Federal Agency for
Cartography and Geodesy

The European Vertical Reference System (EVRS) – development and latest results

Martina Sacher

Development toward a European height system

Central European Triangulation (1864 – 1890)

48 levelling loops, 42 tide gauges, Difference NAP– TG Genoa: -32cm

United European Leveling Network - UELN-55 (1954 – 1963)

(UELN, REUN) Western Europe; NAP, geopotential numbers
Final report 1963

UELN-73 (1971-1986)

Western Europe, wide meshed networks; Realization UELN 73/86

EPNN: Unified Precise Leveling Network of Eastern Europe

Common levelings and adjustments 1954 and 1978

UELN-95 (1995-1999)

Extension to the East, full 1. Order networks; Realization UELN-95/98

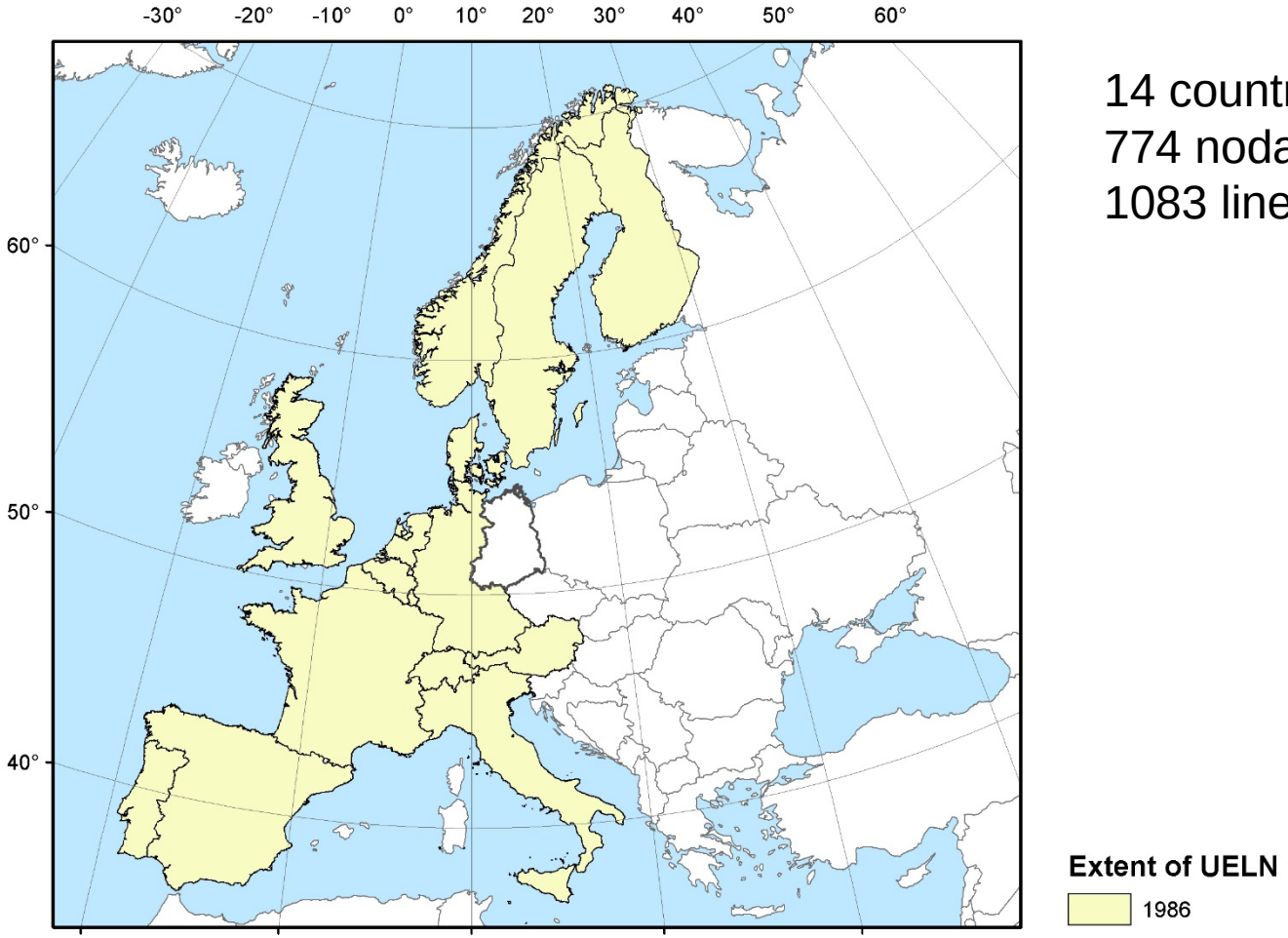
EVRF2000

Extension of UELN-95/98 by EE, LT, LV, RO; Results not distributed

EVRF2007 (2000-2008)

