Analysis of results of the International Comparison of Absolute Gravimeters in Walferdange (Luxembourg) of November 2003

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Abstract. The results of an international comparison of absolute gravimeters held in Walferdange, Luxembourg, in November 2003 are presented here in detail. The absolute meters agreed with one another to within a standard deviation less than 2 μGal (1 Gal = 1 cm/s^2), where we have excluded the results from a single prototype instrument from the analysis. This result, represents the best agreement ever obtained in a comparison of absolute gravimeters. In addition, for the first time, we were able to quantify the effect of the operators on the instrument agreement. The result indicates that the contribution to the errors in the observations due to the operator are less than 1 μGal, i.e. within the observational errors. We also demonstrate that there are no systematic differences between observations taken with FG5's incorporating the bulk interferometer and those using the fiber optic version of the interferometer.

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1. Introduction

On November 3rd to November 7th 2003, Luxembourg's European Center for Geodynamics and Seismology (ECGS) hosted an international comparison of absolute gravimeters. This is the first time in the history of geophysics and metrology that 15 absolute gravimeters were brought together in the same location for simultaneous observations. Teams from all over the world including the United States and Brazil, as well as teams from Europe participated, in the comparison (Table 1).

The comparison was held in the Underground Laboratory for Geodynamics in Walferdange (WULG). This specially designed laboratory, dedicated to the comparison of absolute gravimeters, was build in 1999 (Figure 1). The laboratory lies 100 meters below the surface at a distance of 300 m from the entrance of the mine. To transport the 350 kilograms of equipment (the typical weight of an absolute gravimeter and its peripherals) over the 300 meters to the lab, electric golf carts were used. The cart travels on a smooth newly installed concrete surface.

The WULG is environmentally stable (i.e. constant temperature and humidity within the lab), and is extremely well isolated from anthropogenic noise. It has the power and space requirements to be able to accommodate up 15 instruments operating simultaneously (Figure 2). A description of station is given in Figure 3.

Absolute gravimeters are used in geophysics for monitoring gravity variations due to mass changes within the Earth (i.e. the motion of magma underneath volcanoes), mass changes within the Earth's upper layers (i.e. the seasonal variations of continental water storage that might be related to global warming), density changes and vertical displacement caused by deformations of the Earth's crust (i.e. tectonic deformations associated with the build up and release of strain during an earthquake).

In metrology, absolute gravimeters are used in the determination of standards derived from the kilogram (ampere, pressure, force). However, because these instruments are "absolute", to verify that the instruments are operating properly, they must be regularly compared to other instruments of the same accuracy. Being absolute instruments, these gravimeters cannot really be calibrated. Only some of their components (such as the atomic clock or the laser) can be calibrated by comparison with known standards.

