Federal Agency for
Cartography and Geodesy

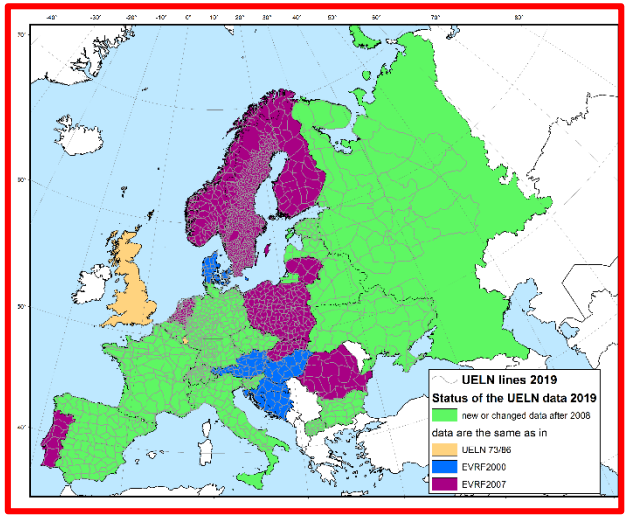
BKG
Wir geben Orientierung.

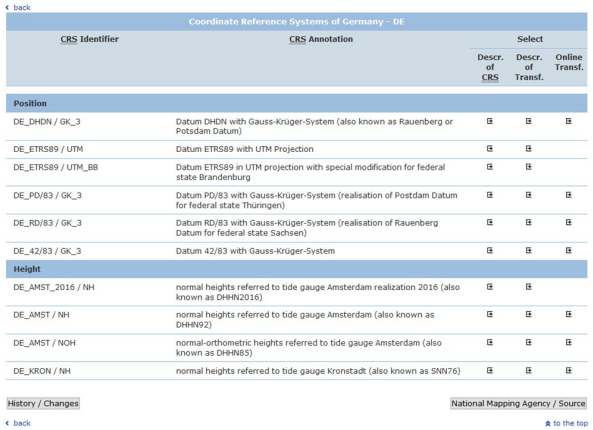
Status of the European Vertical Reference Frame and planned developments

Martina Sacher, Gunter Liebsch, Joachim Schwabe

Content

1. **EVRF2019 release and transformation grids**
2. Revision of CRS-EU
3. EUVN_DA relaunch





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Coordinate Reference Systems of Germany - DE

CRS Identifier	CRS Annotation	Select: Descr. of CRS	Select: Descr. of Transf.	Select: Online Transf.
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DE_DHDN / GK_3	Datum DHDN with Gauss-Krüger-System (also known as Rauenberg or Potsdam Datum)			
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DE_AMST / NOH	normal-orthometric heights referred to tide gauge Amsterdam (also known as DHHN85)			
DE_KRON / NH	normal heights referred to tide gauge Kronstadt (also known as SNN76)			

