



EVRF2007

as Realization of the European Vertical Reference System

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1. Objectives of EVRF2007

EUREF- Symposium 1994 in Warsaw, Resolution No.3:

- Establishing of a Unified vertical datum for Europe at the 1-dm level (CERCO)
- Providing of first results January 1999 – UELN 95/98
- First EVRS Definition Tromsø 2000, realization: EVRF2000

9th EC GI-GIS conference June 24-26 2003, La Coruna:

- Need for harmonization of vertical reference of spatial coordinates

1. Objectives of EVRF2007 (2)

Workshop (EC, EuroGeographics)
„Vertical Reference Systems for Europe“
April 5-7 2004, Frankfurt:

- Consideration of user requirements in Europe
- Realization of an up-to-date European height reference frame
- Continuation of the previous development of EVRS
- Guarantee of a 1 cm accuracy level for datum and network realization
- Alignment to IVRS/WHs

2. EVRS Definition (1)

The European Vertical Reference System (EVRS) 2007 is a kinematical height reference system. The EVRS definition fulfils the following four conventions:

1. The vertical datum is defined as the equipotential surface for which the Earth gravity field potential is constant:

$$W_0 = W_{0E} = \text{const.}$$

And is in the level of the Noormals Amsterdam Peil.

2. The unit of length of the EVRS is the meter (SI). The unit of time is second (SI). This scale is consistent with the TCG time coordinate for a geocentric local frame, in agreement with IAU and IUGG (1991) resolutions. This is obtained by appropriate relativistic modelling.

2. EVRS Definition (2)

3. The height components are the differences ΔW_P between the potential W_P of the Earth gravity field through the considered points P and the potential of the EVRS conventional zero level W_0 . The potential difference ΔW_P is also designated as geopotential number c_P :

$$-\Delta W_P = c_P = W_{0E} - W_P.$$

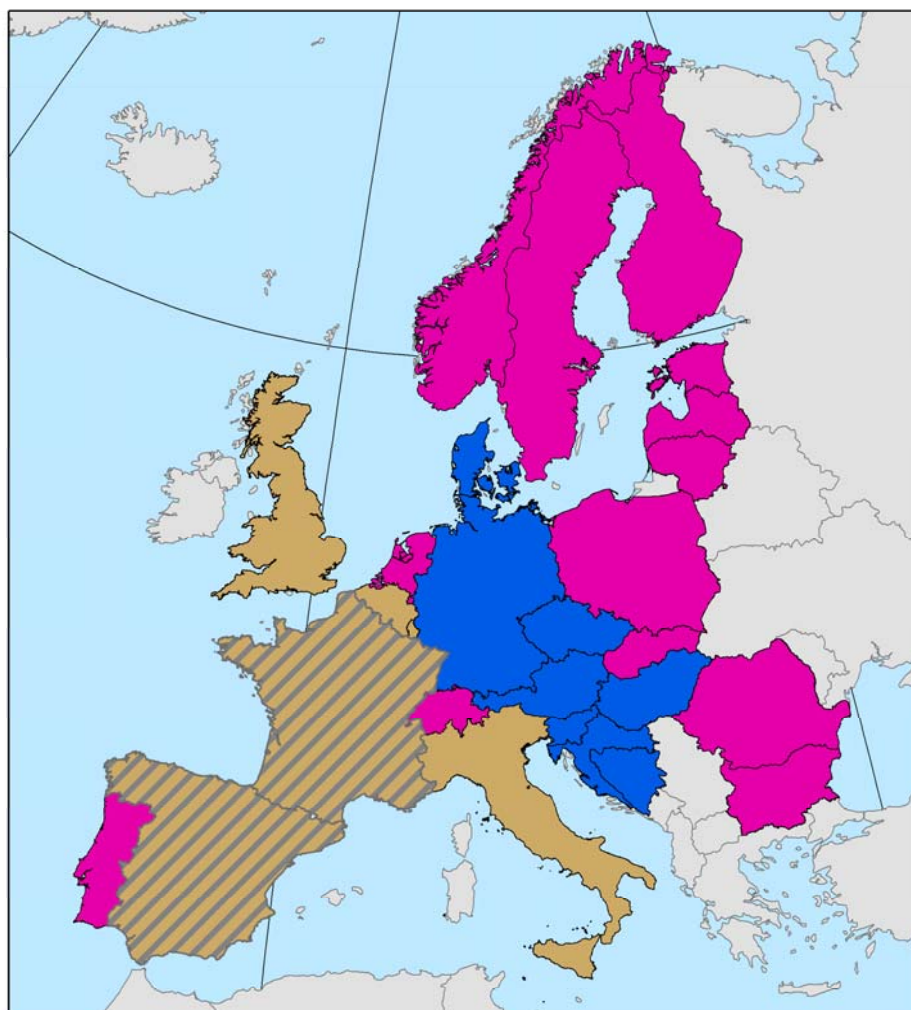
The metric equivalent is the normal height.