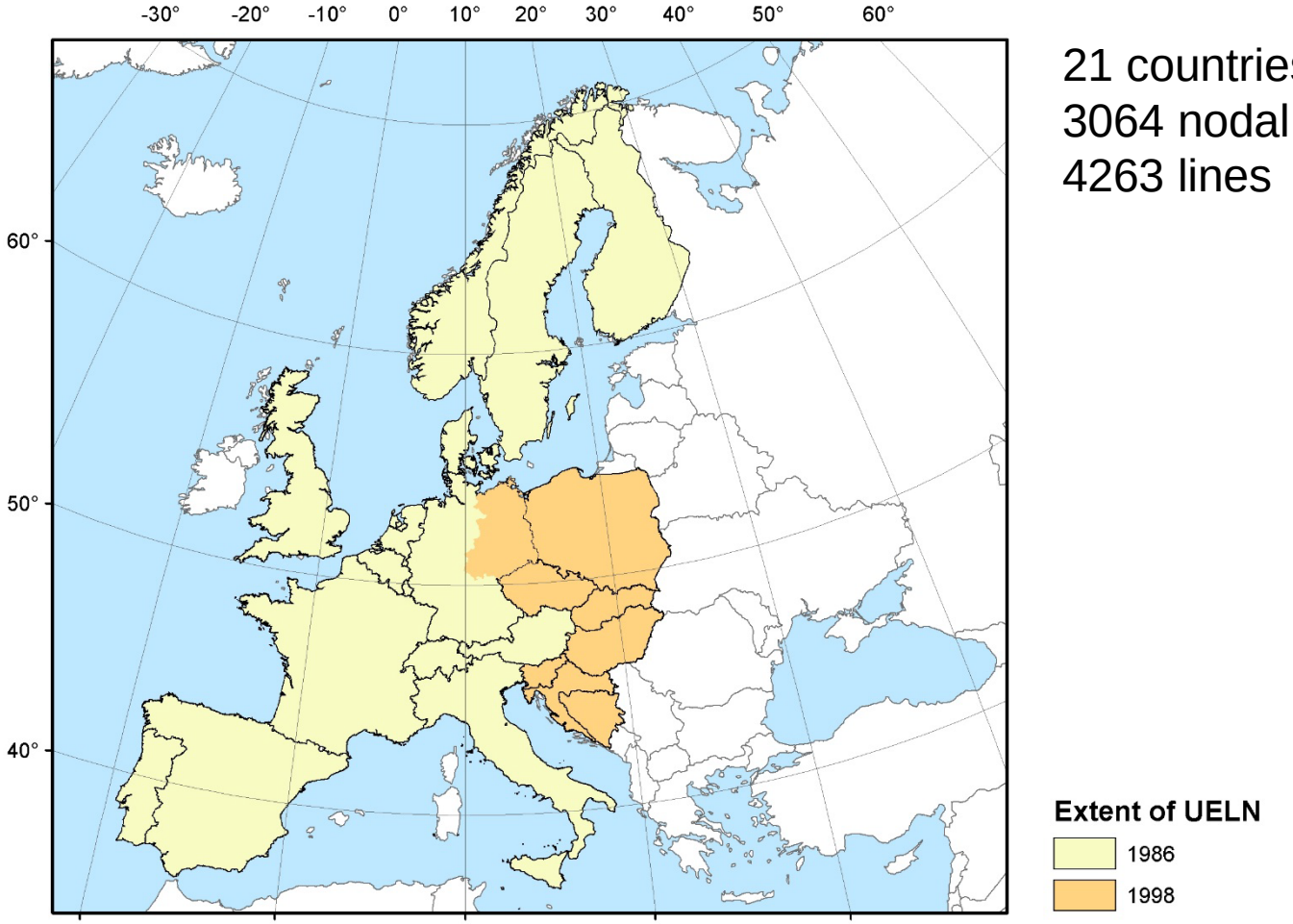
Adopted 2008 in Brussels; results distributed end of 2008