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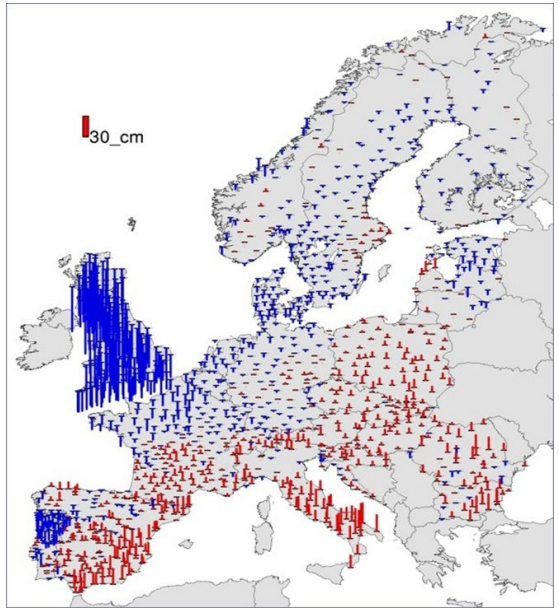
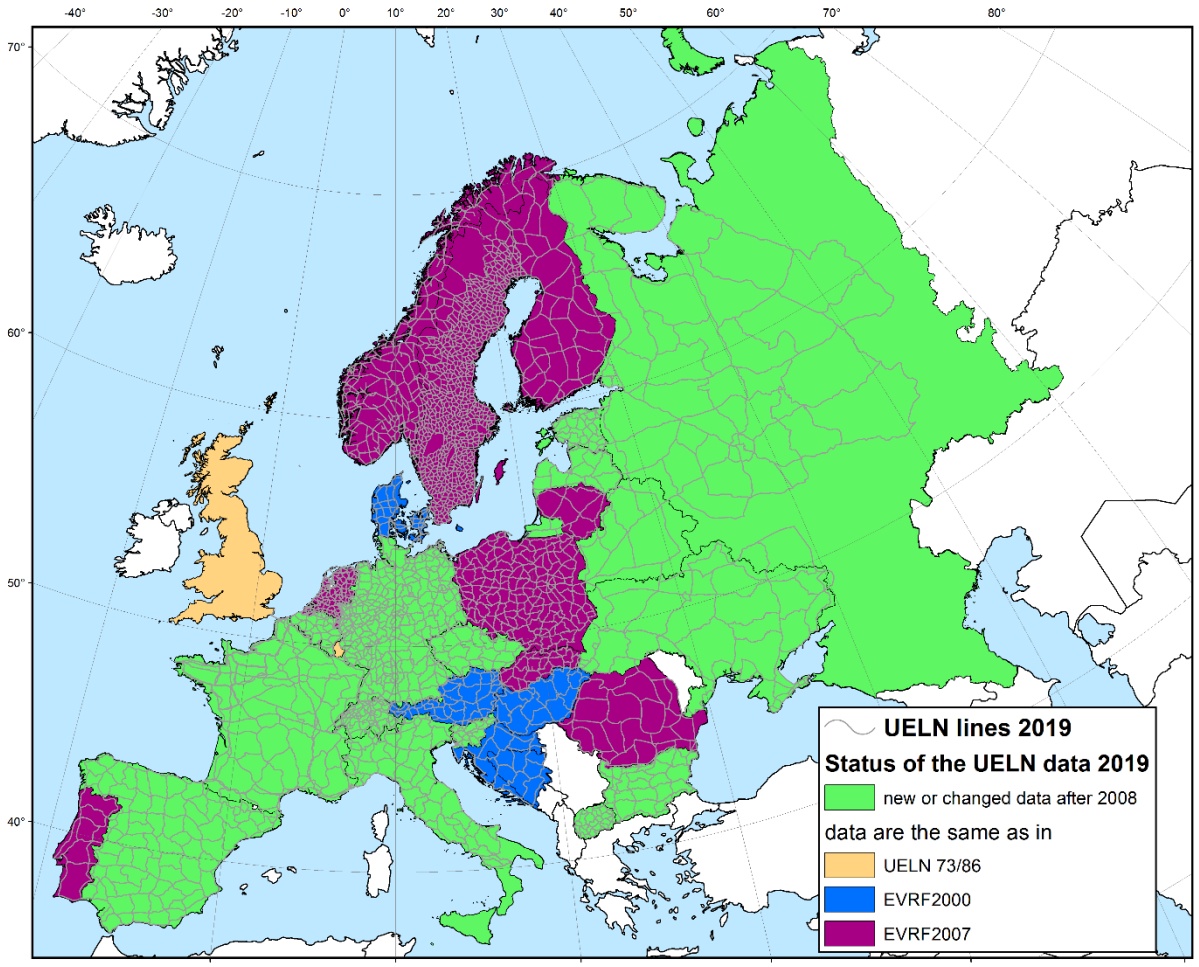
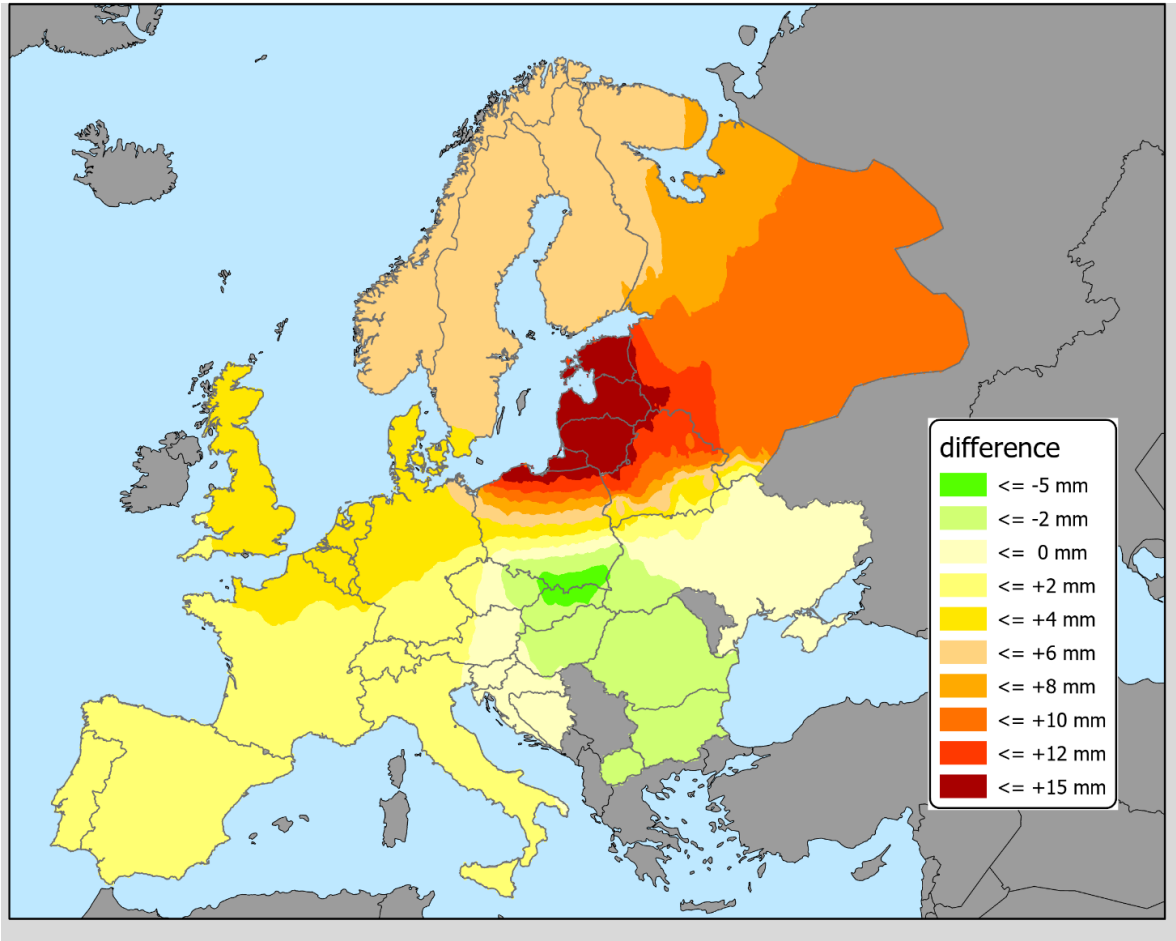