4. The EVRS is a zero tidal system, in agreement with the IAG Resolution No 16 adopted in Hamburg in 1983.

New data of 14 countries since 1999:

- | | |
|--------------------------|-------------------------|
| • Estonia (1999) | new part of the network |
| • Latvia (1999) | new part of the network |
| • Romania (2000) | new part of the network |
| • Lithuania (2001) | new part of the network |
| • Switzerland (2002) | update |
| • Bulgaria (2003) | new part of the network |
| • the Netherlands (2005) | update |
| • Finland (2005) | update |
| • Norway (2005) | update |
| • Sweden (2005) | update |
| • Slovakia (2007) | update |
| • Lithuania (2007) | update |
| • Poland (2007) | update |
| • Portugal (2007) | update |

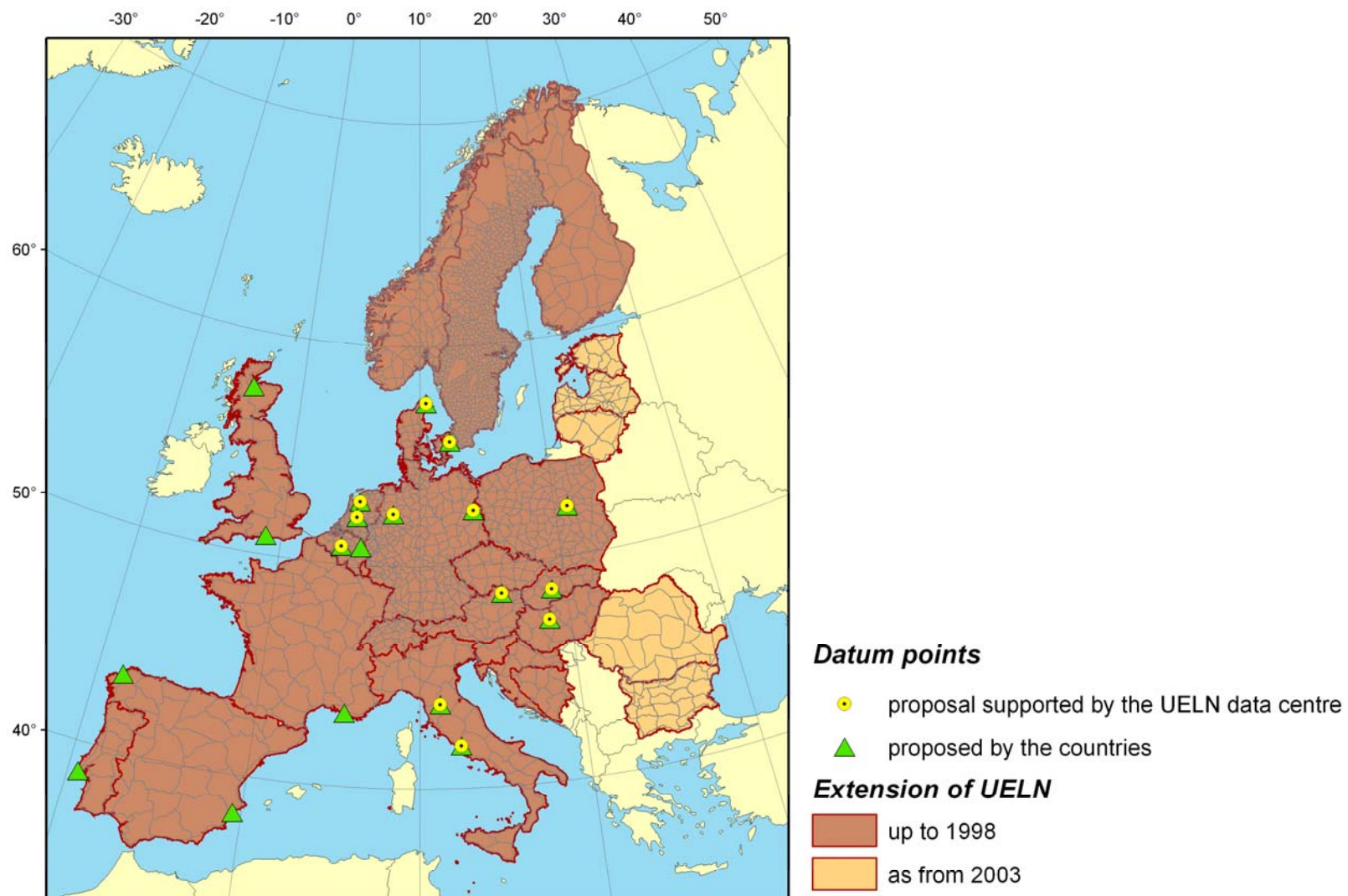
Status of UELN data August 2007



-  data part of UELN 73/86
-  data part of UELN 95/98
-  data provided after 1998
-  new data announced