Extent of UELN-73/86



14 countries
774 nodal points
1083 lines

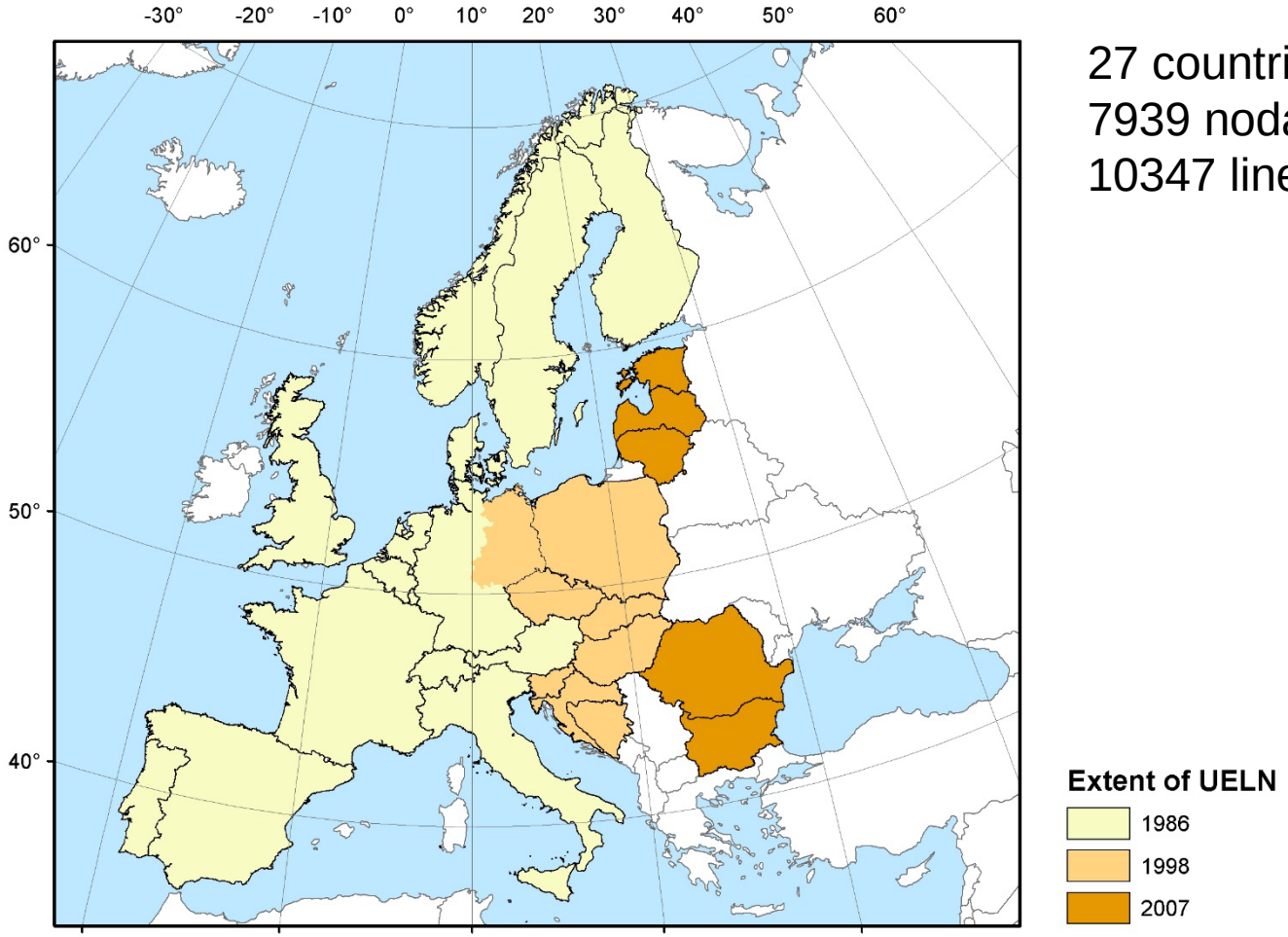
Extent of UELN-95/98



21 countries
3064 nodal points
4263 lines

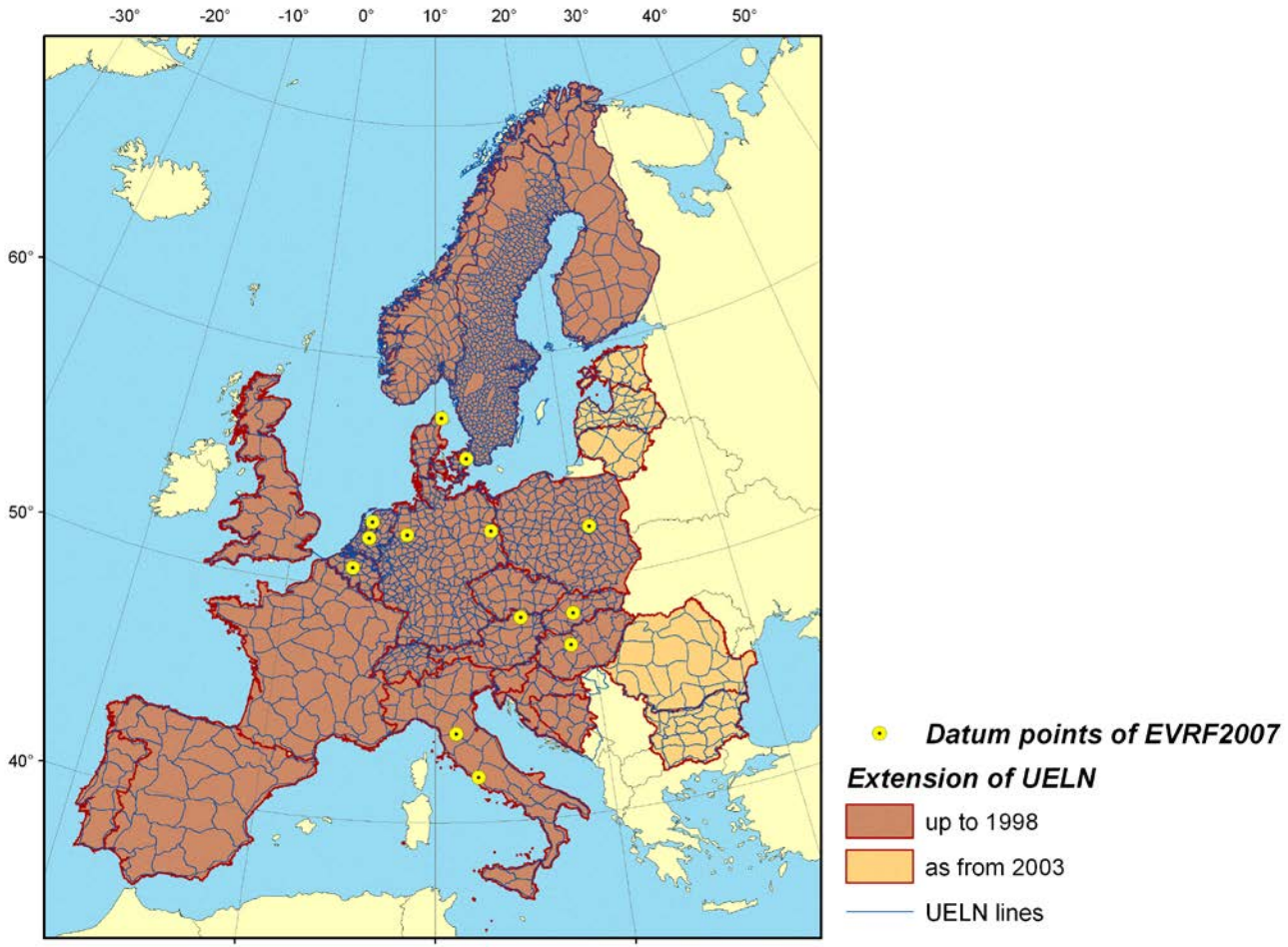
Federal Agency for Cartography and Geodesy

Extent of EVRF2007



27 countries
7939 nodal points
10347 lines

Realization EVRF2007



- 27 countries
- Free adjustment with 13 datum points:

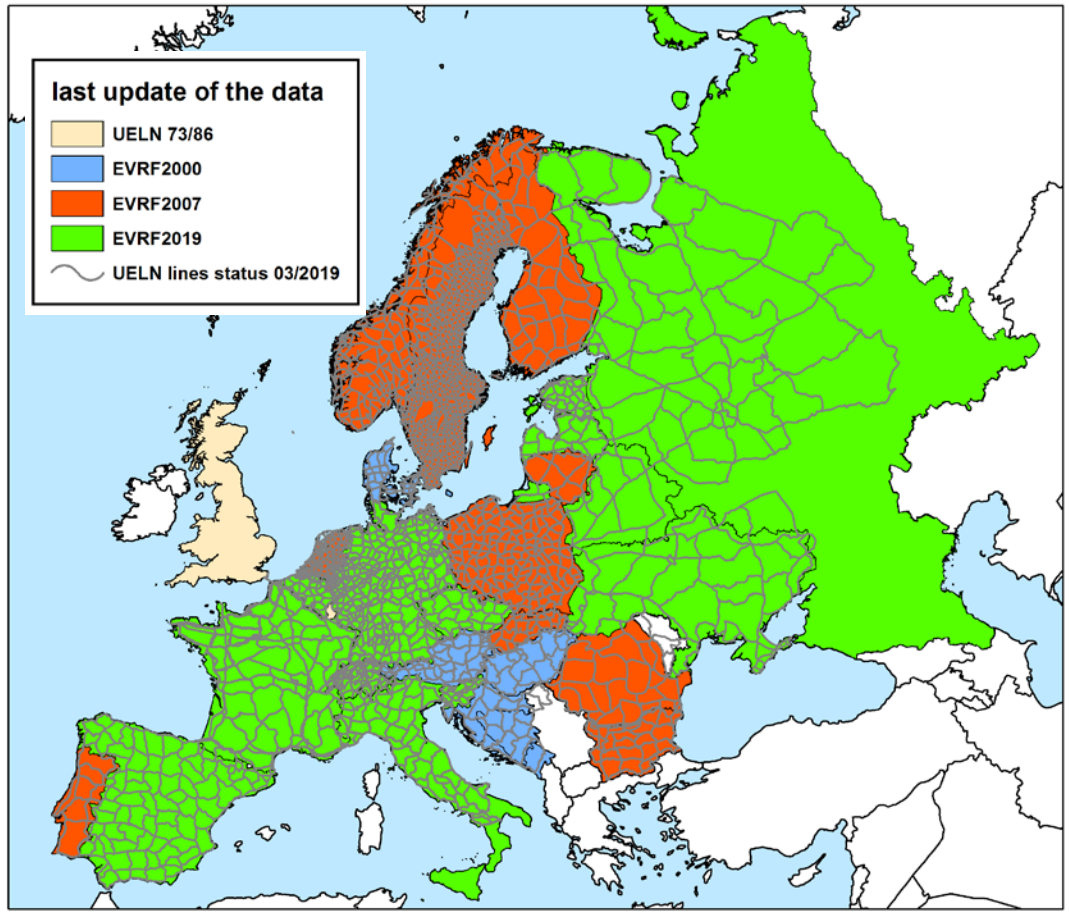
$$\sum_{i=1}^{13}(c_{UELN\,95/98} - c_{EVRS\,2007}) = 0$$

- 7939 nodal points
- 10347 lines
- s_0 = 1.11 kgal·mm
- Adopted 2008 in Brussels

