Federal Agency for Cartography and Geodesy

BKG
Wir geben Orientierung.

Establishment of a „European Height Reference Surface“
as an official realization of the European Vertical Reference System

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EUREF 2021 Symposium, 26 May 2021, online

Motivation
The situation on the national level

- National height reference frames are realized based on leveling networks
- Some European countries have implemented EVRS-compatible height systems (Netherlands, Germany, Baltic countries, …) or provide transformation grids from national heights to EVRS heights (Austria, Switzerland, …)
- These come together with national height reference surface grids (geoid/quasigeoid models) for GNSS-based height determination
- That means, the national height reference frames are usable with two different observation techniques

Motivation
The situation on the European level

- Official realization of the EVRS is based on the UELN, latest realization EVRF2019
- However, there is still no official height reference surface product that provides transformation between the latest EVRS and ETRS89 realizations seamlessly and homogeneously across borders
- Thus, EVRS heights cannot be directly determined based on GNSS observations

- Need for official combined (quasi)geoid model acknowledged many times, e.g.
  - **EUREF Resolution 2009/5** *„[…] asks the TWG to contact the European Geoid Project in order to develop a combined European Geoid to link ETRS89 and the EVRS“*
  - *„Improvement of the coherence“* between ETRS89 and EVRS is explicitly mentioned in the **EUREF Missions & Objectives**

Motivation
The situation on the European level (continued)

- Various scientific gravimetric geoid models have been computed and updated on a continental or regional scale (*↗Geoid Repository at ISG*)

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- Various sc l or regional s

www.isgeoid.polimi.it/Geoid/Europe/europe.html

ISG
International Service for the Geoid

PRESENTATION | NEWS | PROJECTS | SERVICES | NEWTON'S BULLETIN | CONTACTS

GEOID REPOSITORY
- REGIONAL MODELS
  - BY MAP
  - BY LIST
- GLOBAL MODELS
- SUBMIT NEW GEOID

HEIGHT CONVERSION

SOFTWARE DOWNLOAD

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- NEXT SCHOOL
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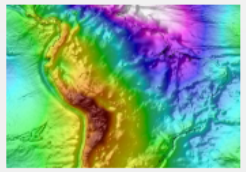
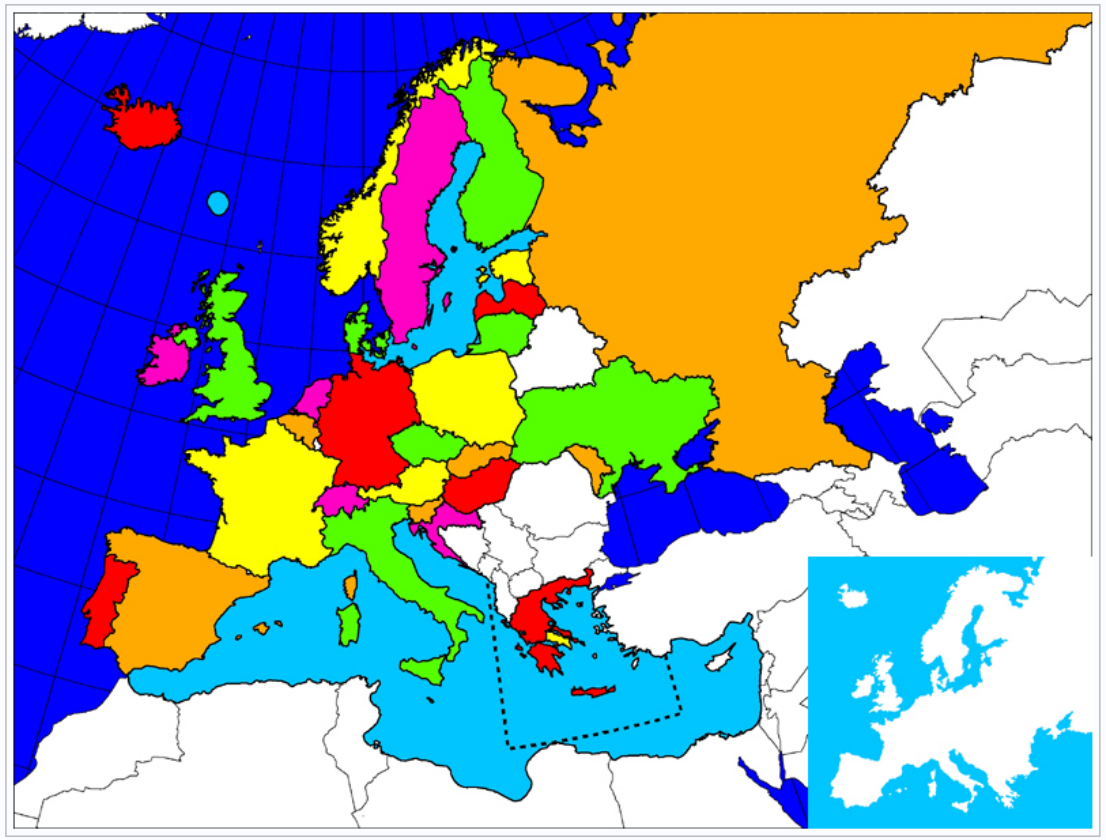