EVRF2019



- New realization of EVRS by UELN adjustment of leveling networks in 30 countries
- New included in UELN:
  - Russia (2012)
  - Belarus (2017)
  - Ukraine (2018)
  - North Macedonia (2019)
- Update of the data of 11 countries
- Small update in 4 further countries
- November 2019: heights were delivered to participating countries
- Heights in EVRF2019 available at https://evrs.bkg.bund.de/ (except BY, RU, UA, HR)

Correction of an error



- In August 2020, an error was detected
- Sign error in the transformation between different tidal systems in Poland
- error caused tilt effect on the adjusted EVRF2019 heights of Poland in the magnitude of 23mm in N-S direction
- On August 27, an updated solution was sent to the participating countries
- On September 07, the data on the EVRS website have been updated

Height changes after correction of EVRF2019

Calculation of transformation parameters

- Information system CRS-EU at http://www.crs-geo.eu/ provides transformation parameters between national vertical reference frames and realizations of EVRS:
  - EVRF2000
  - EVRF2007
  - EVRF2019 (zero tide)
  - EVRF2019 (mean tide)
- 3-Parameter-transformations to EVRF2000 and EVRF2007
- Transformation grids to EVRF2019
- Grids are interpolated using inverse distance weighted technique (IDW)
- For the most countries only the nodal points are available as interpolation points → small grid resolution (0.15 X 0.15 degrees)
- Grids are available as ascii files, readable from GIS tools like QGIS or ArcGIS
- Additional graphics are provided

Agreement to the publication of the transformation parameters

Country	ID	agreement	remarks	Country	ID	agreement	remarks
Austria	AT	yes		Lithuania	LT	yes	
Belarus	BY		letter of acceptance announed, probably lost	Netherlands	NL	yes	corrected national heights
Belgium	BE	yes		North Macedonia	MK	yes	
Bosnia / Hercegovina	BA	yes		Norway	NO		
Bulgaria	BG	yes		Poland	PL	yes	
Croatia	HR			Portugal	PT	yes	
Czech Republic	CZ	(yes)	only 3 parameter transformation and link to national transformation service	Romania	RO	yes	
Denmark	DK		decision in 2021	Russia	RU		
Estonia	EE	yes		Slovak Republic	SK	no	only grids from national transformation will be published in EPSG
Finland	FI	yes		Slovenia	SI	yes	
France	FR	yes		Spain	ES	yes	
Germany	DE	yes		Sweden	SE	yes	
Great Britain	GB	yes		Switzerland	CH	yes	
Hungary	HU	yes		Ukraine	UA		under consideration
Italy	IT			Turkey	TK	yes	transformation calculated from border connections to Bulgaria
Latvia	LV	yes					

31 countries, 23 countries agreed, 4 didn’t made a decision yet, 3 didn’t answer yet, 1 disagreed

