

New leveling data of France and Switzerland in UELN

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1. Review

- 2. Including of NIREF (France)
- 3. Update of Switzerland
- 4. New heights of Great Britain
- 5. Future next steps



EVRF2007

New data since 2008



Russia(2012)extensionLatvia (2011)updateSpain (2012)updateReport on results Paris 2012Germany (2015)updateReport on resultsLeipzig 2015France (2015)add. NIREFSwitzerland (2015)update



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Scientific zero-order leveling network NIREF

- NIREF has been measured between 1983 and 2014
- Tilt in IGN69 had been suspected in France since 1971 (tide gauge observations)
- New observations show tilt between IGN69 and NIREF of 23 cm in N-S direction
- NIREF contains new border connections to neighboring countries
- only NIREF connected to tunnel measurement to GB
- 2015 France provided a new data set consisting on NIREF and some new measured lines of IGN69 to UELN data center
- Density of NIREF is low
- Suitable combination of NIREF and IGN69 is needed



Differences between heights in IGN69 and NIREF



Connection of IGN69 and NIREF in UELN



- Identical points are needed for the combination of the networks
- 8472 identical points between IGN69 and NIREF
- But only old nodal points of IGN69 are contained in UELN data base
- intermediate points on the lines can not be provided
- Point number/ID not suitable for search (changed in some cases)
- Identical points were searched using coordinates and heights
- 37 identical points were used for combination of the networks

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Available border connections to NIREF



6 connections of NIREF to neighboring countries in the UELN2016 adjustment:

- 1 to Great Britain
- 1 to Belgium
- 1 to Germany
- 1 to Switzerland
- 1 to Italy
- 1 to Spain

1 further connection to Spain could not be realized

Common Adjustment of IGN69 and NIREF

- Adjustment only IGN69: s₀= 2.24 mm/km
- Adjustment only NIREF: s₀= 1.25 mm/km
- Result from common adjustment with variance component estimation: IGN69: 3.83 mm/km, NIREF: 1.26 mm/km
- Least squares adjustment presumes the existence of only random errors
- IGN69 contains systematic errors they are not fully be considered in results of variance component estimation
- Answer: Including of IGN69 with very low weights (original variances were multiplied with factor 100)



Comparison of NIREF with EVRF2007 and UELN2016





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Delivered data

- Last dataset of Switzerland in UELN was from 2003
- In Switzerland permanent observations in the leveling network, no separated epochs, currently 3rd repetition in progress
- April 2016: handing over of levelings measured during 1903-2015
- 1902 measurements have been used only the most current data on the lines
- Year of measurement of the used data:
 - 1924-1966: 10
 - 1967-1983: 266
 - 1984-1994: 654
 - 1995-2004: 659
 - 2005-2015: 580



Separate adjustment of the Swiss leveling network

- Adjustment results
 - 1751 unknowns
 - 1902 measurements
 - 1 fixed point
 - 151 degrees of freedom
 - A-posteriori standard deviation for 1km leveling s₀: 1.10 kgal-mm
- Kinematic adjustment
 - Kinematic adjustment with program KINEPOT performed by Swiss colleagues
 - Resulting velocities can be used for reduction of measurements to common epoch 2000
 - A-posteriori standard deviation for 1km leveling s₀: 0.88 kgal-mm
 - Reduced measurements not used in UELN2016 adjustment apart from 1 border connection to France

Connections to neighboring countries



Number of used connections:

- AT: 3
- DE: 21
- FR: 2

IT: 0

(existing new connections could not be used because of missing data of Italy)



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Including measurements through Channel Tunnel

- Up to now tunnel observation was not part of UELN, because start point in France is not part of IGN69, only in the NIREF network
- Measurement 1994, 51km, 789 benchmarks
- HU_{GB}= 44.8090m ± 6mm (trigonometric leveling)
- HU_{FR} = 44.8455m ± 8mm (geometric leveling)
- Difference of 36.5mm conflicts with the estimated accuracy of the 2 techniques
- Reason of the difference could not be found by the involved countries
- Decision 2007: mean value was adopted as result



Results for Great Britain

 Height changes of the point G4868 (Dover) after including NIREF and the measurement through the Channel Tunnel:

• H _{GB} (ODN) :	6.821m
• HEVRF2007:	6.819m
• HUELN2015:	6.818m
• HUELN2016:	6.678m
 HUELN2016a (without Tunnel measurement): 	6.727m
UELN2016-EVRF2007 in Dover:	-141mm
 caused by including NIREF (tilt of IGN69): 	-91mm
 caused by new connection through the tunnel: 	-49mm
Offset H _{GB} (ODN) to UELN2016:	-0.143m
System difference between FR-GB	
NIREF-ODN:	-0.284m
 IGN69-ODN (computed from EVRF2007): 	-0.481m
 IGN69-ODN (with tunnel measurement): 	-0.381m

Future treatment of British leveling data

- ODN heights had been computed as a combination of 2nd and 3rd leveling epoch of GB
- UELN contains only data of 3rd leveling epoch with <u>N-S tilt</u>, EVRF2007 inconsistent with ODN heights and quasigeoid
- Proposal: UELN(GB)= H(ODN)+offset
- Offset computed from current UELN adjustment using tunnel connection and NIREF network, in 2016: -0.143m
- Including of whole British leveling network into adjustment not necessary because there is only 1 connection to the mainland



Tilt between national data of GB and EVRF2007

Data of GB in UELN not consistent to national network:





Results of the common adjustment UELN2016

Parameter	UELN 95/98	EVRF2007	Adjustment 2012	Adjustment 2015	Adjustment 2016
Number of datum points:	1	13	13	13	13
Number of unknowns:	3063	7939	8318	8485	9871
Number of measurements:	4263	10347	10833	11072	12582
Number of condition equations:	0	1	1	1	1
Degrees of freedom:	1200	2409	2516	2587	2712
A-posteriori standard deviation referred to 1 km levelling distance in kgal·mm:	1.10	1.11	1.19	1.17	1.12
Mean value of the standard deviation of the adjusted geopotential numbers (heights), in kgal·mm:	19.64	16.05	16.47	16.07	19.09
Average redundancy:	0.281	0.233	0.232	0.234	0.216



Height differences between adjustment 2016 and 2015



Height variations in mm of affected countries

Country	Mean	Min	Max
Great Britain	-143.8	-145.7	-139.9
France	-24.2	-130.5	43.4
Netherlands	-3.1	-4.0	-2.9
Belgium	-3.1	-9.1	5.4
Denmark	-2.4	-2.5	-2.4
Sweden	-2.3	-2.5	-2.1
Germany	-2.3	-6.5	1.7
Norway	-2.2	-2.8	-1.5
Finland	-2.2	-2.3	-2.1
Estonia	-1.7	-1.8	-1.7
Poland	-1.6	-2.1	-1.3
Switzerland	-0.4	-33.6	16.8
Italy	9.8	0.0	21.4
Portugal	15.8	15.5	16.0
Spain	16.2	-18.7	49.2



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Further expected data

- Italy (information from national reports 2014 and 2015)
 - Current Italian part of UELN is measured between 1942 and 1971
 - Densification and re-measurement of leveling network in Italy since 1996
 - Leveling finished ?
 - Interpolation or measurement of gravity values ongoing
 - Computation of geopotential differences
 - After finishing including in UELN is planned
- Belarus
 - In March 2016 Belarus contacted BKG
 - Belarus thinks of participating in UELN project
 - UELN data center described necessary data and conditions
- Resolution No. 4 EUREF 2015:... "asks the NMAs to provide any new levelling to the UELN data center "
- New realization 2018?

Thank you for your kind attention!

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