- Realization of the datum of EVRF2000
 - Reference point *000A2530 in the Netherlands*
- Realization of the datum of EVRF2007
 - Several datum points distributed over the stable part of Europe
 - Participating countries were asked to propose stable points
 - 19 points were proposed
 - 13 points have been used $\sum_{i=1}^{13} (c_{EVRS2000} - c_{EVRS2007}) = 0$
 - Points of Great Britain, France, Spain and Portugal weren't used because of expected height changes in the area after the planned including of new measurements of France and the connection between F and UK
 - Only 2 of 3 proposed points of NL were used (for the reason see the report)

Proposed datum points



3.3 Epoch of the measurements

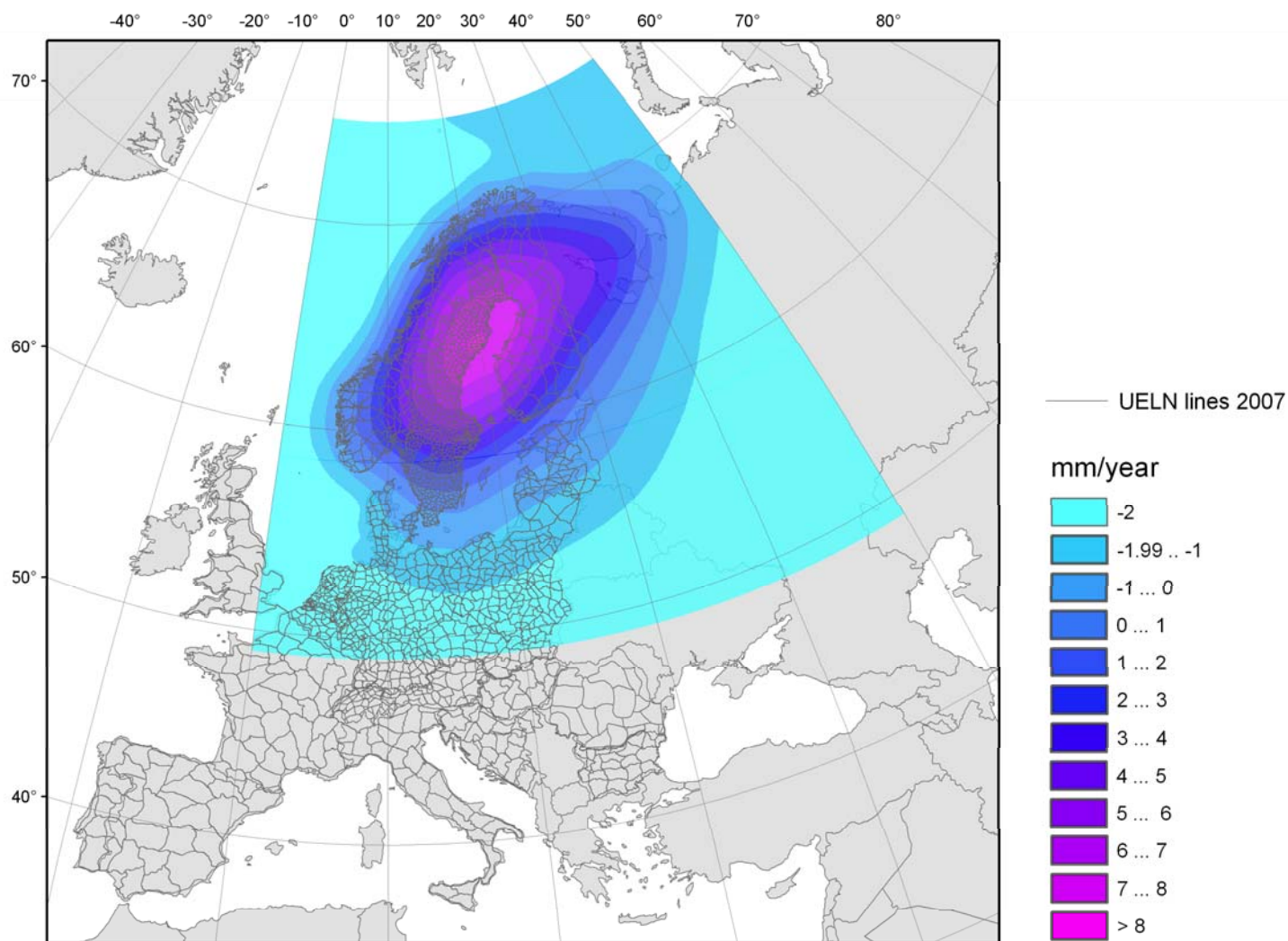
EVRF2000:

- Measurements of Finland, Norway and Sweden had been reduced to the epoch 1960
- All other data had not been reduced to a common epoch

EVRF2007

- Reduction to the epoch 2000 by the land uplift model [NKG2005LU](#) (Ågren and Svensson)
- 3 modalities of reduction:
 - a) only the data of Finland, Norway and Sweden
 - b) Finland, Norway, Sweden and additional Denmark
 - c) all data located in the validity area of the model (just as in the BLR2000 adjustment) **final variant**
- Assumption: datum points have velocity zero

NKG2005LU and UELN lines



3.4 Tidal reductions

EVRF2000:

- EVRS defined as zero tidal system
- no reductions were applied - in practice mean tidal system

EVRF2007

- Reduction of the geopotential differences by

$$\Delta C_Z = \Delta C_M - 0.28841 \cdot (\sin^2 \varphi_2 - \sin^2 \varphi_1) - 0.00195 (\sin^4 \varphi_2 - \sin^4 \varphi_1)$$

in kgal·m

Treatment of the datum points:

- a) $C_{dp2007} = C_{dp95/98} - 0.28841 \cdot \sin^2 \varphi - 0.00195 \cdot \sin^4 \varphi + 0.09722$ [kgal·m]
Corrections range between –0.014 (E) and –0.108 (DK)
kgal·m.

- b) Additionally transformation by +0.08432 kgal·m, the tidal reduction of the datum point of EVRF2000 with opposite sign:

$$C_{dp2007} = C_{p95/98} - 0.28841 \cdot \sin^2 \varphi - 0.00195 \cdot \sin^4 \varphi + 0.09722 + 0.08432$$

[kgal·m]

Points with the same latitude as the former datum point 000A2530 have the tidal reduction 0

Corrections range between +0.070 (E) and –0.024 (DK)
kgal·m. **final variant**

4. Summary of the adjustment parameters

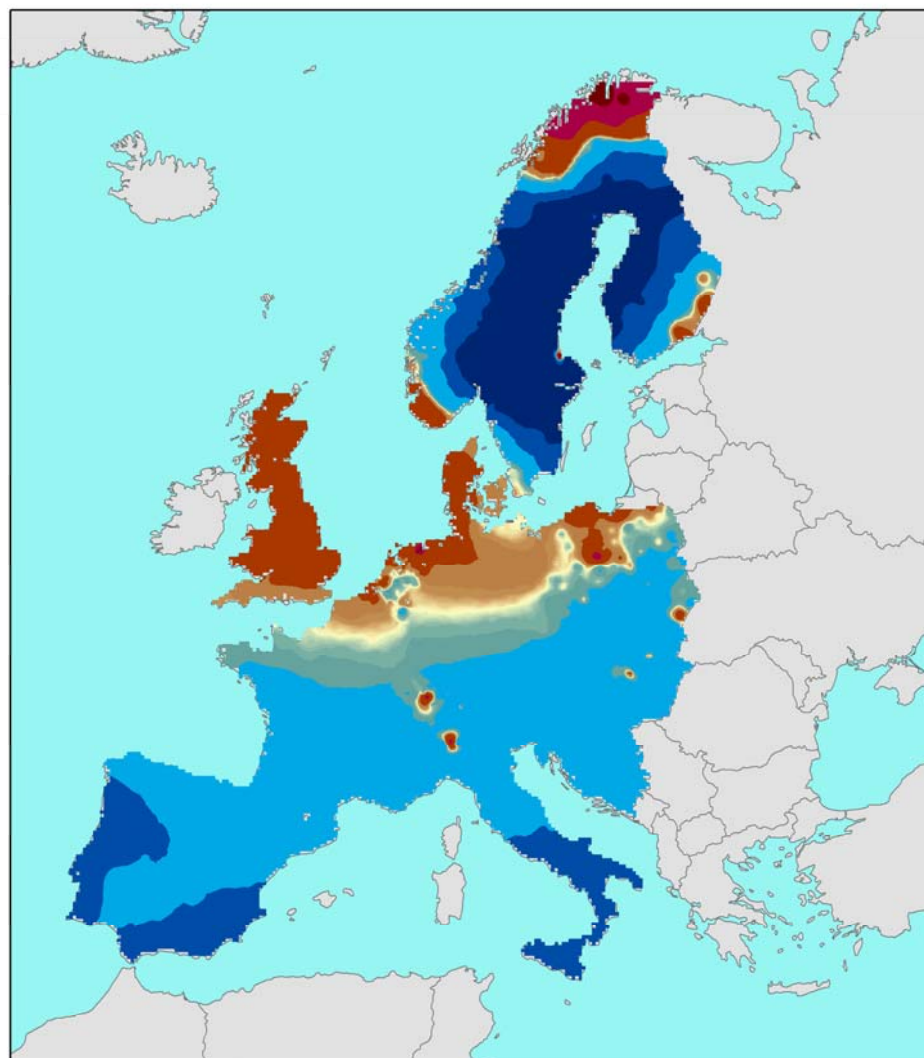
- Datum realization by 13 datum points
- Reduction to the zero tidal system
- Reduction of the measurements to the epoch 2000 using the whole NKG2005LU model