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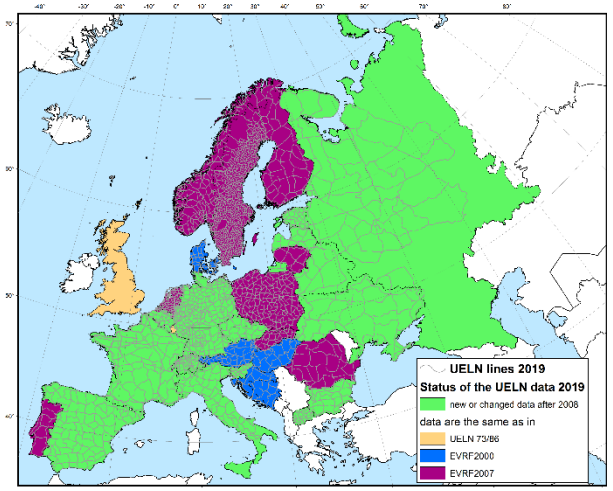

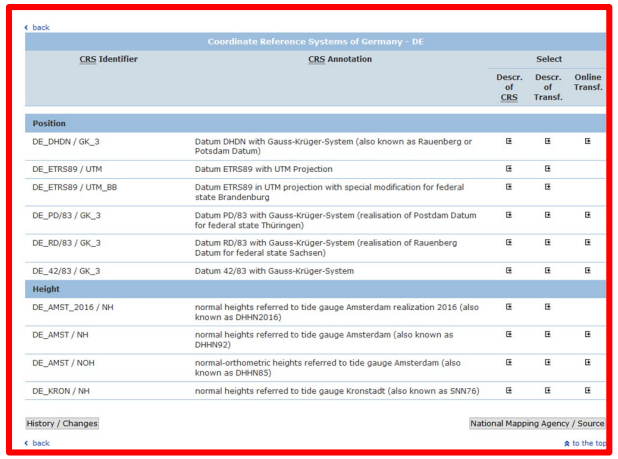

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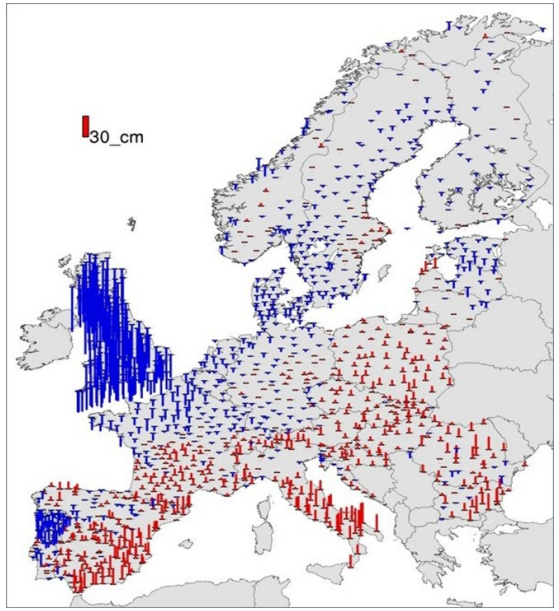

Information system on Coordinate reference Systems in Europe (CRS-EU)

Content for Germany

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http://www.crs-geo.eu

- established in 2000 with the aim of promotion the use of ETRS89
- initially only description of national horizontal CRS + description of transformation to ETRS89
- In 2005 extension to:
  - vertical CRS
  - online Transformation (single point for height, files for position)
- since then no changes at the general structure, only addition of records

Information system on Coordinate reference Systems in Europe (CRS-EU) (2)

Content for position:

- Provision of ETRS89 is no longer necessary
- only a few new entries for horizontal CRS in the last years
- no distinction is made between ETRFs
- No description of national realizations of ETRS

Content for height

- importance of the part of vertical CRS is increased:
- in European countries are many different national vertical CRS in use
- transformations between national VRS and EVRF are necessary for use of EVRS
- since the year 2000, 3 realizations of EVRS + corresponding transformation parameters have been included
- Distinction between different realizations of national VRS

New edition of standard ISO 19111:2019-12 “Geographic information – Referencing by coordinates”

CRS-EU is designed according to ISO 1911-2007-10.

Important modifications in ISO 19111-2019-12:

- Datum ensembles: grouping of different datums with small differences, which are not important for lower accuracy, such as
  - WGS84(G1674), WGS84(G1762)
  - Different realizations of ETRS
  - Kronstadt – Baltic 1957, Kronstadt- Baltic 1982
  - in geo-information: datum = reference frame
- Description of Vertical reference frames
  - Leveling-based
  - Now also possible: Geoid-based
- Possibility to describe geoid/quasigeoid (as transformation)
- Dynamic geodetic reference frames

Revision of the Information system CRS-EU

- Adaption to the new edition of ISO 19111:2019-12
- Focus on vertical reference frames and geoid:
  - Description of vertical reference frames (VRF)
  - Transformations from national VRF to EVRFs (description and online transformation)
  - description of national height reference surfaces (geoid/quasigeoid)
  - Description of realizations of ETRS89 – compatible with the respective VRF and geoid
- What about older national reference frames for position?
  - They are usually described in EPSG
  - NMAs should decide, which particular old national CRS should be kept in CRS-EU
- ISO-Standard describes the minimum content for the description of coordinate reference systems for the purpose of GI, but we are allowed to publish additional information for geodesy, e.g.:
  - Kind of heights (normal, orthometric…), tidal systems, EPSG code…

