



Short description of the European vertical reference system and its realizations

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- 1. Development towards EVRF2007**
2. EVRS and its realization
3. News since EVRF2007
4. Future – next steps



Development towards EVRF2007

Central European Triangulation (1864 – 1890)

Comparison of European sea levels; 48 levelling loops, 42 tide gauges

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

UELN-95 (1995-1999)

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

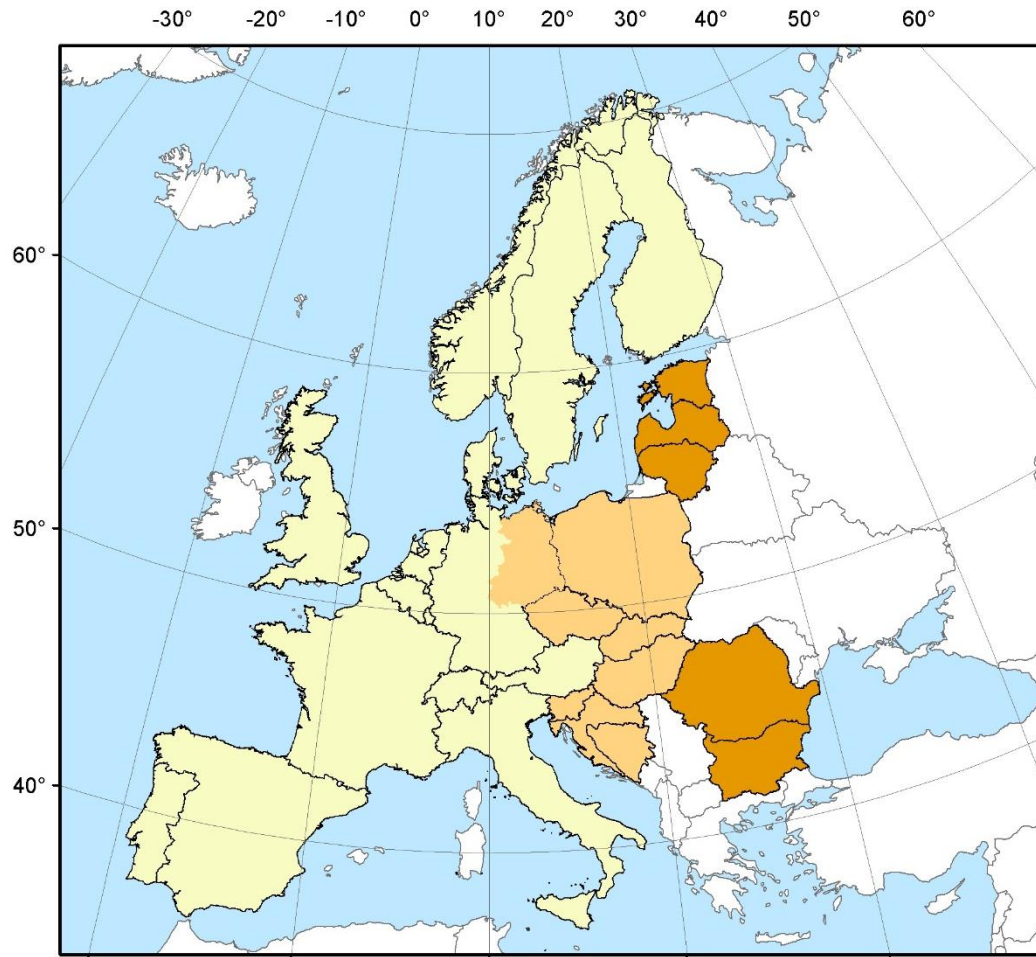
EVRF2000

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 in 2007



27 countries
7939 nodal points
10347 lines



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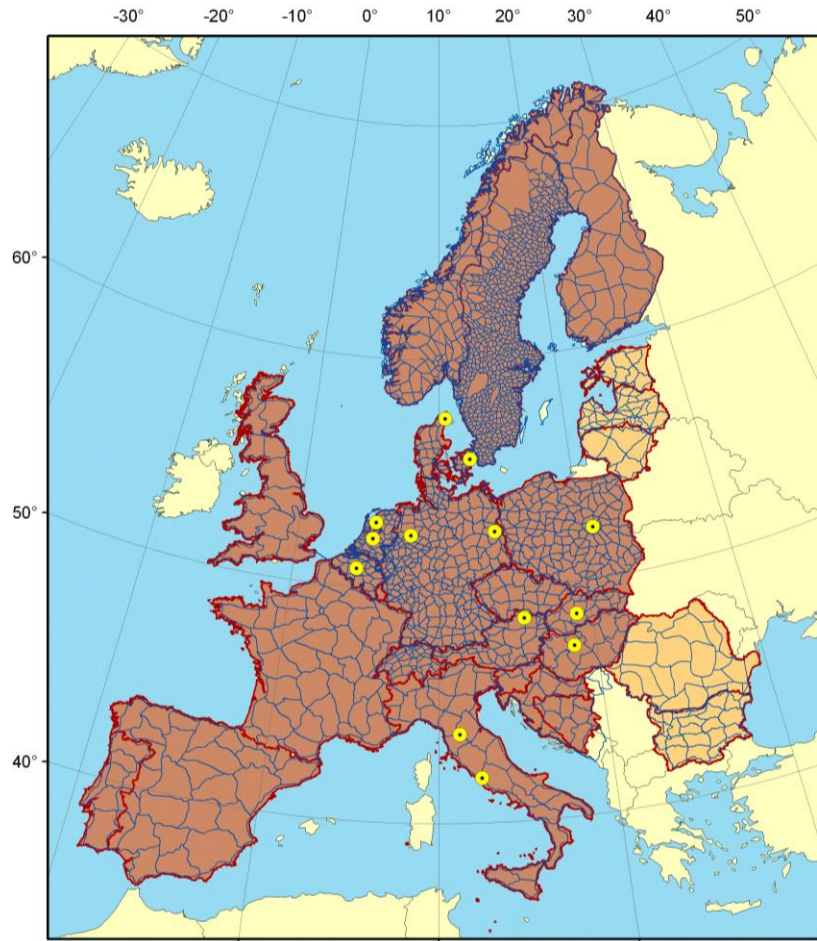
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Definition of the European Vertical Reference System and related realizations (frames)

| System | EVRS(2000) | EVRS2007 |
|-----------------------------|---|---|
| description | Gravity related height reference system | +kinematical |
| datum | $W_0=U_0$ | $W_0=W_{0E}=\text{const.}$, level NAP |
| scale | SI- meter, second | SI – meter, second, TCG time |
| Kind of heights | Geopotential numbers: $-\Delta W_p = c_p = W_{0E} - W_p$ normal heights equivalent (specification of reference gravity field provided) | |
| Tidal system | Zero tide | |
| Realization | EVRF2000 | EVRF2007 |
| datum | 1 point: 000A2530 in the Netherlands with the same geop. number as in UELN-73/86 | 13 datum points with their geopotential numbers of EVRF2000 |
| scale | rod scale and temperature correction, in the authority of the particular countries | |
| reference gravity field | normal gravity field of GRS80 | |
| adjustment | free | |
| network | UELN-95/98+ EE, LV, LT, RO (status 2000) | UELN status 2007 |
| tidal system | No reductions applied: mean tide | Zero tide |
| Reduction to a common epoch | FI, NO, SE reduced to 1960 | FI, NO, SE, DK, PL, EE, LT, LV, parts of DE, PL reduced to 2000 |