Services - Geoid Repository

Regional Models by Map

Click on the map to select a Geoid



Search in ISG Website

Search

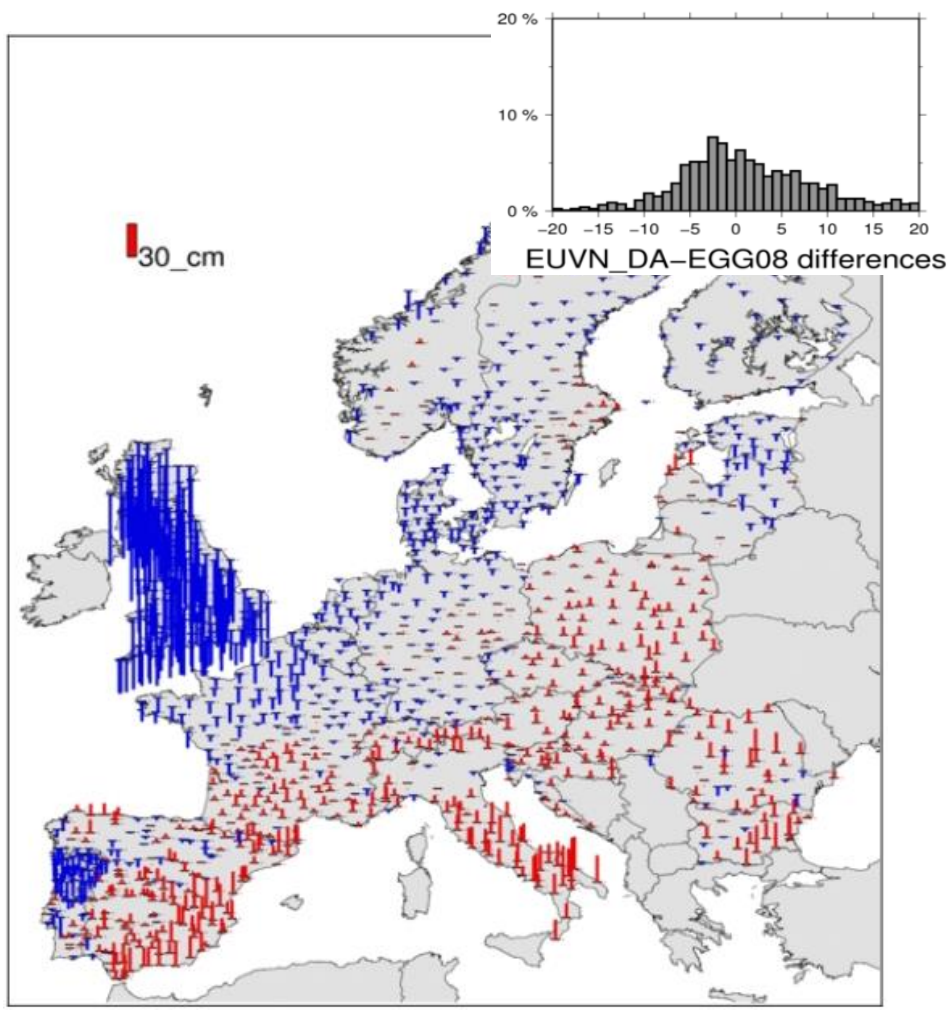
Links:

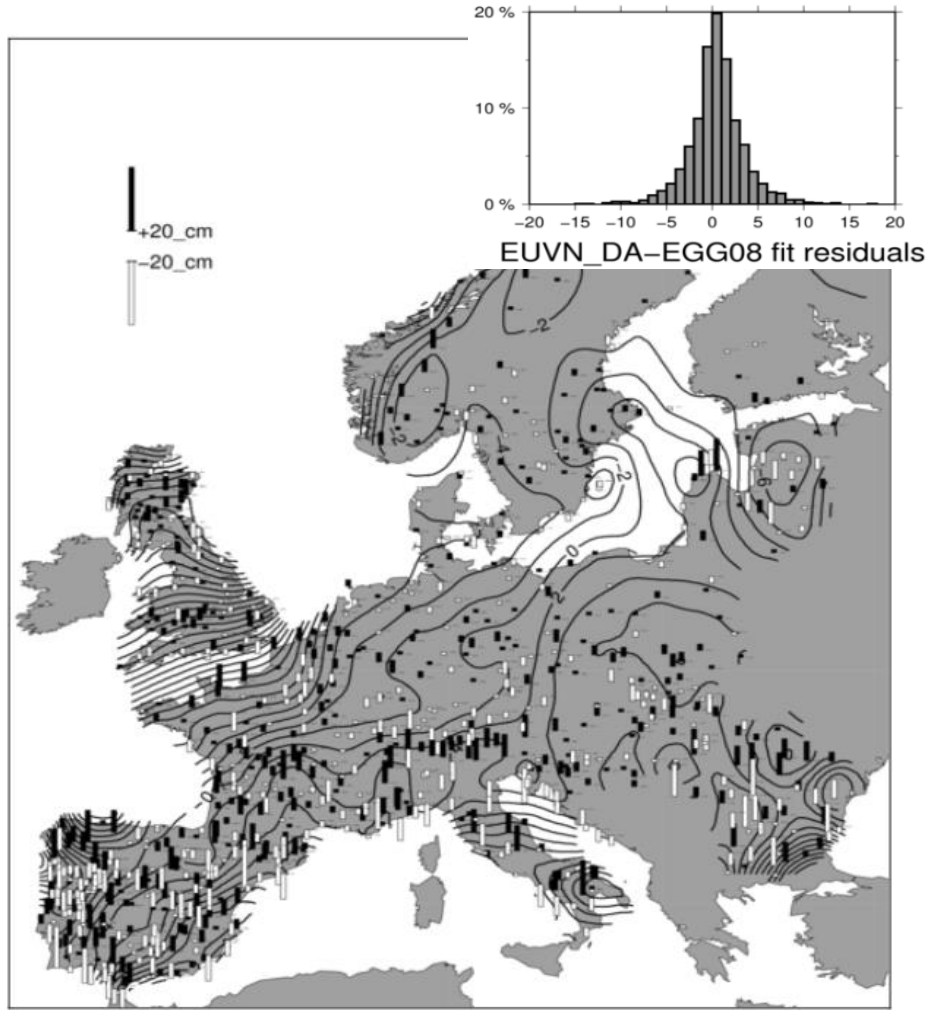
- IAG - International Association of Geodesy
- IGFS - International Gravity Field Service
- BGI - International Gravimetric Bureau
- COST-G - Combination Service for Time-variable Gravity Fields
- ICGEM - International Centre for Global Earth Models
- IDEMS - International DEM Service
- IGETS - International Geodynamics and Earth Tide Service

Motivation
The situation on the European level (continued)

- Various scientific gravimetric geoid models have been computed and updated on a continental or regional scale (*↗Geoid Repository at ISG*)
  - EGG models (H. Denker, European Geoid Project, IAG SC 2.4a)
  - NKG geoid (Scandinavia), FAMOS/BSCD2000 (Baltic Sea)
  - Geomed/Geomed-2 (Barzaghi et al.)
  - recently: D-A-CH project (BKG, BEV, swisstopo, …) → *extension to European Alps (↗EGU21-7567)*
- The successful EUVN-DA action (2001-2010) improved the data situation for geoid validation, height system unification etc.