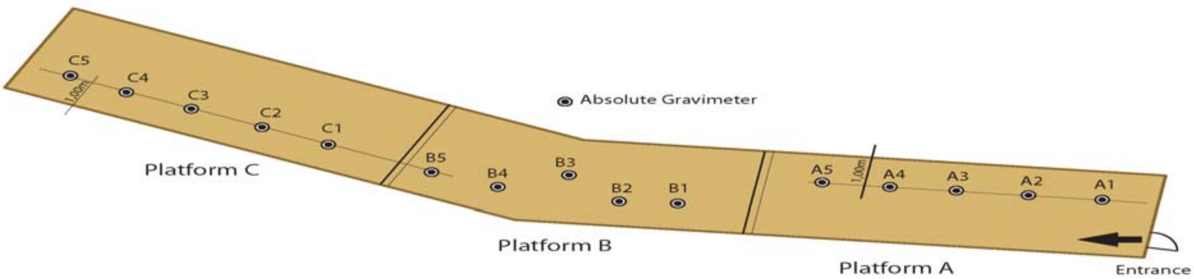
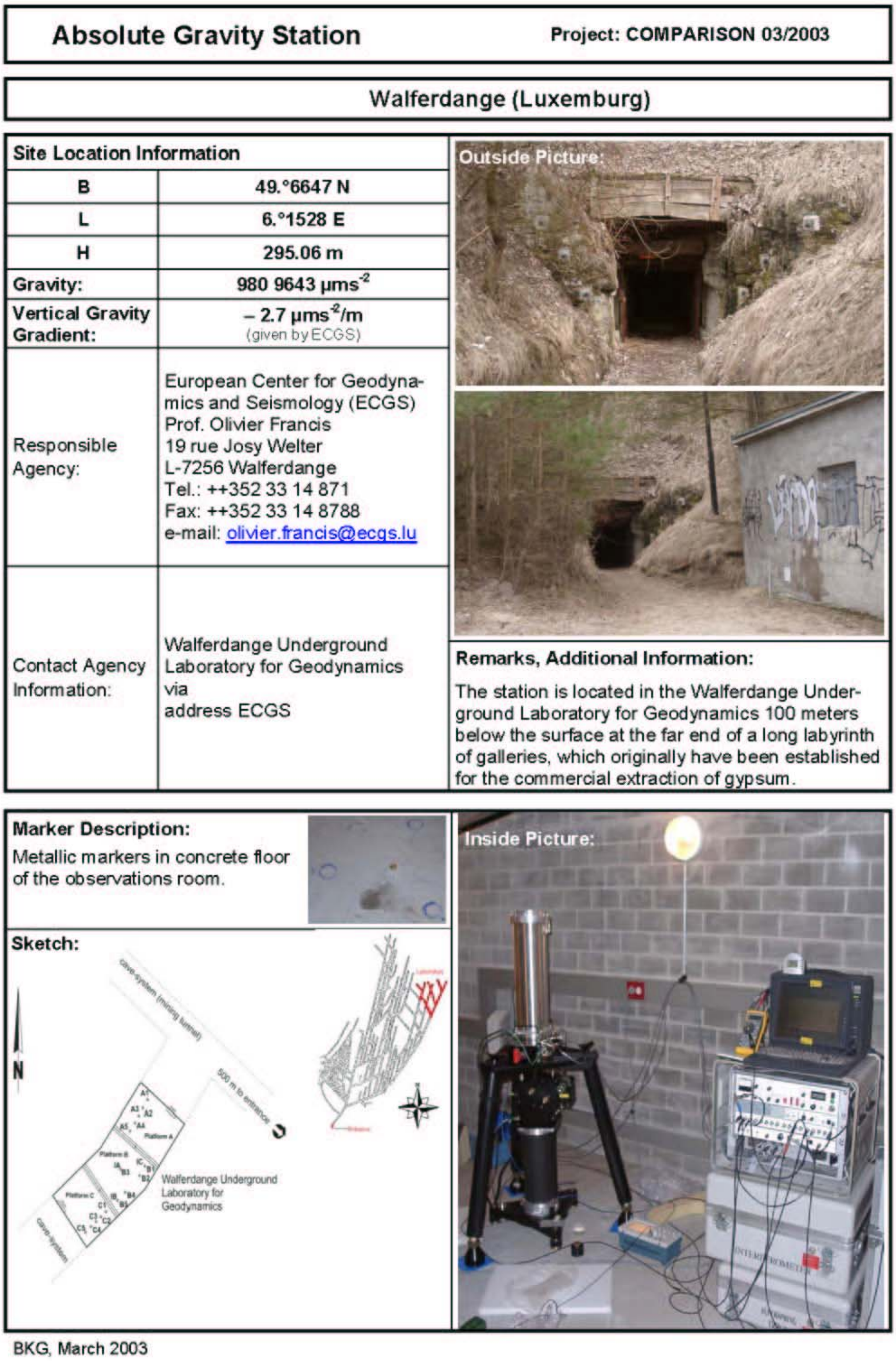


Figure 1. Sketch of the underground laboratory allowing for the simultaneous set up of 15 gravimeters (40 m length and 3.6 m wide)

Figure 2. Picture taken during the international comparison of absolute gravimeters in the Underground Laboratory of Geodynamics in Walferdange of November 2003.



Absolute Gravity Station — Project: COMPARISON 03/2003

Walferdange (Luxemburg)

Site Location Information	
B	49.°6647 N
L	6.°1528 E
H	295.06 m
Gravity:	980 9643 µms^{-2}
Vertical Gravity Gradient:	– 2.7 µms^{-2}/m (given by ECGS)
Responsible Agency:	European Center for Geodynamics and Seismology (ECGS) Prof. Olivier Francis 19 rue Josy Welter L-7256 Walferdange Tel.: ++352 33 14 871 Fax: ++352 33 14 8788 e-mail: olivier.francis@ecgs.lu
Contact Agency Information:	Walferdange Underground Laboratory for Geodynamics via address ECGS

Outside Picture:

Remarks, Additional Information:

The station is located in the Walferdange Underground Laboratory for Geodynamics 100 meters below the surface at the far end of a long labyrinth of galleries, which originally have been established for the commercial extraction of gypsum.

Marker Description:

Metallic markers in concrete floor of the observations room.

Sketch:

Inside Picture:

BKG, March 2003

Figure 3. Site description kindly provided by Reinard Falk from Bundesamt für Kartographie und Geodäsie, Germany

The only way one currently has to verify their good working order is via a simultaneous comparison with other absolute gravimeters of the same and/or if possible even of a different model, to put in evidence systematic errors.

