EUREF Symposium – Brussels, June 18-21, 2008

The new French zero-order levelling network

First global results and possible consequences for UELN

P. Rebischung (IGN/SGN) H. Duquenne (IGN/LAREG) F. Duquenne (IGN/SGN)





Summary

- The French data included in UELN95/98
- The NIREF network
 - Objectives
 - Measurements (methods, status)
- First global results
 - Different computations
 - Comparisons with: IGN69, GPS+geoid, MSL
- Including NIREF into UELN
 - Strategies and consequences





The French data included in UELN95/98

- The IGN69 network:
 - Geopotential differences measured during the 60's
 - Included in UELN since 1973
 - A posteriori standard deviation:
 2.01 kgal×mm/km^{1/2}, the poorest precision of national networks
 - North-South bias suspected since 1970 (from comparison with tide-gauges data)
- Obsolete, unaccurate and biased data: probably diminishing the quality of UELN







The NIREF network (1/3)

- Objectives
 - Geodesy
 - Research on vertical reference systems
 - Unification of vertical reference systems
 - Geodynamics: crustal deformation
 - **Oceanography:** sea level temporal and spatial variations
 - Participation in UELN and EUVN
 - Not for common use: IGN69 will remain the official reference for a long time





The NIREF network (2/3)

• Main specifications:

- Motorized levelling
- Instrument: ZEISS NI002
- Fore and back levelling
- Max. line of sight: 50 m
- Fore back tolerances:
 - 0,3 mm
 - $87\% < 0.83 \text{ mm/km}^{1/2}$
- Gravity not measured
- Rough topography avoided





EUREF 2008, Brussels

The new French zero-order levelling network First global results and possible consequences for UELN



The NIREF network (3/3)

- Progress:
 - Marseille-Dunkerque traverse observed in 1983
 - Augmented with new traverses during 2000-2006
 - Junction with Italy being observed now
 - Traverse La Rochelle Geneva planned for
 2009/2010





EUREF 2008, Brussels The new French zero-order levelling network First global results and possible consequences for UELN



Partial re-observation of IGN69 network





The new French zero-order levelling network First global results and possible consequences for UELN



Data processing

• Main steps:

- Interpolation of gravity
- Computation of geopotential differences
- Least-squares adjustment
- Computation of normal heights
- Comparison with IGN69, GPS+geoids, MSL





Interpolation of gravity (1/3)

• Data:

- Free-air anomalies from BRGM, BGI and IGN
- Precise DTM from IGN (resolution: 1") combined with SRTM and Sandwell bathymetry
- Network divided into 16 zones





EUREF 2008, Brussels

The new French zero-order levelling network First global results and possible consequences for UELN



Interpolation of gravity (2/3)

• For each zone:

- Extraction of a local DTM
- Selection of gravity data
- Removal of terrain effects
- Interpolation on levelled points by least-squares collocation
- Restoration of terrain effects and normal gravity





EUREF 2008, Brussels The new French zero-order levelling network First global results and possible consequences for UELN eurs

Interpolation of gravity (3/3)





EUREF 2008, Brussels

The new French zero-order levelling network First global results and possible consequences for UELN



Adjustments of geopotential differences

• Four adjustments performed:

- Two gravity reference systems:
 - Potsdam31
 - IGSN71
- Two ways of handling NIREF / 1st order observations:
 - Global adjustment with different a priori weights
 - Adjustment of NIREF only, then adjustment of 1st order constrained on NIREF
- A posteriori standard deviations:
 - NIREF only: 1.31 kgal.mm/ \sqrt{km}
 - NIREF + 1st order: respectively 1.00 and 1.13 kgal.mm/ \sqrt{km}





Computations of normal heights

- Two computations of « IGN69 like » altitudes: (for each type of adjustment)
 - Fixed point: Marseille tide-gauge with IGN69 altitude
 - -g referred to Potsdam31 system
 - Reference ellipsoid: Clarke1880
- Two computations of « UELN like » altitudes: (for each type of adjustment)
 - Fixed point: Dunkirk tide-gauge with UELN altitude
 - -g referred to IGSN71 system
 - Reference ellipsoid: GRS80





Differences between both types of adjustment



NIREF & constrained 1st order - Global adjustment (cm)

- Differences arising from:
 - An inconsistency between NIREF and the 1st order
 - An important misclosure of a 1st order loop
- Consistency at the cm level between NIREF and the 1st order



EUREF 2008, Brussels

The new French zero-order levelling network First global results and possible consequences for UELN eur

14

0.8

0.6

0.4

0.2

0

-0.2

-0.4

-0.6

-0.8

-1

Comparison with IGN69

- North-South slope from 0 cm in Marseille to -23 cm in Dunkirk
- Confirmation of the North-South bias of IGN69
- Irregularities...





EUREF 2008, Brussels

The new French zero-order levelling network First global results and possible consequences for UELN



Comparison with IGN69: North-South traverses





EUREF 2008, Brussels

The new French zero-order levelling network First global results and possible consequences for UELN eur

Comparison with IGN69: West-East traverses





EUREF 2008, Brussels

The new French zero-order levelling network First global results and possible consequences for UELN eur

Comparison with IGN69: Irregularities

- Changes of slope occur at the crossings with 1st order sections!
- Possible explanation: cumulative effects of errors in the IGN69 1st order
- Needs further investigation to confirm this hypothesis





The new French zero-order levelling network First global results and possible consequences for UELN



Comparison with GPS+EGG97

• 75 points of the RBF located near the NIREF traverses

IGN69 - EGG97 (m)

NIREF - EGG97 (m)





EUREF 2008, Brussels

The new French zero-order levelling network First global results and possible consequences for UELN eurst

Comparison with GPS+EGG97: N-S traverses

• Large undulation probably due to uncorrected effects of the Alps in the global gravity field model (EGM96)

• According to NIREF, the mean geoid North-South slope is quite zero.





The new French zero-order levelling network First global results and possible consequences for UELN



Comparison with GPS+EGG97: W-E traverses

- Another undulation probably due to uncorrected effects of the Pyrenees in the global gravity field model
- Even with NIREF, a West-East slope of the geoid remains (-2.5 cm/deg = -1.7 cm / 100 km)





The new French zero-order levelling network First global results and possible consequences for UELN eursf

Comparison with tide-gauges data





EUREF 2008, Brussels

The new French zero-order levelling network First global results and possible consequences for UELN eurs

Comparison with tide-gauges data

• According to NIREF:

- There is no significant N-S slope of the oceanic MSL.
- Mediterranean Sea surface is roughly 19 cm lower than the Atlantic Ocean surface.





EUREF 2008, Brussels The new French zero-order levelling network First global results and possible consequences for UELN



Including NIREF into UELN

• NIREF would probably increase the accuracy of UELN.

(and would lead to significant height changes in Spain, Portugal, Italy and France)

- But the NIREF network is far too loose !
- So, what should be the French data in the next UELN ?
 - IGN69 until NIREF is dense enough?
 - IGN69 + NIREF ? (consistency...)
 - Recomputed IGN69 + NIREF ?





Conclusions

- NIREF gives another proof of the deficiencies of IGN69.
 - North-South slope (-23 cm from Marseille to Dunkerque)
 - Local faults ? (to be further examined)
- According to NIREF, both EGG97 and Atlantic MSL North-South slopes are quite zero.
- Discussion on how to include NIREF into UELN is open.