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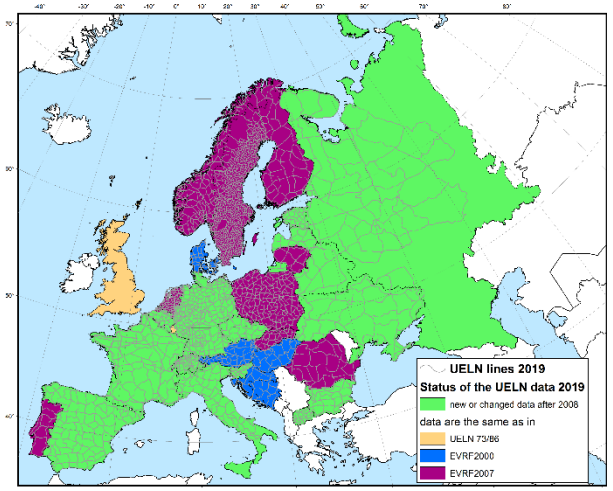

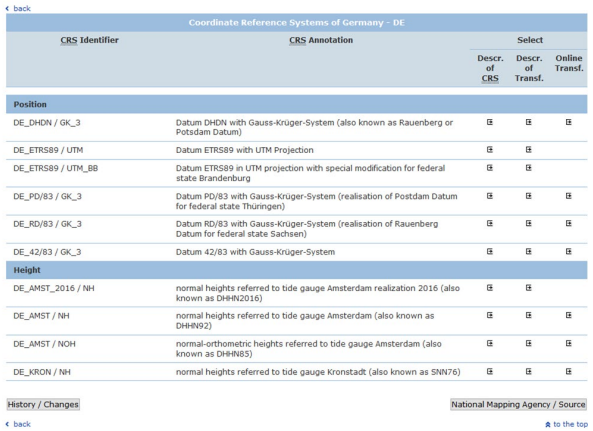

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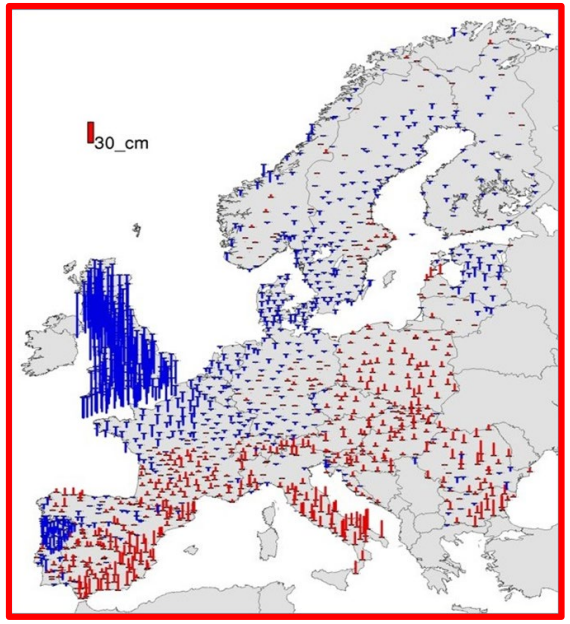
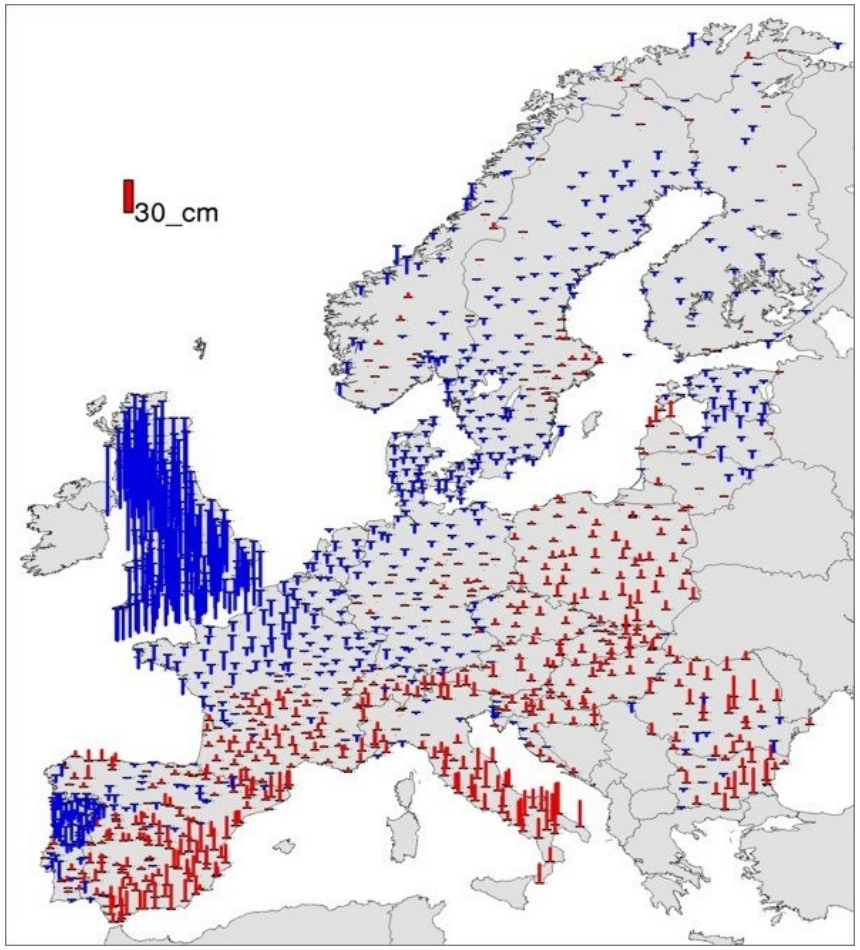