During a comparison, we cannot estimate how accurate the meters are: in fact, as we have no way to know the true value of g, we can only investigate the relative offsets between instruments. This means that all instruments can suffer from the same unknown and undetectable systematic error. In addition, differences larger than the uncertainty of the measurements, is an indication of possible systematic error.

For the first comparison in Walferdange, 15 meters from 13 countries including 5 types of absolute gravimeters were present: 1 JILAg, 11 FG5's with bulk and fiber interferometer, 2 A10's, and 1 prototype from the Istituto di Metrologia "G. Colonnetti" of Turin, IMGC#02. For the first time, simultaneous observations were taken by all instruments in the same room.

An original experiment was also conducted to estimate the observational error introduced into the measurements by the operators themselves.

The final offsets of each instruments are calculated using the data of the official 3-day comparison but also using all the data collected before, during and after the comparison. The results are quite similar.

We also apply weighting to the g-values of the different gravimeters. Overall, there is no impact on the final result as all the instruments except the A#10 have quite the same precision.

2. Protocol

Ideally to compare gravimeters, they should measure at the same site at the same time. Obviously, this is practically impossible. The comparison was spread over three days. The first day, each instrument was installed at one of the 15 sites. The second day, as the WULG is composed of three different platforms, all instruments moved to another site on a different platform and again on the third day. Overall, each instrument occupied at least 3 sites one on each platform. We also planned the observations in such a way, that two different instruments which occupied the same site, did not measure at another common site again. This allows us to compare each instrument to as many other instruments possible.

Some teams arrived a few days before the comparison and others teams did stay longer afterward. We give the results for adjustments with the data collected during the "official" 3-day comparison and also with the all the g-values measured a few days before, during and after the comparison.

The time table of the site occupation for each instrument is given in Table 2. Due to power supply problems, the observations of the A10#006 were extremely unreliable. The owner of the instrument proposed to discard the data from the all comparison. The FG5#211 measured after the official comparison due to a delay in the shipment.

The data of the 6^{th} of November were collected by the Micro-g Solutions Inc. operators to test the error of the usual engineers. These data will not be used at all in the adjustment of the g-values.

3. Data reduction

Raw data of the absolute gravimeters consist of vectors of time intervals between successive positions of the falling object during the drops. To obtain the gravity value, a linear equation representing the equation of motion, including the vertical gravity gradient which has been measured with relative meters (see below), is fit to the raw data. The procedures followed are the same as those implements for the comparisons in Sèvres (Francis and van Dam, 2003). Geophysical corrections are applied to the raw gravity data: earth tides using observed tidal parameters (Table 3) from the superconducting gravimeter GWR-CT040 installed in a gallery next to the laboratory, atmospheric pressure using a constant admittance of –0.3 μGal/mbar and the polar motion effect using pole positions from IERS (http://hpiers.obspm.fr/eop-pc/).

3.1 Vertical gravity gradient

The vertical gravity gradients were measured by three different operators (O. Francis, M. Van Camp and Ph. Richard) with two Scintrex's CG3-M and one Scintrex CG5 (Table 1). The measurements were performed the week-end before the comparison. All the data were processed by O. Francis.

Due to the slight non-linearity of the vertical gravity gradient, two different values were used: one for the equation of motion (Table 4) and another one for the transfer from the observed height (so-called Z_{top} in Table 7) to a common height of 1.30 m (Table 5). However, for the FG5's the same values of the vertical gravity gradient were used for the equation of motion and the transfer as the observed height for these instruments is close to 1.30 m.

3.2 Clock and barometer calibrations

Comparisons between the rubidium clocks and the barometers were carried out by M. Van Camp and R. Falk. They used their own rubidium clock carefully calibrated at their institutes as secondary standards. The clocks of most of the gravimeters were compared by measuring the time taken for the tested clock to shift by a complet cycle with respect to the reference clock on an oscilloscope. This method is known as phase difference method (Stein, 1990). Its precision is around 0.1 mHz. A 1 mHz error on the 10 mHz of the gravimeter clock causes a 0.2 μGal error if no correction is applied. he clock calibration results are provided in Table 6.

The barometers were calibrated using a transportable barometer. The calibration was obtained by taking a few simultaneous readings. Due to the lack of time, one could not measure over a few days (or over large pressure variations) to check the linearity of the sensor. All the results are given in Table 6 and were used in data processing.

Most of the data were processed with the "g-soft" version 4.0 from Micro-g Solutions Inc. which runs on Microsoft Windows®. However, the JILAg gravimeter operating with old electronics is not compatible and the program, "Replay", from "Olivia" was used. This early version of the software contains the same coded algorithms for computing the g-values and the geophysical corrections as in "g-soft". The only difference is in the data input format.

4. Errors due to the operators

An original experiment to estimate the operators' error has been performed with the agreement of all the participants. After the third day, all the operators of the FG5s and one A10 left their instruments in the hands of engineers from Micro-g Solutions Inc., the manufacturer of the FG5. The instruments remained at the same site but were run by Micro-g engineers.