EVRS: Definition and Realizations

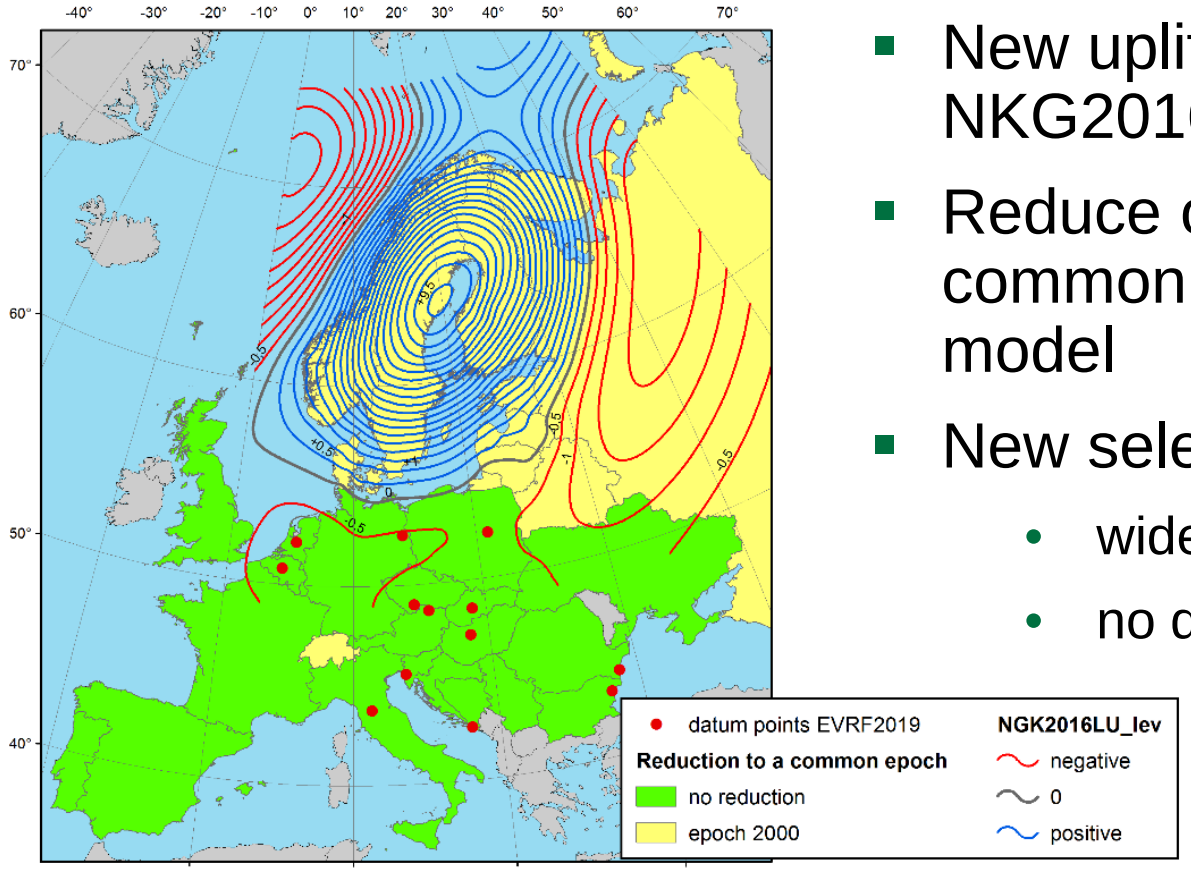
System / Realization	description	datum	kind of heights	tidal system	reduction to a common epoch
EVRS	gravity related height reference system	$W_0=W_{0E}$=const., level NAP	Geopotential numbers: $-\Delta W_P = c_P = W_{0E} - W_P$ normal heights are equivalent (specification of reference gravity field)	zero tide	kinematical system
EVRF2000		1 datum point: 000A2530	normal gravity field of GRS80	no reductions: mean tide	FI, NO, SE reduced to epoch 1960
EVRF2007		13 datum points with their geopotential numbers of UELN-95/98		zero tide	FI, NO, SE, DK, EE, LT, LV, parts of DE, PL reduced to 2000 by NKG2005LU
EVRF2019		13 datum points with their geopotential numbers of EVRF2007		zero tide; mean tide additionally	BY, DK, EE, FI, LT, LV, NO, RU, SE reduced to 2000 by NKG2016LU_lev, CH reduced to epoch 2000 by Swiss model

Next realization of EVRS – EVRF2019 (1)



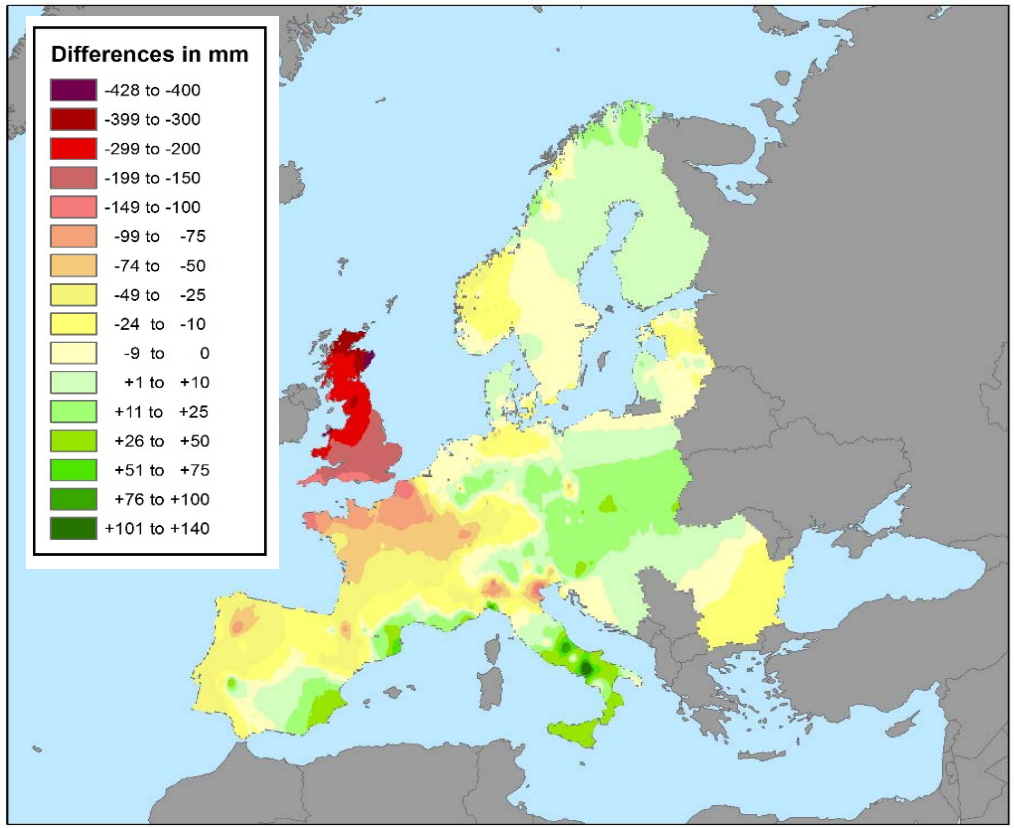
- Update of the leveling networks of 13 countries since 2008
- Extension of the network to Russia, Belarus and Ukraine
- Computation of the heights for Great Britain
  - UELN(GB)= H(ODN)+ offset + conversion from mean tide to zero tide
  - Offset computed from adjustment + measurement through the channel tunnel