Example for quasigeoid model fitted to ETRS89 and EVRS: EGG08 corrector surface (not officially implemented)





Source: EUVN-DA final report (Kenyeres et al. 2010)

Motivation
The situation on the European level (continued)

- Deficiencies of the ISG geoid repository
  - Submission of information is not actively managed by EUREF and the national mapping agencies
  - Does not provide necessary metadata about reference frames for consistent use, even for combined models

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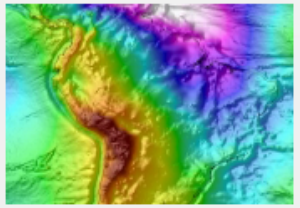

Services - Geoid Repository

Regional Models

Austria

Author: H. Suenkel, et al. **Created:** 1996 **Resp:** H. Suenkel
Status: PRIVATE

Description:
The Austrian geoid is computed by the fast collocation method. As for the Austrian territory, the input data consist of a 50 x 50 m digital terrain model, about 30.000 gravity data, about 700 deflections of the vertical, and GPS derived points. As for the neighboring countries, gravity and height information is available in different quality and density. The provided output is the geoid and quasi geoid undulation (in meters) from north to south and for each latitude from west to east.

A header file is also provided with the following information (unit degree):
southern latitude northern latitude
western longitude eastern longitude
latitude increment longitude increment

In particular:
Western part
46 ° 38.25' dlat. = 0.05; dlon. = 0.083333
Eastern part
46 ° 20.25' dlat. = 0.05; dlon. = 0.083333

References:
E. Erker, B. Hofmann-Wellenhof, H. Moritz, H. Suenkel (1996). **Austrian Geoid 2000**. Osterreichische Zeitschrift fuer Vermessung und Geoinformation, 84, Heft 3, pp. 289-293.

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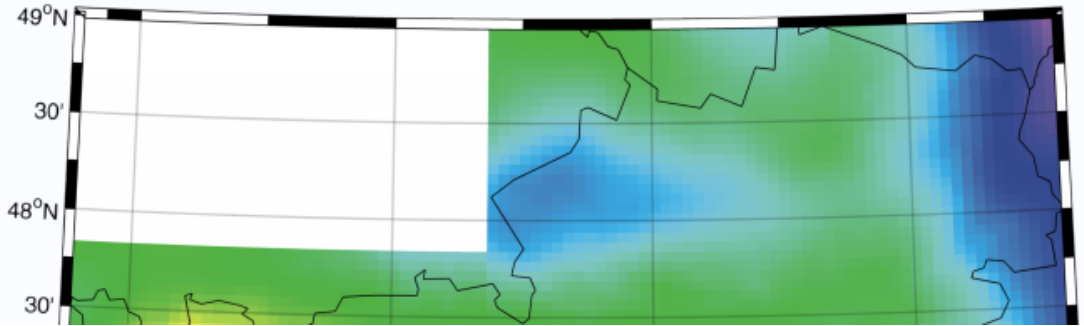


Motivation
The situation on the European level (continued)

- Deficiencies of the ISG geoid repository
  - Submission of information is not actively managed by EUREF and the national mapping agencies
  - Does not provide necessary metadata about reference frames for consistent use, even for combined models

- Even national height products aligned to ETRS89 and EVRS realizations can differ systematically by some centimeters

- EUVN-DA dataset
  - Outdated (e.g. new data available in UELN)
  - Weakly homogenized ETRS realizations and epochs

Proposal for EUREF Working Group “European Height Reference Surface”

Goals

- Provide comprehensive and easily accessible information about the national integrated spatial reference
- Improve interoperability of the national products of the height reference across borders
- Enable seamless GNSS-based height determination, thereby strengthen the importance of the EVRS
- Establishment of an European height reference surface as an official realization of EVRS which is compatible to the latest realizations of ETRS89 and ETRS (= fulfill EUREF resolutions)

Actions

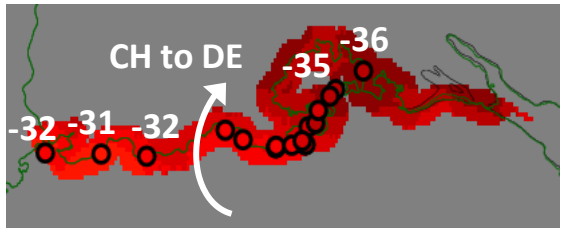
- Collect, update and provide information about *current official* national height reference frames and products (geoid models, transformation grids, …) and their metadata
  - **Establish and maintain inventory** of national geoid models (and height correction grids)
  - Integrated in the future **CRS-EUv2 database** (conforming ISO 19111:2019)
- **Renew GNSS/leveling dataset** in current ETRS89/EVRS realization
- Develop and provide **quasigeoid model (as above) fitted to ETRS89/EVRS realizations** *(cooperation with IAG SC2.4a European Geoid / European Geoid Project)*