The results (Figure 4) show that the measurements agree within the error bar of the observations. There are two exceptions: a systematic error of –2.7 μGal was detected by one of the Micro-g engineers on the FG5#211 due to a bad collimation the laser and an anomalous offset on the FG5#216 which cannot be due to an operator error as to help the organizer, the FG5#216 was operated the all week by Micro-g Solutions Inc. experts.

This unique experiment shows that FG5 and A10 operators of this comparison are highly well trained.

5. Adjustment of the data

5.1 The data

Measurements from one instrument (A10#006) were discarded due to a problem with the power supply. The data from site A1 were not included in the final adjustment as only one instrument occupied the site. The observations of the prototype gravimeter IMGC#02 were not included in the adjustment because an offset of –46.7 μGal was detected and would have biased the adjustment. The data from the FG5#211 were corrected for an offset of –2.7 μGal due to the collimation error (see previous section).

5.2 Observational equation

Due to the duration of the experiments each gravimeter could not occupy all the sites. To compare their measurements, the following least-square adjustment has been performed:

$$g_{ik} = g_k + e_i$$

where g_{ik} is the gravity value at the site k measured by the instrument i, g_k is the adjusted value at the site k and e_i is the uncertainty containing a systematic component (the offset) and a stochastic component.

5.3 Error assessment and data weighting procedure

In the least-square adjustment, one might be tempted to use the set standard deviation as an estimate of the observational errors. One would like to give less weight to observations or instruments with the largest error bars. This set standard deviation only partially represents the errors in the measurements. Any systematic error (which is what we are trying to estimate) is not included in this error estimate.

As this standard deviation is computed from the residuals (raw observations corrected for a few geophysical corrections), it also includes the error on the models used to correct the observations and not only the instrumental error. The information we need is a measure of the repeatability of observations at one given station. To estimate this stochastic component of the error, we performed an adjustment of the data with the same uncertainty of 2 μGal for all the instruments. Because all the data have an equal weight, the final adjusted g-value at each site will be the average of the g-values obtained for the instruments, which actually occupied the site. In a second step, we calculated the differences between the average value and the g-value obtained for each instrument at the stations where it has been operated. We can them draw a table with these differences and compute the standard deviation (see Tables 9 and 10). The mean values of these differences are a first guest of the systematic error. Its associated standard deviation is an experimental estimate of the repeatability of the instruments that we used to estimate the precision (the stochastic part) of each instrument .

A systematic error of 2 μGal for the FG5s and JILAg and 5 μGal for the A10 were prescribed following the specifications of the manufacturer.

Two data sets will be considered. The first set includes only the data of the 3-day comparison, the second one with all the available data.

5.4 Adjustment of the data from the 3rd of November to the 6th of November 2003

For this adjustment, we use 35 g-values measured at 14 sites by 13 instruments. Each instrument occupied one station per day. A first adjustment of the data is obtained by prescribing uniform observational errors to each gravimeter. This first iteration allows us to determine the uncertainties of the gravimeters that will be used as a weight in the second iteration.

5.4.1 *Unweigthed adjustment*

Table 8 gives the adjusted g-value for each site combining the 3-day data assuming the same observational error of 2 μGal for each instrument. Because a uniform weight was applied, the adjusted values are simply the arithmetic mean of the g-values obtained at the same site with the different gravimeters.

In Table 9, the difference between the adjusted g-values from Table 8 at each site and the actual g-values of each individual instrument is given. The average differences gives the instrument offset while the standard deviations provide an estimate of the repeatability of the gravimeter. The uncertainties are calculated by combining the standard deviation with a systematic error of 2 μGal for the FG5s and JILAg and 5 μGal for the A10. The uncertainties listed in the last column of Table 9 are the weights that will be used for the weighted adjustment presented in the next section.

5.4.2 *Weigthed adjustment*

A new adjustment of the data is carried out using the estimated uncertainties of the gravimeters in the previous section as a weighting factors. The results of the adjustment is given in Table 10.

In Table 11, the difference between the weighted adjusted g-values from Table 10 at each site and the actual g-values of each individual instrument is given. The average differences gives the instrument offset while the standard deviation gives an estimate of the repeatability of the gravimeter. The uncertainties are calculated by combining the standard deviation with a systematic error of 2 μGal for the FG5s and JILAg and 5 μGal for the A10.

5.5 Adjustment with all the data

In this section, we used all the available data except the data collected by the Micro-g Solutions Inc. operators on the night between the 6th and 7th of November. It involves 13 instruments, 14 sites and 50 g-values.