Next realization of EVRS – EVRF2019 (2)



- New uplift model for the Nordic countries NKG2016LU_lev
- Reduce of the Swiss measurements to a common epoch by velocities of Swiss uplift model
- New selection of datum points
  - widely distributed,1 point per country
  - no datum points in area of vertical land movements
    - no datum points in countries with known systematic tilts or big differences to the former realization

Comparison EVRF2007 - EVRF2019



Parameter	EVRF2007	EVRF2019
Number of datum points:	13	13
Number of unknowns:	7942	10698
Number of measurements:	10354	13540
Number of condition equations:	1	1
Degrees of freedom:	2413	2843
A-posteriori standard deviation referred to 1 km levelling distance in kgal·mm:	1.11	1.10
Mean value of the standard deviation of the adjusted geopotential numbers (heights), in kgal·mm:	16.00	19.34
Average redundancy:	0.233	0.210

Results of variance component estimation

Country / group	EVRF2007		EVRF2019		Country / group	EVRF2007		EVRF2019	
	number of observations	s_0 [kgal·mm] (1 km)	number of observations	s_0 [kgal·mm] (1 km)		number of observations	s_0 [kgal·mm] (1 km)	number of observations	s_0 [kgal·mm] (1 km)
Austria	167	0.82	**160**	**0.94**	Czech Republic new			**185**	**0.77**
Belgium	63	1.24	**113**	***0.55***	Czech Republic old	100	1.16	**83**	**1.31**
Switzerland	413	1.09	**718**	**0.91**	Hungary	82	0.47	**83**	**0.49**
Germany	846	0.85	**1112**	**0.66**	Croa.,Bosn./Hc	112	0.90	**81**	**1.08**
Denmark	194	0.91	**196**	**0.85**	Slovenia			**67**	**0.50**
Spain	110	1.75	**227**	**2.38**	Poland	456	0.88	**473**	**0.87**
France	348	2.02	**344**	***3.08***	Slovakia	214	1.55	**196**	**1.48**
France (NIREF)			**1223**	**1.39**	Romania	90	1.75	**133**	**1.80**
Italy	110	1.75	**202**	**1.20**	Estonia	78	1.30	**418**	**0.23**
Netherlands	1424	0.75	**1373**	**0.75**	Latvia	159	1.72	**151**	**0.85**
Portugal	30	2.09	**30**	**2.01**	Lithuania	72	0.87	**64**	**0.74**
Great Britain	60	1.72	**4**		Bulgaria	109	1.14	**109**	**1.15**
Norway new	360	1.33	**489**	**1.34**	Russia			**176**	**2.21**
Norway old	341	1.57	**410**	**1.44**	Belarus			**31**	**2.19**
Finland	262	0.73	**272**	**0.74**	Ukraine			**211**	**1.71**
Sweden	4154	1.00	**4206**	**1.00**	**Total**	**10566**	**1.11**	**13540**	**1.10**

new data after 2008
small update after 2008

Next steps

- Preliminary solution and report about EVRF2019 have been sent to participating countries in March 2019
- EVRF2019 is expected to be adopted at EUREF symposium May 2019 in Tallinn
- Some small data additions after EUREF symposium → providing of the final results in autumn 2019
- Questionnaire about handling of the data of EVRF2019 was sent to participating countries:
  - Results of EVRF2007 had been distributed only to participating countries
  - Publishing heights of EVRF2019 on website?
  - Height and gravity in the past confidential data
  - Evaluation of the results at the EUREF symposium in May