Parameter	EVRF2000	EVRF2007
Number of datum points:	1	13
Number of unknowns:	3063	7939
Number of measurements:	4263	10347
Number of condition equations:	0	1
Degrees of freedom:	1200	2409
A-posteriori standard deviation referred to 1 km levelling distance in kgal·mm:	1.10	1.11
Mean value of the standard deviation of the adjusted geopotential numbers ($\hat{=}$ heights), in kgal·mm:	19.64	16.05
Average redundancy:	0.281	0.233

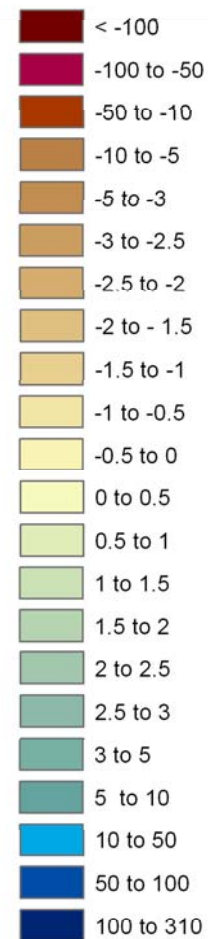
5. Comparison to previous adjustments

- Comparison EVRF2007 to the adjustment UELN 95/98 (EVRF2000)
- Different extension of EVRF2000 and EVRF2007
- interim solution of 2003 very similar to EVRF2000 – main differences at the north-eastern and south-eastern boundaries of the network because of additional data of BG, EE, LT, LV, RO + updated data of CH
- therefore UELN (2003) can be used as basis for comparison:
- Comparison EVRF2007 to the adjustment UELN (2003)
- Causes for differences:
 - updated levelling data of 8 countries (NL, SE, FI, NO, SK, LT, PL, PT)
 - land uplift (new reference epoch, new model, new data)
 - different tidal correction (mean/zero)
- Comparison EVRF2007 to the adjustment UELN (2003) without tidal correction – both in the mean tidal system

