showing the link between EEV's and geodetic products.

Example ECV Classification

Example: Glaciers

- **Domain:** Terrestrial
- **Subdomain:** Cryosphere
- **Scientific Area:** Snow and Ice
- **ECV Stewards:** Huilin Li

- **Products:**
 - Glacier Area
 - Glacier Elevation Change
 - Glacier Mass Change

Example EEV Classification

Example: Surface Deformation Model

- **Domain:** Solid Earth
- **Subdomain:** Land Surface
- **Scientific Area:** ?
- **EEV Stewards:** NN

- **Products:**
 - ITRF
 - Station coordinates & Velocities
 - Loading time series

3. What Variables Provided by Geodesy are Essential?

What are the requirements for these variables?

- Requirements in terms of **spatial resolution, temporal resolution and accuracy** need to be specified for each essential variable.
- Example: Satellite gravity field requirements for hydrological applications:

Thematic field	<u>Time scale</u> S: Short-term (3-5 days); M: Monthly; L: Long-term trend	<u>Threshold: Resolution & Accuracy [EWH]</u>	<u>Target: Resolution & Accuracy [EWH]</u>
Hydrology	S <i>Latency: 3-5 days</i>	Threshold-a: 600 km @ 2.5 cm; Threshold-b: 400 km @ 4.2 cm	Target-a: 600 km @ 0.25 cm; Target-b: 400 km @ 0.42 cm
	M <i>Latency: 1 month</i>	Threshold-a: 400 km @ 1.7 cm; Threshold-b: 260 km @ 4.8 cm	Target-a: 400 km @ 0.17 cm; Target-b: 260 km @ 0.48 cm
	L	Threshold-a: 350 km @ 0.1 cm/yr; Threshold-b: 150 km @ 5.0 cm/yr	Target-a: 350 km @ 0.01 cm/yr; Target-b: 150 km @ 0.5 cm/yr
Thematic sub-field			
Groundwater storage	L	See Hydrology	Target: 200 km @ 0.1 cm/yr
Water balance closure	M <i>Latency: 1 month</i>	See Hydrology	Target: 200 km @ 1 cm
Global change impact on water cycle	L	See Hydrology	Target: 200km @ 0.1 cm/yr

The Way Forward

Step 1:

- Decision if we **stay with EGV's** or shall we consider to **define "Essential Earth System Variables"** (EEV's or EESV's)? **Who shall decide this?**
 - Disadvantage: We **give up geodesy** in the name (our home base).
 - Advantage: **Better visibility** and higher interest to user groups. Better **link to** existing **ECV's and EOV's**.

Step 2:

- **Develop a concept on how** to define essential variables in a small core group operated by the BPS with expertise from all geodetic domains.
 - Result: **Roadmap** towards the definition of Essential Variables

Step 3:

- **Define Level 3 Essential Variables** and prepare a **classification scheme (matrix)** linking variables with geodetic products (extended core group coordinated by the BPS)

Step 4 to X: tbd