Relaunch of EUVN_DA project



Height anomaly differences of EUVN_DA and EGG08.
Figure from the final report.

original **EU**ropean **V**ertical reference **N**etwork project:

- GNSS campaign with 200 sites in 1996
- heights in EVRF2000
- compared with EGG97

Densification **A**ction:

- start of EUVN_DA with resolution No. 4 in Dubrovnik 2001
- Dense European GNSS/leveling network
- Analyzing gravimetric and GNSS/leveling geoid differences
- realization of a European height reference surface (HRS), consistent with ETRS89 and EVRF2000/2007
- first data delivered in 2003
- ca. 1400 GNSS/leveling points in 25 countries
- Tilt and/or large offsets in some countries: GB, IT, PT, ES, FR
- final report 2010

Available Data in EUVN_DA

Country	connection to UELN	new national level. Data	date of GNSS campaign	Country	connection to UELN	new national level. Data	date of GNSS campaign
AT	D		1994, 2000	HU	D		2003
BA	no data available			IT	T	x	1992-96/2007
BE	D	x	2005	MK		x	
BG	D	x	2004	LV	T	x	1993
BY		x		LT	D		1997/2000
CH	D	x	1998	NL	D		1998/2002
CZ	D	x	2007	NO	D	(x)	1994-1996
DE	D	x	2008	PL	D		1999
DK	D		2001	PT	T		2006
ES	T	x	1994/2001	RO	D		2007
EE	D	x	1997	RU		x	
FR	D	(x)	1994	SE	D		1999.5
FI	D		2005	SK	D		1993-2003
GB	T		1999	SI	D	x	1997/2006
HR	D		various	UA		x	