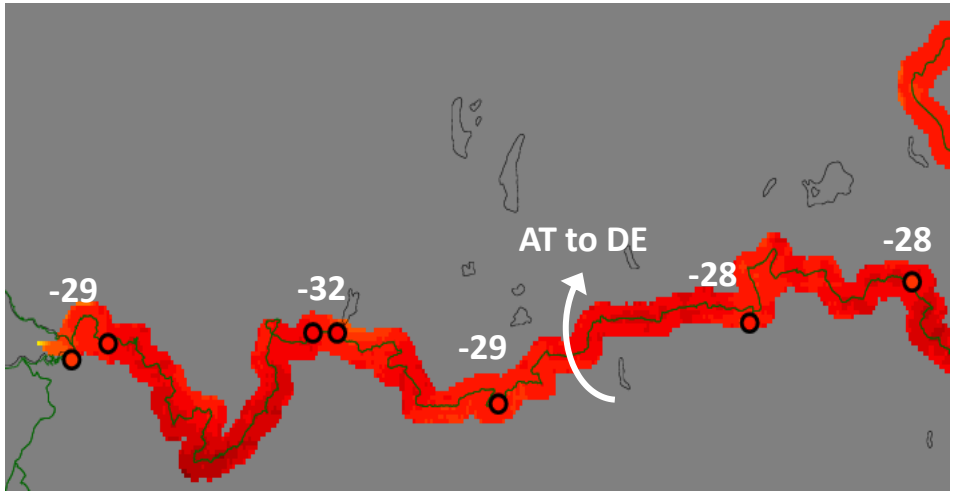
Example: Germany (non-exclusive metadata)

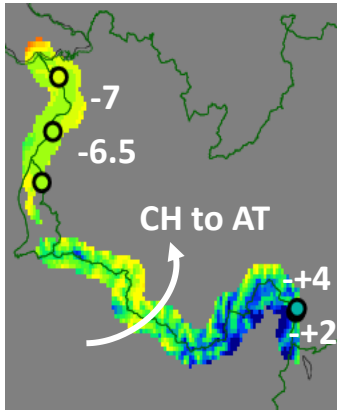
Model name	**GCG2016**
Type	Quasigeoid (hybrid, corrector surface)
Period of validity	2016-12-01 – today
Affiliation	Federal Agency for Cartography and Geodesy (BKG)
First-level contact	dlz@bkg.bund.de / +49 341 5634-333
Second-level contact	quasigeoid@bkg.bund.de
Reference	https://dx.doi.org/10.5675/Raumbezug_2016_Hauptdokument
Height reference frame	DHHN2016
Height type	Normal height
Permanent tide	Mean-tide
Datum	EVRS (72 datum points)
Tide gauge	NAP (Amsterdam)
Epoch	2006 – 2012
Land uplift model (epoch)	None (none)
3D-Position reference frame	ETRS89/DREF91/Realization 2016
Permanent tide	Conventional tide-free
Epoch	2008.459
Transformation parameters to	ETRF2000 (R_X +0.658 mas, R_Y –0.208 mas, R_Z +0.755 mas)
Ellipsoidal heights equivalent to	ETRF2000
Land uplift model (epoch)	None (none)

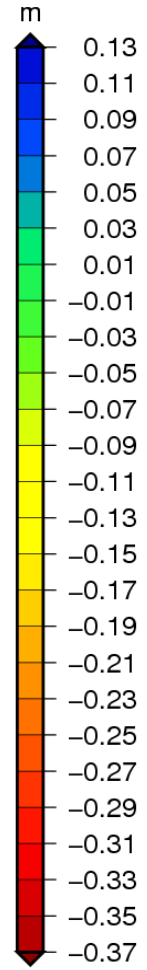
Example for non-EVRS national height systems: Austria and Switzerland
Outcome of the "D-A-CH" geoid and height project