5.5.1 *Unweighted adjustment*

The procedure here is exactly the same as the one described in Section 5.4.1. The results are given in Tables 12 and 13.

5.5.2 *Weighted adjustment*

The procedure is exactly the same as the one described in Section 5.4.2. The results of the weighted adjustment using the complete set of data are given in Tables 14 and 15. Results of Table 15 are shown in Figure 4.

The standard deviation of the relative offset between the different instruments varies from 1.8 for the unweighted solution to 1.9 μGal for the weighted solution if we exclude the prototype instrument IMGC#02 which has an offset of –46.7 μGal (Figures 5). It is worth noting that all the error bars cross the zero line. The A10 shows the largest offset and uncertainty as we could expect from the specifications of the instrument: repeatability and accuracy of 10 μGal.

6. Discussion

The final results (Table 16) show that all the gravimeter measurements agree within a standard deviation of 1.4 μGal and 1.8 μGal for the 3-day comparison if the prototype gravimeter (IMGC#02) is excluded. If all the data before and after the 3-day comparison are used, the final result is almost identical. These are the best results ever obtained in past comparisons.

In the data adjustment, we first assigned equal weight to all the gravimeters observations. In a second step, we estimated a weight for the observations from each instrument based on the repeatability and the accuracy specifications of each gravimeter. We found out that the weights were very similar for all the FG5s and slightly different for the A-10. The impact of the final results is insignificant. It mainly due to the repeatability of the observations for each gravimeters that can be attributed to the instrument robustness and to the skill of the operators.

We investigated the possibility that a potential bias exists between the FG5s equipped with the bulk interferometer and those with the fiber interferometer (Personal communication, T. Baker). The results are shown in Table 17. It seems that the FG5s with the bulk interferometer give a g-value of 1 μGal higher in average. These results should be considered as very preliminary as the sampling (3 and 8 FG5s of each type, respectively) is certainly not statistically significant. Moreover, the error bars are almost overlapping. It would be interesting to collect data from as many comparisons as possible to increase the data set to obtain more definitive results.

To conclude, we compare the results of ICAG-03 with the previous comparisons at the Bureau International des Poids et Mesures (BIPM) (Robertsson et al., 2001; Vitushkin et al., 2002) in Sèvres (Figure 6). The objectives of the comparison in Paris being slightly different than in Waferdange, one must inerpret a direct comparison with caution. First, the site in Walferdange has a few advantages: (a) the anthropongenic noise is very low; (b) All the

FG5s can measure on 15 piers simultaneously reducing the entire comparison to 3 days, and having the effect of reducing noise due to unmodelled geophysical gravity variations that would be expected to occur over longer periods; and (c) the engineers of Micro-g Solutions Inc. were on hand to tune the instruments before the comparison. A second goal of the Walferdange comparison is for the participants to not only get an estimate of their instrument offset but also to leave with a properly operating gravimeter. The comparison in Walferdange, as it has been organised, does not conform to the same metrological regulations has been imposed at the BIPM up to now. Finally, except for one prototype instrument, all the gravimeters that took part in the comparison in Walferdange have been built by the same manufacturer. This is not the case for comparisons held at the BIPM where the variety of the gravimeters is one of the reason of the biggest dispersion of the results.