Datum points of EVRF2007



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

• Datum points of EVRF2007

Extension of UELN

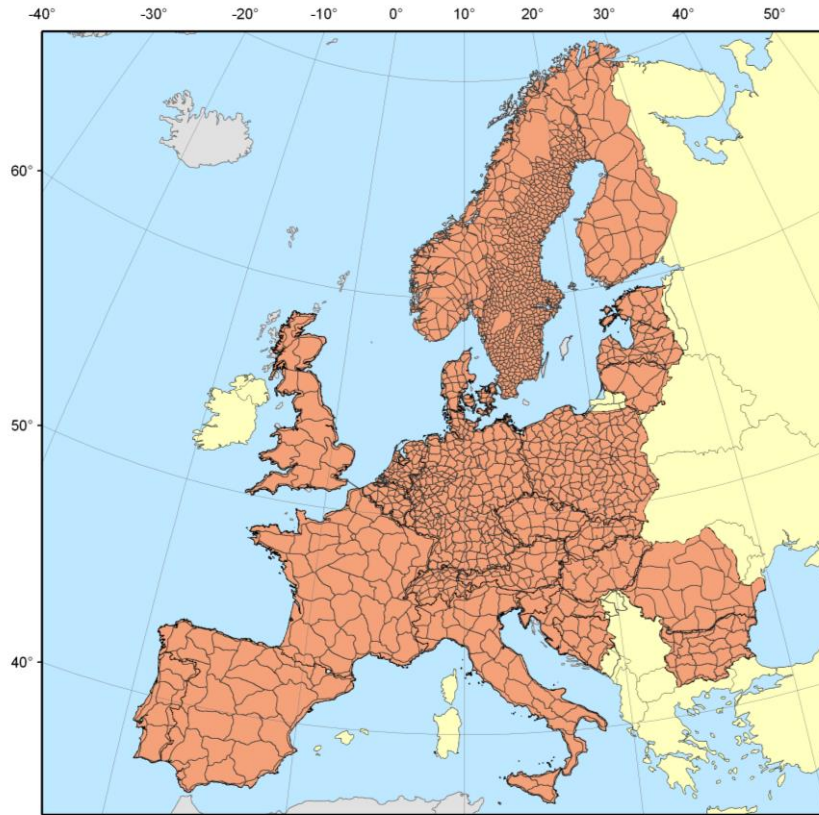
- up to 1998
- as from 2003
- UELN lines



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EVRF2007



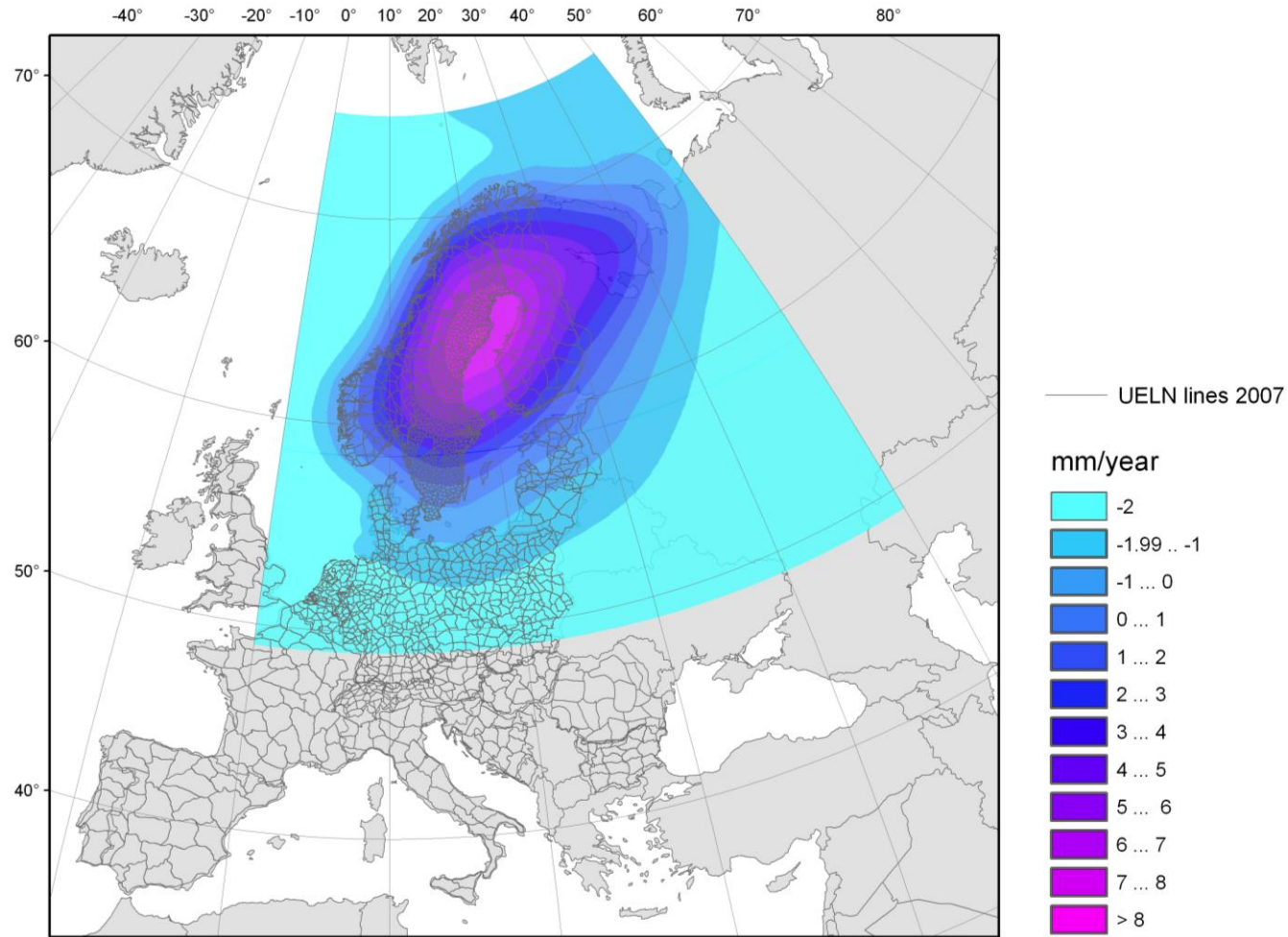
- 27 countries
- 13 datum points
- 7939 nodal points
- 10347 lines
- $s_0 = 1.11 \text{ kgal}\cdot\text{mm}$
- Adopted 2008 in Brussels