- For *surveying users*, Austria and Switzerland keep to their spherical/uncorrected heights w.r.t. the Adriatic/Mediterranean Sea, respectively
- ➢ Differences at the decimeter scale which also vary along the national borders





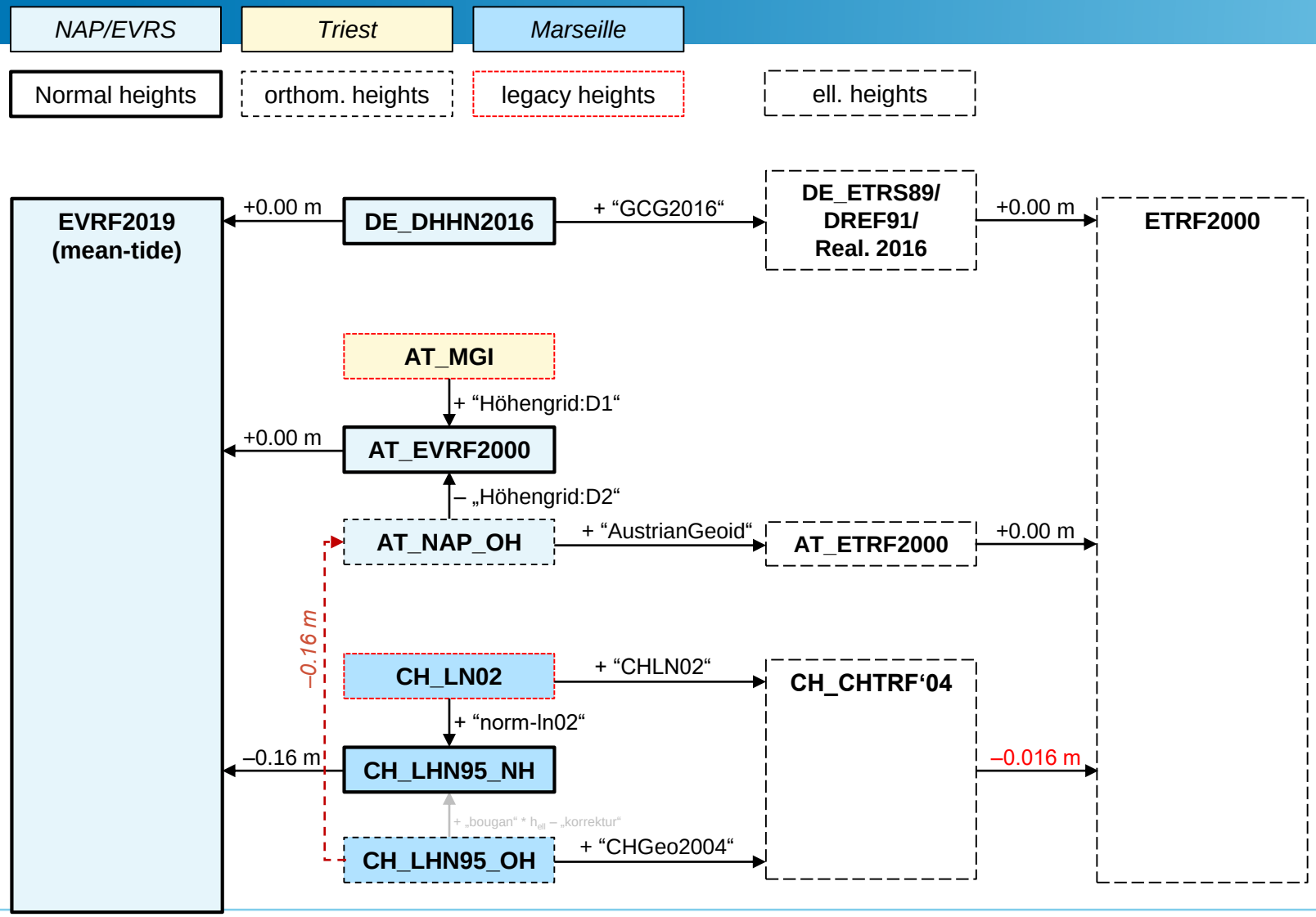




(Schwabe et al. 2021, ↗EGU21-7567)