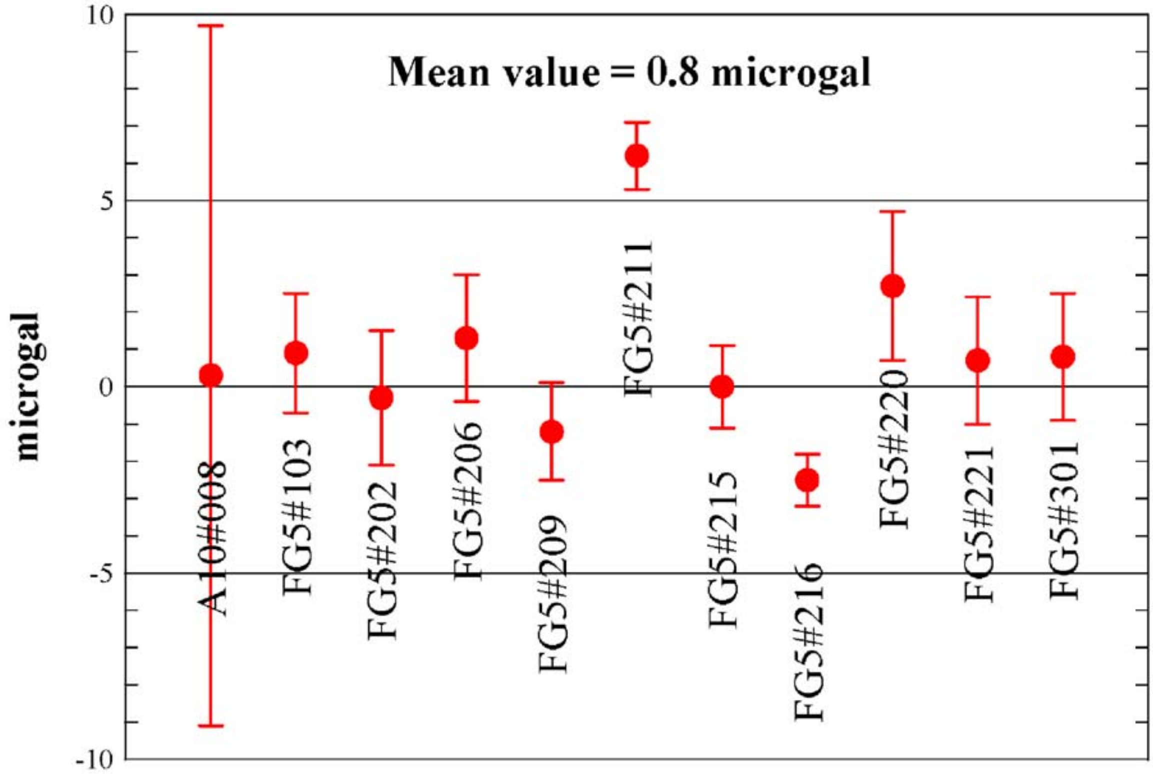
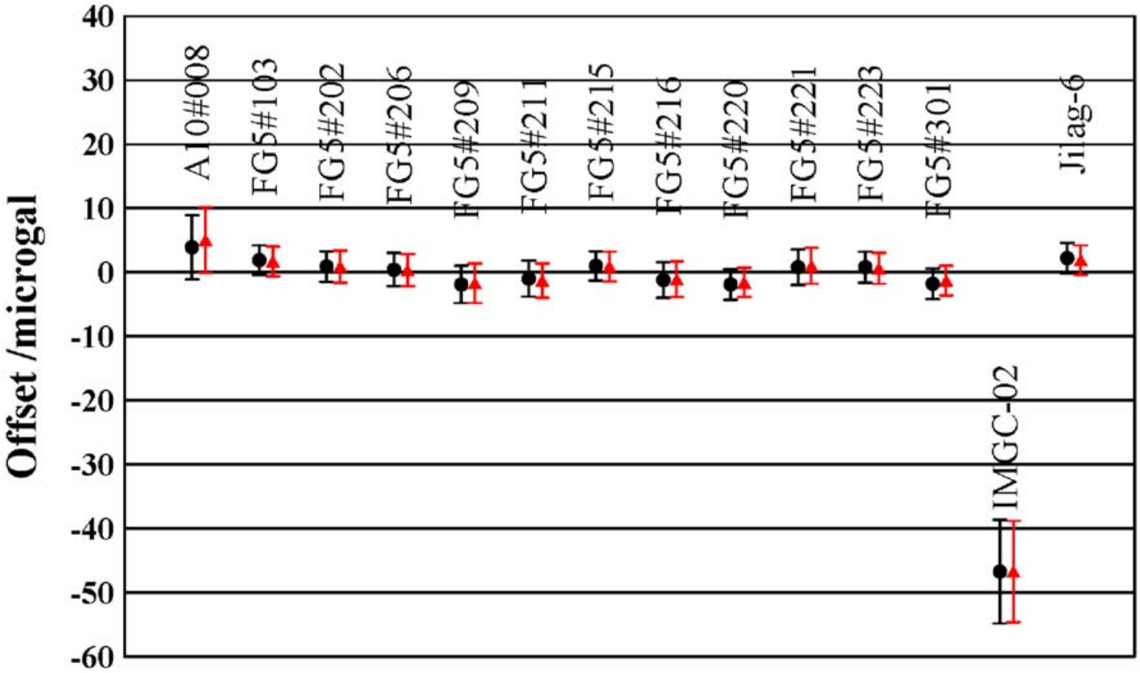
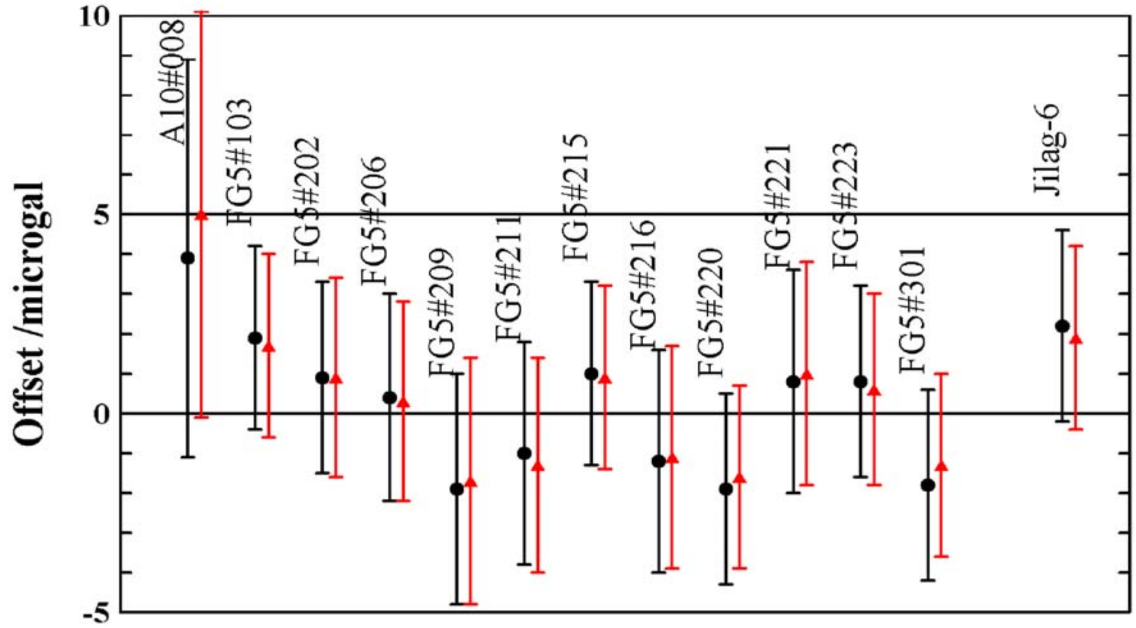