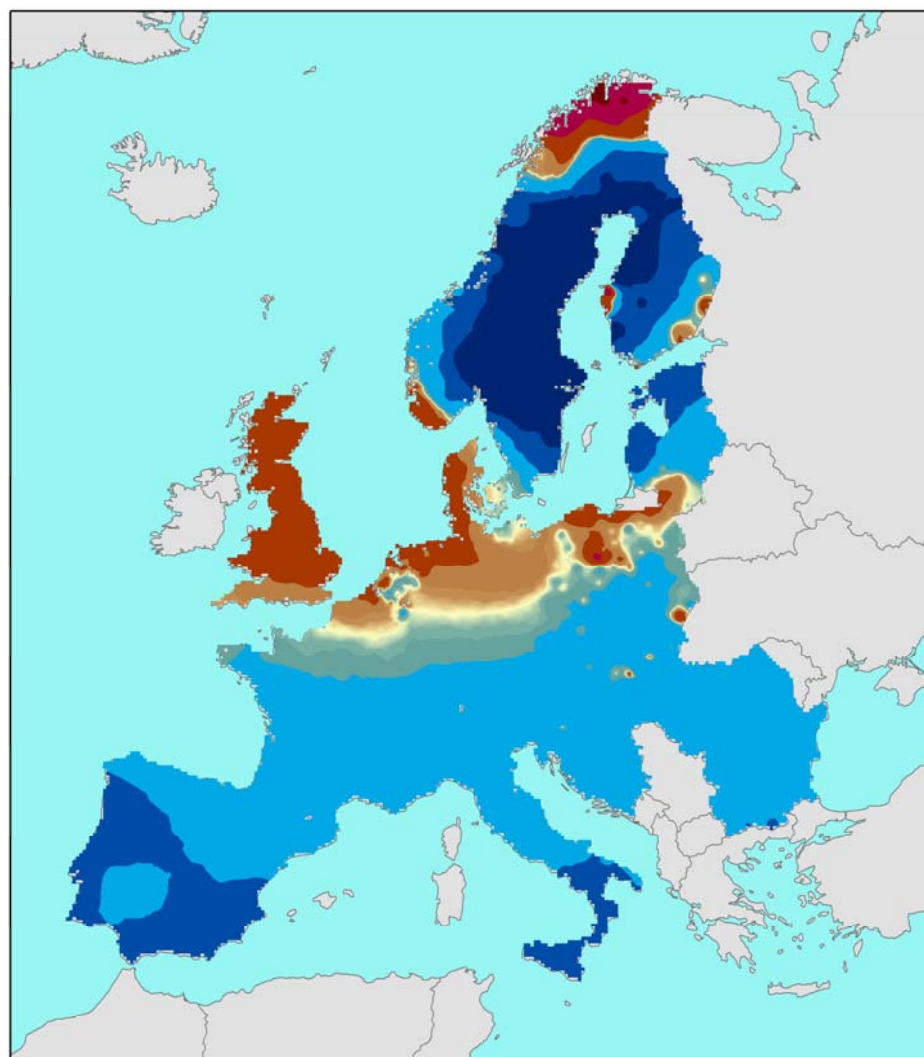
Comparison of the adjusted heights of EVRF2000 and EVRF2007



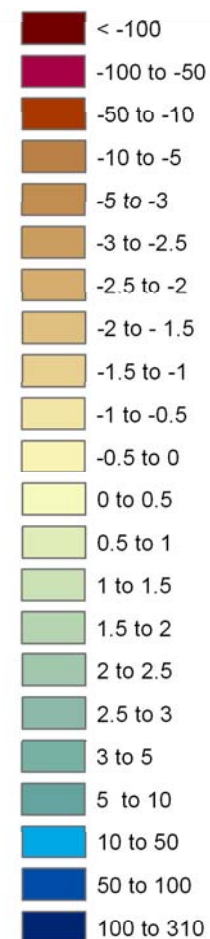
Differences in kgal*mm



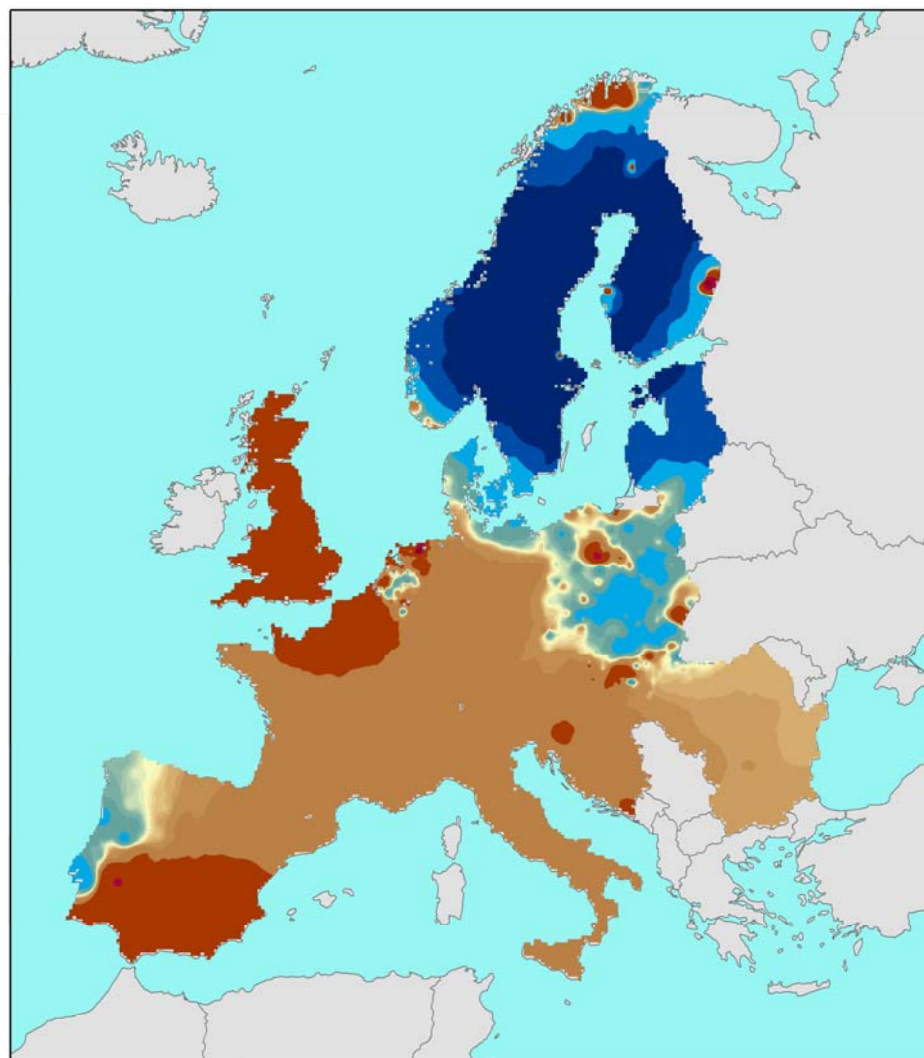
Comparison of the adjusted heights of 2003 adjustment and EVRF2007