	Realization	Alias	Height type	Zero level	EVRS
DE	DHHN2016	H.ü.NHN	Normal	NAP	X
AT	MGI	H.ü.Adria	Normal-orthometric	Triest	
CH	LN02		Uncorrected	Marseille	

Example: Simplified D-A-CH height transformation scheme



Preparation of the Working Group

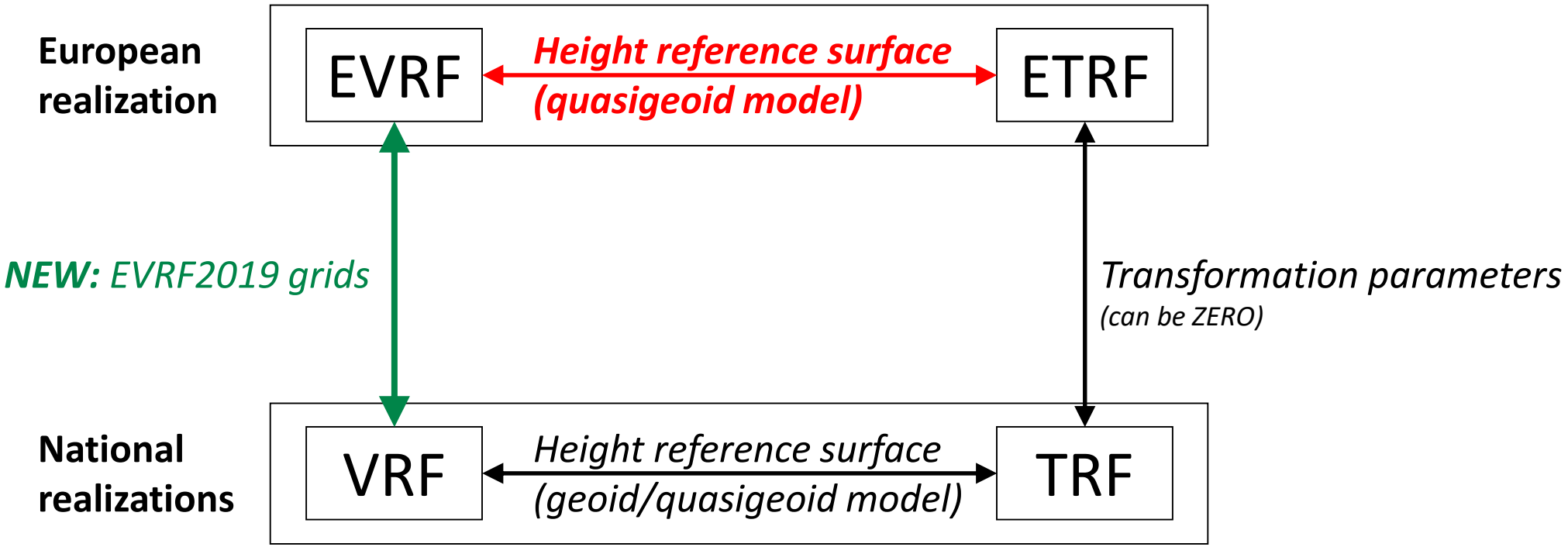
- ✓ Draft WG Charter
- ✓ First member candidates confirmed
- ✓ Approval by the Governing Board
- ➢ **Draft resolution**

- ⌛ Work in progress
  - ➢ *Martina:* **New CRS-EU database structure** conforming ISO 19111 (2019)
    - Including metadata structures for national geoid models
  - ➢ **Questionnaire** about official national height reference grids (2 pages plus 1 page for references and comments)
  - ➢ Coordinated action to extend “D-A-CH geoid project” to European Alps

Currently confirmed member candidates

Joachim Schwabe (BKG, chair)
Martina Sacher (BKG, GB member, chair of UELN)
Heiner Denker (IfE Hannover, observer, advisor)
Ambrus Kenyeres (SGO c/o Lechner Non-profit Ltd., Hungary)
Gunter Liebsch (BKG, Germany)
Urs Marti (swisstopo, Switzerland)
Andreas Hellerschmied (BEV, Austria)
Jonas Ågren (Lantmäteriet/HiG, SWE)
Anders Alfredsson (Lantmäteriet, SWE)
Mirjam Bilker-Koivula (NLS, FI)

Generalized scheme of the integrated spatial reference in Europe



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Thank you for your kind attention!

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