Application of EVRS

- INSPIRE:
  - For the vertical component on land, the EVRS shall be used to express gravity related heights within its geographical scope
- National vertical reference systems can still be used
- Direct use of points (1. order) with heights in EVRF for cross-border projects
- Use of transformations national heights → heights in EVRF
  - http://www.crs-geo.eu
  - Future: transformation grid
- Goal for the future: Possibility to compute physical heights from GNSS measurements + European quasi-geoid model
- Fitting the gravimetric European quasi-geoid to GNSS/leveling points
- update of EUVN_DA

Information system about Coordinate Reference Systems in Europe

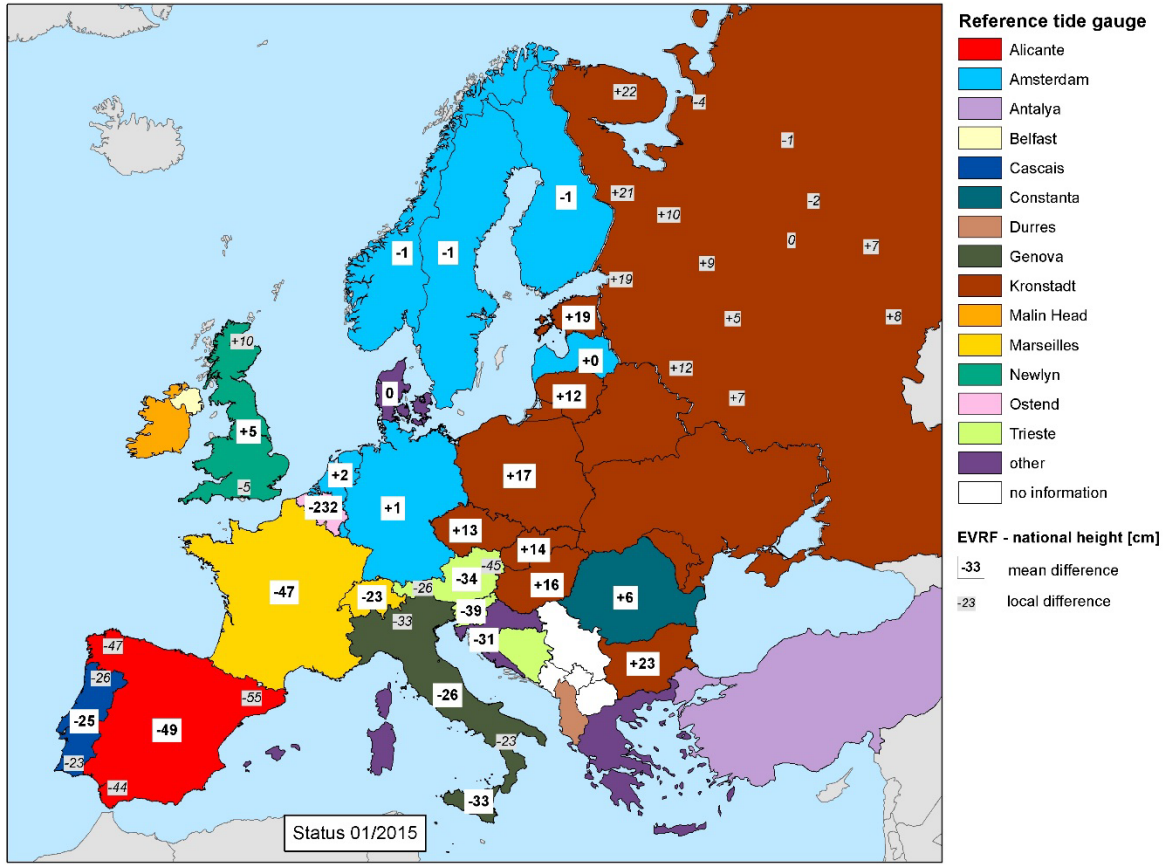
http://www.crs-geo.eu

Part for height:

- Description of height reference systems in Europe
- transformation parameters from national height reference frame to EVRF2007

After adoption of EVRF2019:

- New parameters
- Transformation grids



Thank you for your kind attention!

Contact:

Federal Agency for Cartography and Geodesy
Section G3
Karl-Rothe-Str. 10-14
04105 Leipzig, Germany

contact person
Martina Sacher
martina.@bkg.bund.de
www.bkg.bund.de
Tel. +49 (0) 341 5634-423