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NKG2005LU and UELN lines



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New data since 2008

Russia

– European part (2012) extension

Latvia (2011) update

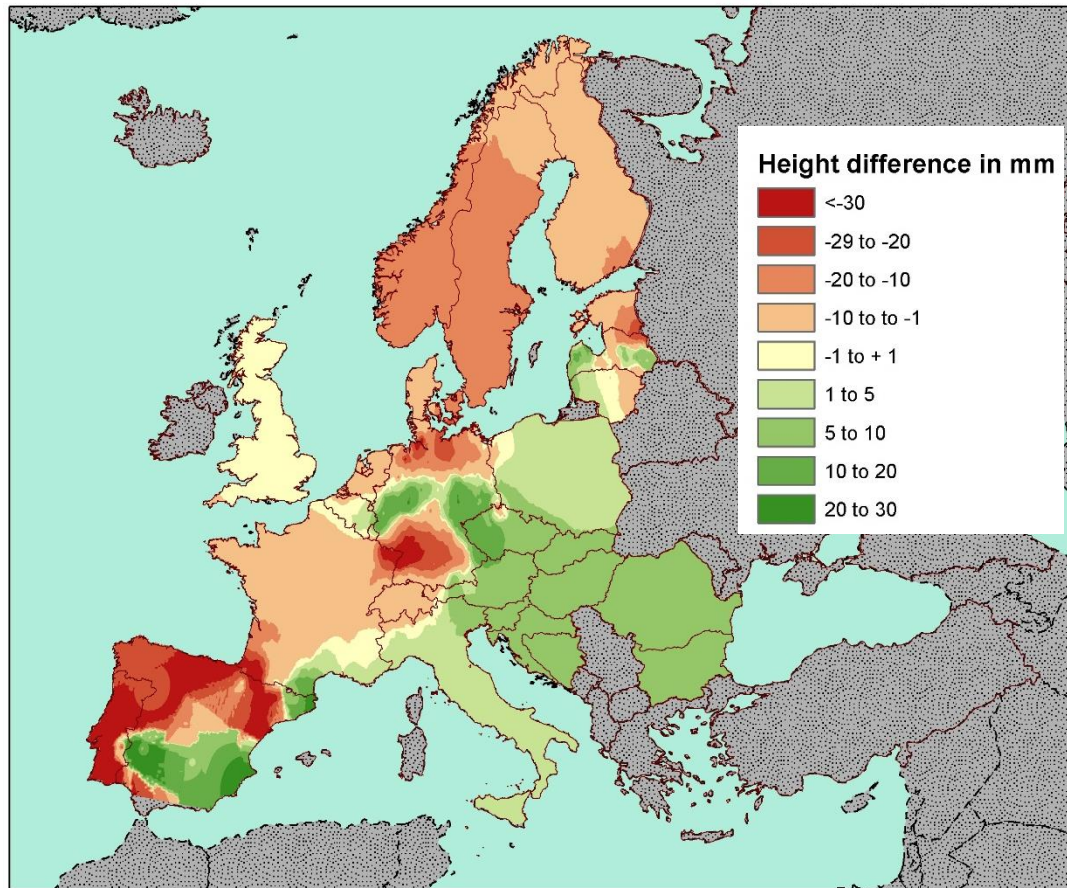
Spain (2012) update