Figure 4. Difference in the gravity values as measured by the usual operators and the expert operators from Micro-g Solutions Inc.





Figures 5. Relative offsets between the gravimeters for the unweighted (black dots) and weighted (red triangles) adjustments.

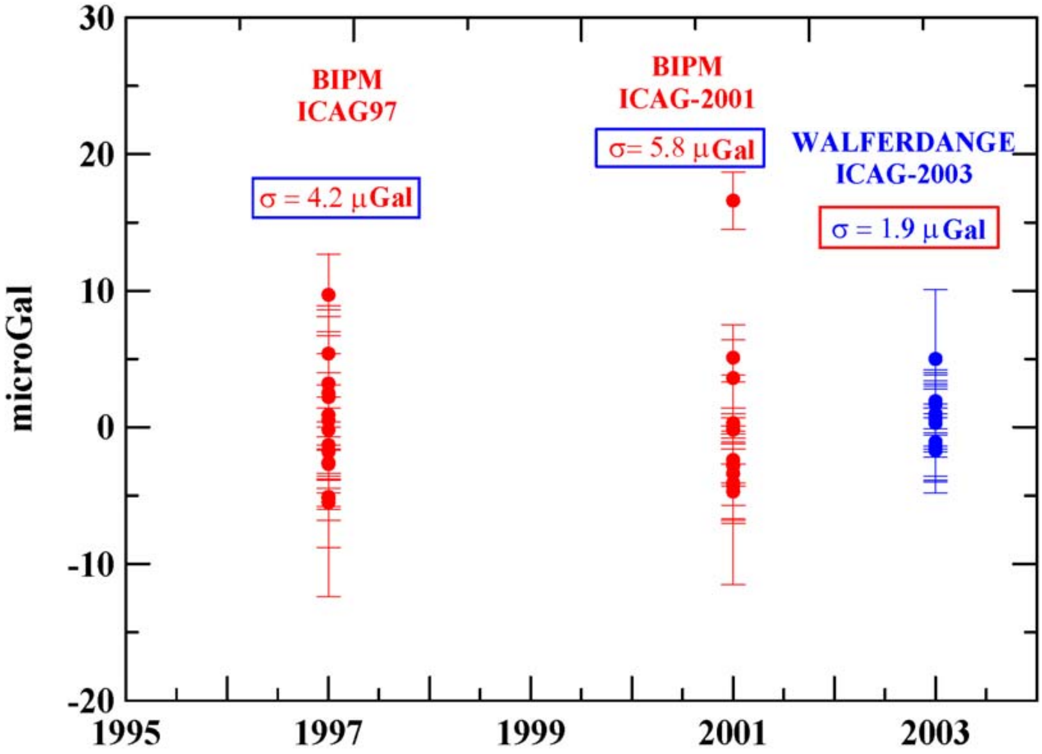


Figure 6. Comparison of the results of the ICAG97, ICAG-2001 at the BIPM in Sèvres and the ICAG-2003 in Walferdange

7. Conclusions

The comparison of absolute gravimeters held in Walferdange shows an agreement between the participating gravimeters at 1.9 μGal (1 standard deviation), exclude one prototype instrument. This the best agreement ever achieved during an comparison. The quality of this result is due to a number of factors: a very good site with stability in temperature and low microseismic noise, excellent operators, the ability to have all measurements in a span of a few days, a helpful and cooperative interaction between the participants, and the engineer support provided by Micro-g Solutions Inc. during the experiment.