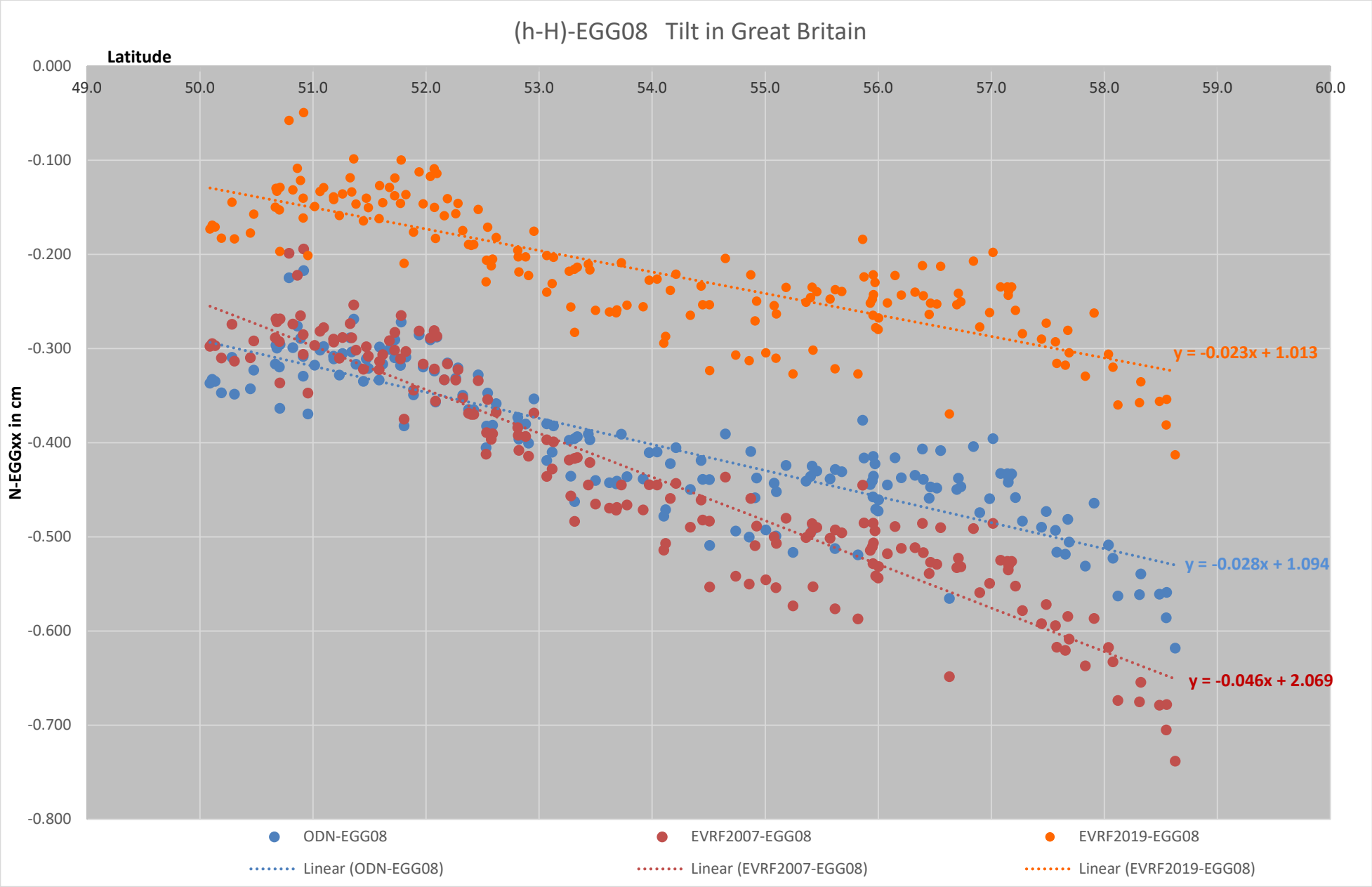
new country with EVRF heights

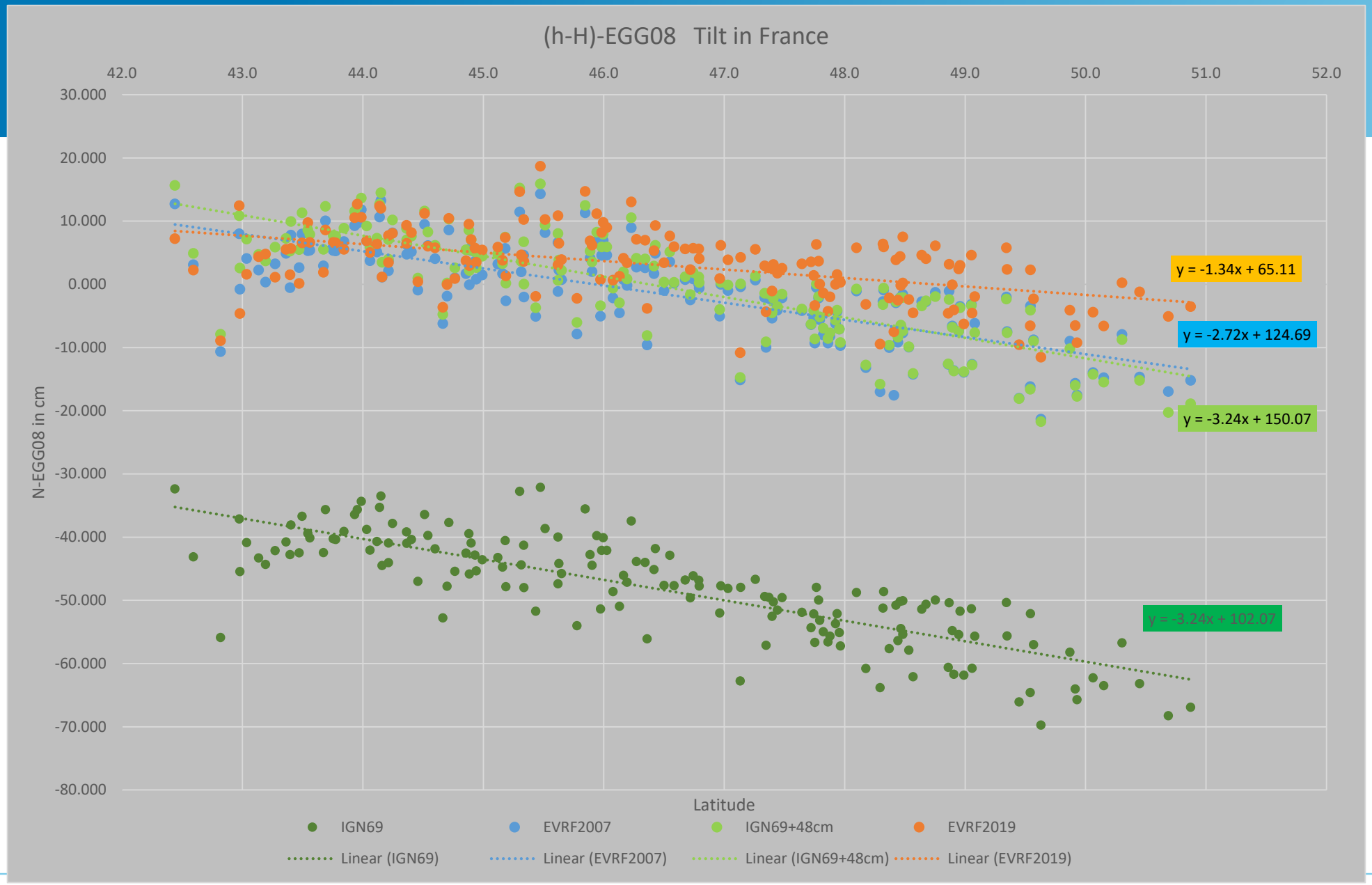
leveling data transformed to EVRF2007

- 5 countries without any data in EUVN_DA
- Average age of the GNSS data: 20 years – more recently data available?
- 11 countries with new leveling data
- 4 countries with EVRF data calculated by transformation only

Changes in EUVN_DA results after change from EVRF2007→ EVRF2019

	EVRF2007/EGG08				EVRF2019/EGG2015			
	number of sites	average diff.	RMS[cm]	MAX-MIN	number of sites	average diff.	RMS[cm]	MAX-MIN
Austria	17	5	5	16	13	3	4	14
Belgium	9	-5	3	8	9	-5	2	7
Bulgaria	26	8	8	27	19	6	3	10
Croatia	20	7	7	12	20	8	4	14
Czech Rep.	22	2	4	12	19	0	4	13
Denmark	41	-6	2	9	40	-6	2	8
Estonia	26	-5	4	14	12	-4	2	7
Finland	50	-2	2	8	47	-4	2	9
France	168	-1	7	32	164	3	5	31
Germany	85	-2	3	13	358	0	2	12
Great Britain	189	-43	12	48	181	-22	7	36
Hungary	20	6	3	9	22	6	3	12
Italy	195	11	12	47				
Latvia	19	-1	7	28	20	-3	5	11
Lithuania	9	2	3	9	8	-1	3	9
Netherlands	17	-6	2	7	15	-5	2	6
Norway	63	-3	5	21	62	-3	4	21
Poland	52	7	3	12	60	3	2	8
Portugal	81	-7	7	27	76	-2	6	24
Romania	43	6	8	30	38	7	8	29
Slovakia	28	4	3	9	23	4	3	12
Slovenia	13	3	3	11	6	4	4	10
Spain	30	4	7	33	31	-1	8	32
Spain	142	7	8	36	140	1	8	41
Switzerland	20	3	5	19	20	1	4	18
Sweden	136	-3	3	15	128	-3	2	11


(h-H)-EGG08 Tilt in Great Britain
Latitude
0.000
-0.100
-0.200