Report on results of a preliminary adjustment with data status 2012 was held on the EUREF symposium in Paris

Latvia (2012) update (use of own parameters for reducing to epoch 2000)

Germany (2015) update

Height differences between adjustment 2015 and EVRF2007



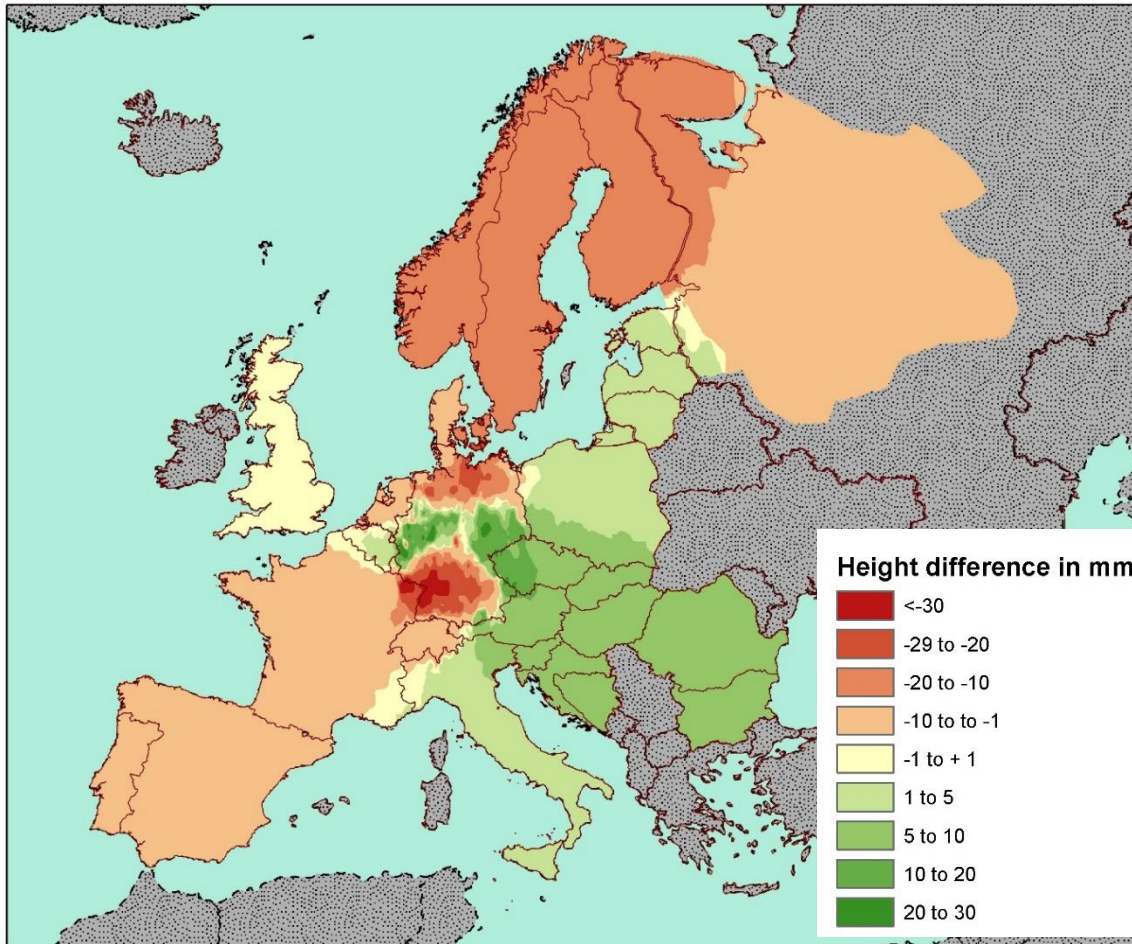
Included data changes
compared to
EVRF2007:

- Russia (new)
- Spain (update)
- Latvia (update)
- Germany (update)
- differences > 3 cm in Spain und Portugal

New German network block

- Measurements between 2006 and 2012
- 7504 nodal points
- 7826 leveling lines
- S_0 for 1km leveling: 0.63kgal·mm
- Border connections Epoch difference DE - neighbor
 - 3 to DK (old 3) 23-28 years
 - 5 to PL (old 5) 3- 8 years
 - 6 to CS (old 9) 18-35 years
 - 9 to AT(old 11) 21-39 years
 - 13 to CH (old 1) 9-54 years
 - 1 to FR (old 2) 46 years
 - 1 to BE (old 2) 40 years
 - 14 to NL (old 11) 8-14 years

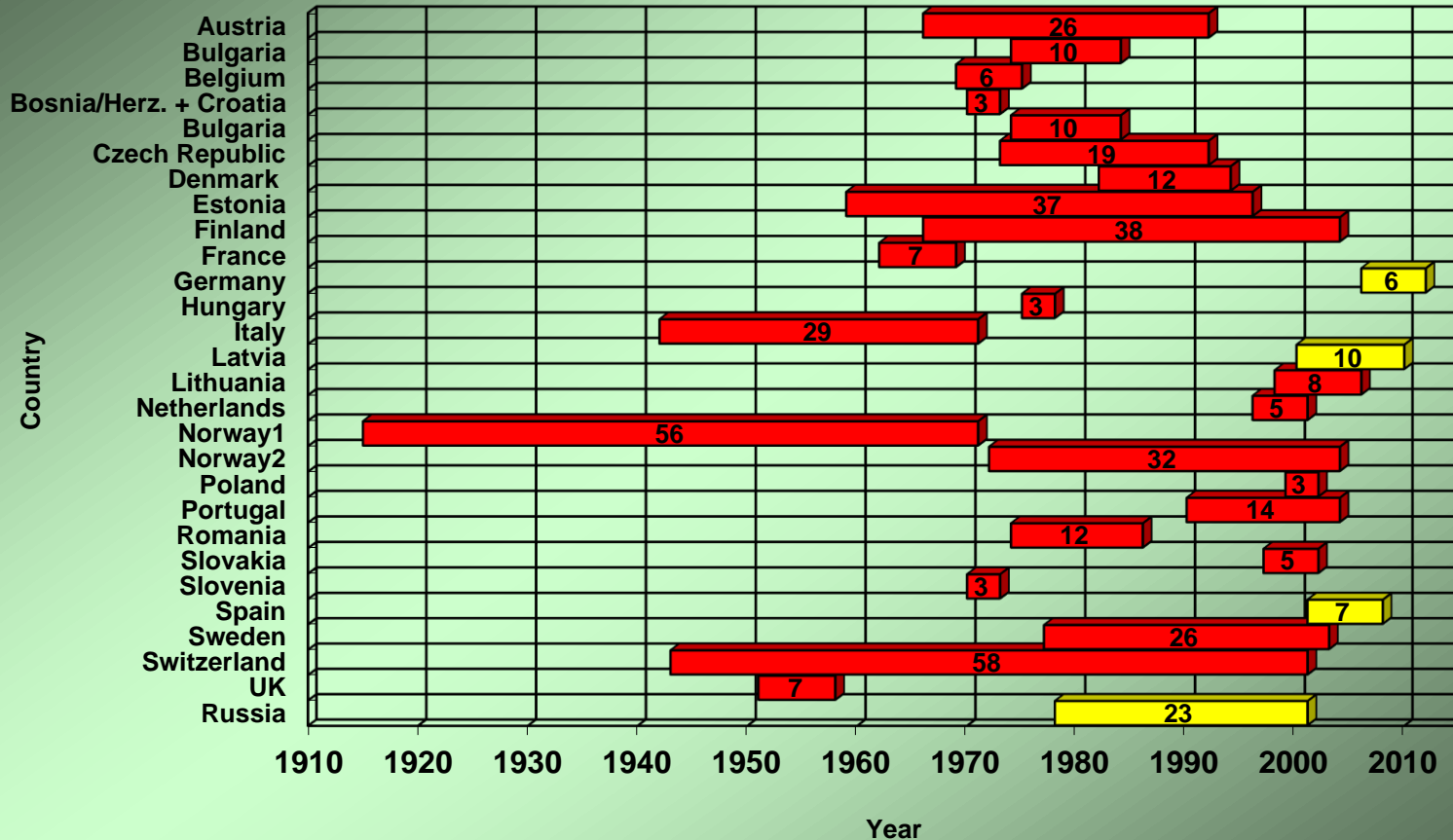
Height differences because of the change of the German network