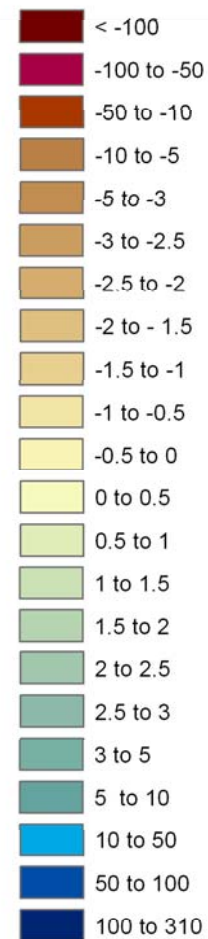
Differences in kgal*mm



Comparison of the adjusted heights of 2003 adjustment and EVRF2007 in the mean tidal system



Differences in kgal*mm



Differences of EVRF2007 to EVRF2000

Country	Differences in kgal-mm				Country	Differences in kgal-mm		
	min	max	mean			min	max	mean
Austria	14	25	19		Norway	-134	195	55
Belgium	-11	3	-4		Sweden	-132	280	154
Switzerland	-153	41	-7		Finland	-114	200	54
Germany	-24	20	0		Poland	-88	40	8
Denmark	-23	-4	-11		Slowenia	25	30	27
Spain	11	62	46		Slovakia	-22	42	18
France	-8	39	17		Croatia	26	47	35
Italy	23	75	44		Latvia	31	74	47
Netherlands	-222	29	-10		Estonia	45	83	67
Portugal	58	93	72		Romania	20	40	32
Hungary	14	29	23		Lithuania	-16	79	13
Czech Republic	3	28	14		Bulgaria	38	51	43
Great Britain	-43	-3	-21		total			15
compared to 95/98					compared to 2003			

6. Delivery of the Results

Handing over to the participating countries at May 5th 2008:

- Draft: “*EVRF2007 as Realization of the European Vertical Reference System*“
- Draft: “*Conventions for the Definition and Realization of a European Vertical Reference System (EVRS)*”
- 2 files with adjustment results
 - a) point related data
 - adjusted geopotential numbers
 - normal heights (using the normal potential of GRS80)
 - standard deviation
 - b) measurement related data
 - weight, improvement
 - standardized improvement, redundancy
 - adjusted geopotential number + standard deviation

6. Delivery of the Results (2)

- Up to now no agreement on data exchange exists.
- Therefore only the national part of the results have been handed over to the respective country.
- Should the complete results be available to all participating countries (at least the adjusted heights and coordinates of the nodal points) ?

Splinter meeting this afternoon after the last session

Representatives of all participating countries have been invited.