-0.300
-0.400
-0.500
-0.600
-0.700
-0.800
49.0
50.0
51.0
52.0
53.0
54.0
55.0
56.0
57.0
58.0
59.0
60.0
N-EGGxx in cm
y = -0.023x + 1.013
y = -0.028x + 1.094
y = -0.046x + 2.069
ODN-EGG08
EVRF2007-EGG08
EVRF2019-EGG08
Linear (ODN-EGG08)
Linear (EVRF2007-EGG08)
Linear (EVRF2019-EGG08)


(h-H)-EGG08 Tilt in France
42.0
43.0
44.0
45.0
46.0
47.0
48.0
49.0
50.0
51.0
52.0
30.000
20.000
10.000
0.000
-10.000
-20.000
-30.000
-40.000
-50.000
-60.000
-70.000
-80.000
N-EGG08 in cm
Latitude
y = -1.34x + 65.11
y = -2.72x + 124.69
y = -3.24x + 150.07
y = -3.24x + 102.07
IGN69
EVRF2007
IGN69+48cm
EVRF2019
Linear (IGN69)
Linear (EVRF2007)
Linear (IGN69+48cm)
Linear (EVRF2019)

Next activities

Query for new GNSS/leveling data will be sent out

BKG:

- Current content of EUVN_DA (status 2010)
- EVRF2007→ EVRF2019

Countries:

- No data supplied to EUVN_DA so far? (BA, BY, MK, RU, UA) → Invitation to participate in the project
- New GNSS/leveling sites available ?
- Update of GNSS data possible?
- If new national leveling data exist: please provide updated connections to UELN points
- If EVRF leveling heights were calculated by transformation: Please provide connections to UELN points
- France: please provide connections to NIREF

Federal Agency for
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Thank you for your kind attention!

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