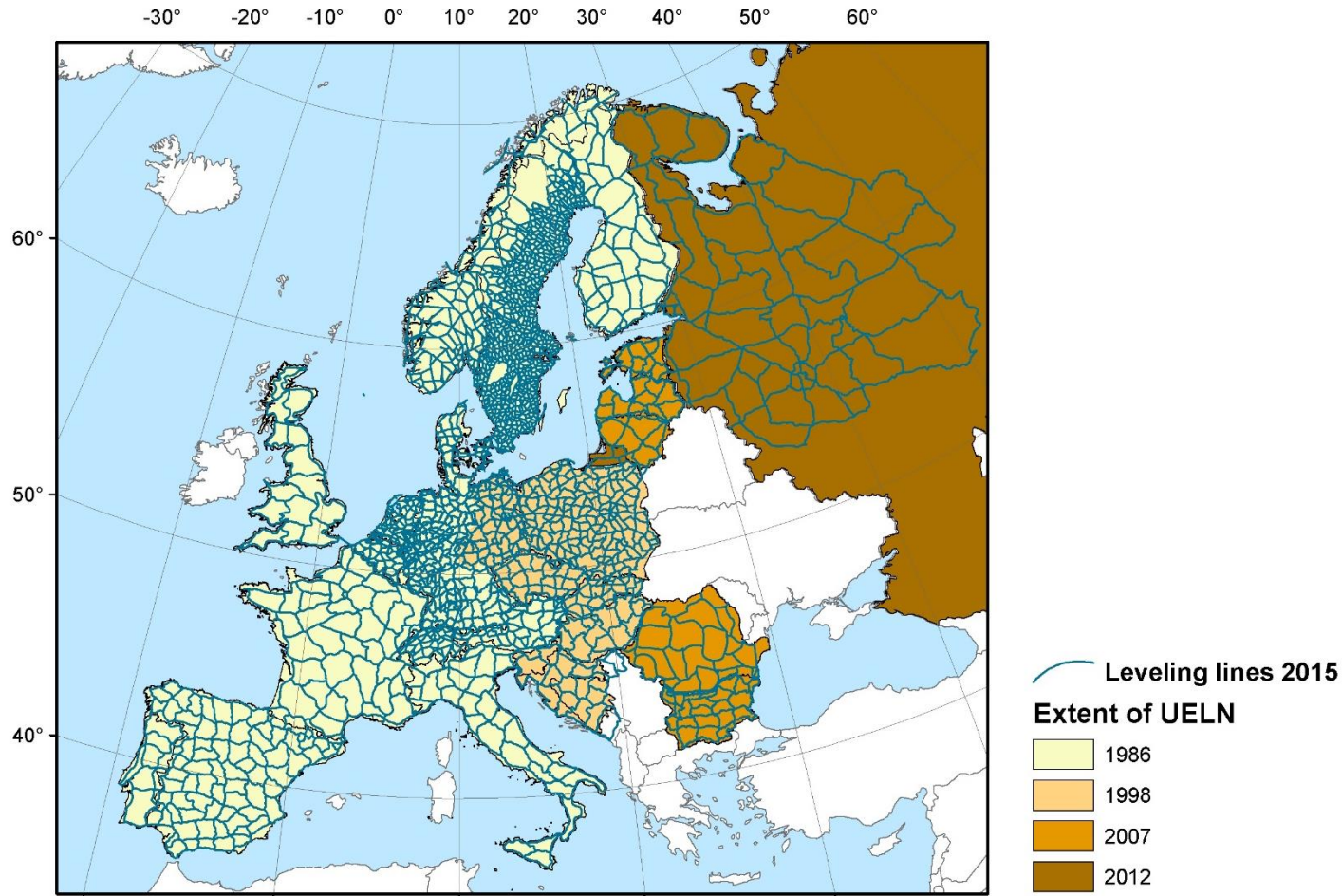
Included data changes compared to preliminary adjustment 2012:

- Only Germany
- -15 mm in Northern Europe
- 6 mm in South East Europe

Epochs of measurement in UELN



Current extent of UELN and configuration



Parameter of the adjustment

| Parameter | UELN 95/98 | EVRF2007 | Adjustment 2012 | Adjustment 2015 |
|---|-------------------|-----------------|----------------------------|----------------------------|
| Number of datum points: | 1 | 13 | 13 | 13 |
| Number of unknowns: | 3063 | 7939 | 8318 | 8485 |
| Number of measurements: | 4263 | 10347 | 10833 | 11072 |
| Number of condition equations: | 0 | 1 | 1 | 1 |
| Degrees of freedom: | 1200 | 2409 | 2516 | 2587 |
| A-posteriori standard deviation referred to 1 km levelling distance in kgal·mm: | 1.10 | 1.11 | 1.19 | 1.17 |
| Mean value of the standard deviation of the adjusted geopotential numbers ($\hat{=}$ heights), in kgal·mm: | 19.64 | 16.05 | 16.47 | 16.07 |
| Average redundancy: | 0.281 | 0.233 | 0.232 | 0.234 |

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Further activities (1)

■ Ukraine

- 2008 decision to join UELN
- 2009 selection and preparing of border connections by Ukraine and BKG
- Since 2010 Data preparation in Ukraine

■ Belarus

- RU prepared data of Belarus
- 2012 selection and preparing of border connections by Russia and BKG
- Russia expected leveling data of Germany, Poland, Baltic states in exchange for the Belarus data
- Providing of leveling data only possible with permission of the owner of the data

Further activities (2)

■ France

- Scientific zero-order leveling network NIREF (not yet available at data center)
- Tilt between IGN69 and NIREF suspected (23 cm N-S)
- NIREF contains new border connections to ES, IT, DE, CH, BE
- only NIREF connected to tunnel measurement to UK
- France will provide a new data set consisting on NIREF and some new measured lines of IGN69 already 2015
- Suitable Combination of the data of NIREF and IGN69 is needed

■ Switzerland

- New data available, also new border connections to France and Italy
- Exchange of the data sensibly in combination with new data of Italy and France

Further activities (3)

■ Italy (information from national report)

- Densification and re-measurement of leveling network in Italy since 1996
- Leveling almost finished
- Interpolation or measurement of gravity values ongoing
- Computation of geopotential differences
- After finishing including in UELN is desired
- Current Italian leveling data in UELN are obviously different from official height system

■ UK

- Including of tunnel measurement with new data of France possible
- In UK 3rd leveling epoch was included under constraint in 2nd epoch
- UELN contains only data of 3rd leveling epoch with N-S tilt, EVRF2007 inconsistent with quasigeoid
- Including of national heights + offset in UELN? New adjustment isn't necessary because there is only 1 connection to the mainland

Proposal for a new realization of EVRS2007

- A new realization of EVRS should be computed
- New network parts of RU(2008), LV(2011), ES(2012), DE(2015) are already included
- Countries that observed new 1. order leveling data are requested to make them available to the EVRS data center (also such countries that intend to join the UELN)
- Countries that will update their leveling data in the next years are requested to
 - Signalize the upcoming data update
 - Give an estimate for the date of finishing and possible providing of the data before the next EUREF symposium 2016
- After evaluation of the feedback a date for a new EVRF can be determined

Thank you for your kind attention!

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