7. Next steps

- Transformation parameters between national height systems and EVRF2007 will be provided at <http://crs.bkg.bund.de/crs-eu/> (autumn 2008)
- Update of EUVN_DA leveling heights (autumn 2008)
- Integration of the new French zero-order leveling network including the measurement through the Euro-tunnel (2009 ?)
- Integration of new Spanish leveling data (20??)
- Integration of some bordering loops of Russia (2009) at first step of closing the Baltic Ring

***Thanks to all participating countries
for your contribution!***

Austria

Belgium

Bosnia and Hercegovina

Bulgaria

Croatia

Czech Republic

Denmark

Estonia

Finland

France

Germany

Great Britain

Hungary

Italy

Latvia

Lithuania

Netherlands

Norway

Poland

Portugal

Romania

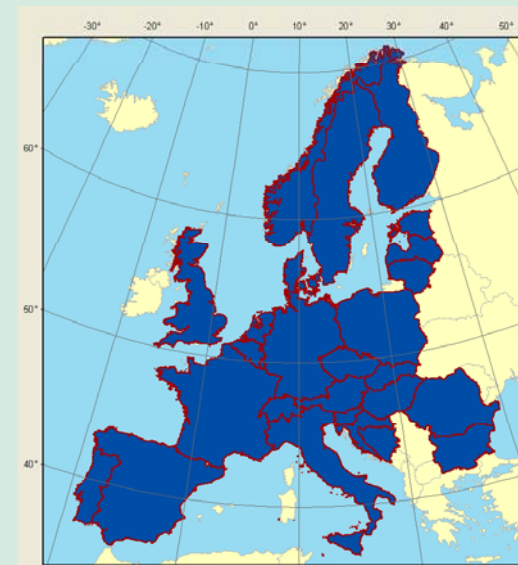
Slovakia

Slowenia

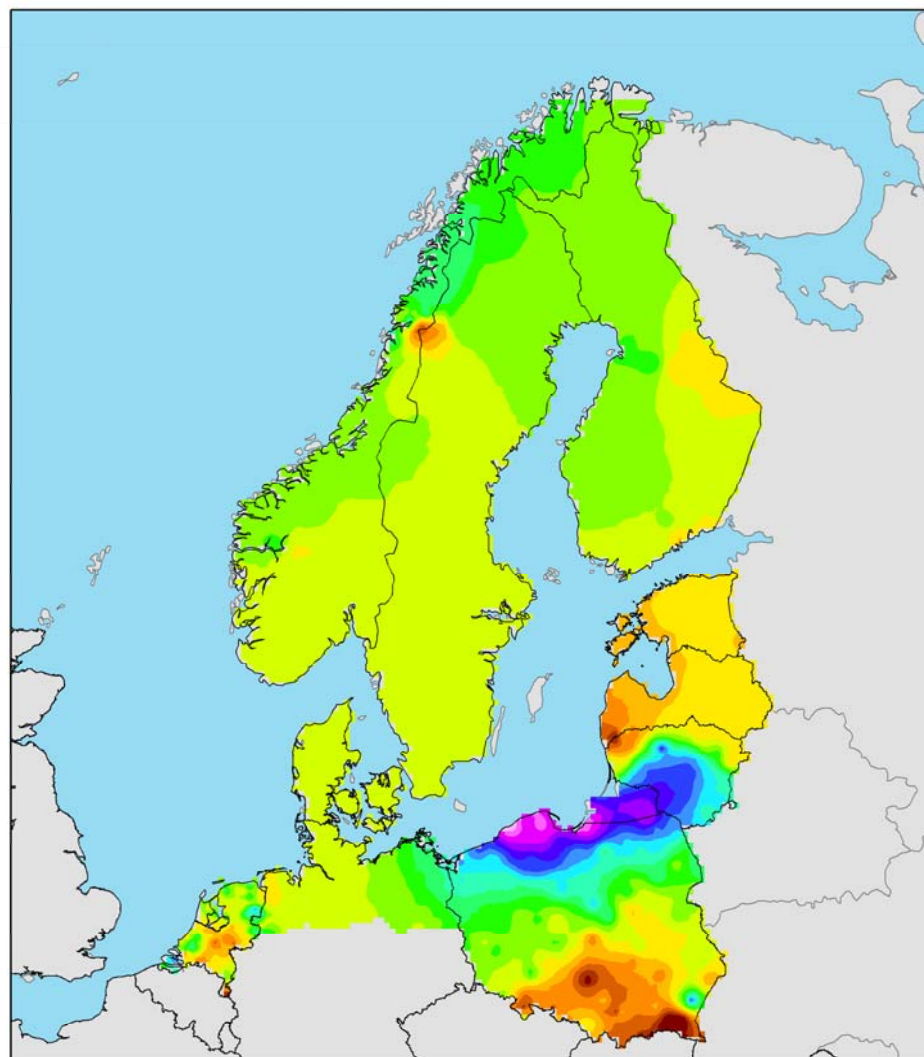
Spain

Sweden

Switzerland



Variant c) - Differences to the BLR2000



Differences UELN - NKG in kgal*mm
 FIN, NO, SE, DK, D, PL, LT, EST, LV
 reduced to epoch 2000