This experiment marks the recognition of the WULG as high quality site for absolute gravimeter comparisons. It is expected, that these comparisons will occur regularly as a complement to the comparisons at the BIPM.

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Table 1. Participants in the International Comparison of Absolute Gravimeters in Walferdange of November 2003.

Country	Institution	Absolute gravimeter	Scintrex gravimeter
Austria	Bundesamt für Eich- und Vermessungswesen, Vienna	JILAg#6	
Belgium	Observatoire Royal de Belgique, Brussels	FG5#202	CG3M#256
Brazil	Observatorio Nacional, Rio de Janeiro	FG5#223	
Finland	Finnish Geodetic Institute, Masala	FG5#221	
France	École et Observatoire des Sciences de la Terre, Strasbourg	FG5#206	
Germany	Institut für Erdmessung, Universität Hannover, Hannover	FG5#220	
Germany	Bundesamt für Kartographie und Geodäsie, Frankfurt	FG5#301	
Italy	Istituto di Metrologia “G. Colonnetti”, Turin	IMGC#02	
Luxembourg	European Center for Geodynamics and Seismology, Walferdange	FG5#216	CG5#021210008
Czech Republic	RIGTC, Geodetic Observatory Pecny	FG5#215	
Spain	Instituto Geográfico Nacional, Madrid	FG5#211	
	"	A10#002	
Switzerland	Swiss Federal Office of Metrology and Accreditation, Bern	FG5#209	CG3M#494
UK	Proudman Oceanographic Laboratory, Bidston	FG5#103	
USA	United States Geological Survey, Tucson	A10#008	

Table 2. Time table of the site occupation.

Instrument	29/10	30/10	31/10	01/11	02/11	03/11	04/11	05/11	06/11*	07/11	08/11
A10#006						B2	C2		A3		
A10#008							B1	C2	C2	A1	
FG5#103						B5	C5	A1	A1		
FG5#202		B3		C5		C4	B4	B1	B1		
FG5#206						B3	C3	A4	A4		
FG5#209			C4		B3	C2	A2	B4	B4		
FG5#211						B4	C4	A5	A5	A4	
FG5#215						A5	B5	C1	C1		
FG5#216	B3		B5		C2	C5	A5	B2	B2	C3	C1
FG5#220						A2	B2	C3	C3		
FG5#221						C3	A3	B5	B5	B1	C1/A2
FG5#223**									C5	B4	A4
FG5#301						B1	C1	A2	A2		
IMGC#02						C1	A1	B3			
JILAg#6						A3	B3	C4	C4		

*All the FG5’s and the A10#008 operated by Micro-g Solutions Inc. engineers.
** Due to a delay in the shipping , the measurements by FG5#223were performed after the "official" time schedule for the comparison.

Table 3. Observed tidal parameters (delta factor and phase alpha) for Walferdange from the tidal analysis of one year of the superconducting gravimeter GWR-CT040. For the DC, long-periods, M_3 and M_4 tides, the theoretical values have been used.

Wave	from (cpd)	To (cpd)	Amplitude Factor	Phase Lead (degree)
DC	0.000000	0.002427	1.00000	0.0000
Long Periods	0.002428	0.249951	1.16000	0.0000
Q_1	0.721500	0.906315	1.14218	-1.4047
O_1	0.921941	0.940487	1.15001	0.1310
M_1	0.958085	0.974188	1.16448	1.1522
K_1	0.989049	1.011099	1.13628	0.3612
J_1	1.013689	1.044800	1.17370	0.8380
OO_1	1.064841	1.216397	1.17638	4.7836
$2N_2$	1.719381	1.872142	1.12839	3.3773
N_2	1.888387	1.906462	1.18419	3.5318
M_2	1.923766	1.942754	1.19031	2.5519
L_2	1.958233	1.976926	1.19620	2.7367
S_2	1.991787	2.182843	1.19406	1.1885
M_3	2.753244	3.081254	1.05599	0.0000
M_4	3.791964	3.937897	1.05000	0.0000

Table 4. Vertical gravity gradient used in the equation of motion.

Site	Vertical gravity gradient			
	at 0.55 m µGal/m	at 0.70 m µGal/m	at 0.84 m µGal/m	at 1.20 m µGal/m
A1	-294.8±2.3	-279.5±1.3	-266.5±1.2	-289.7±2.0
A2		-276.2±1.3		-271.5±1.9
A3		-263.9±1.3		-262.0±2.0
A4				-267.7±2.3
A5				-262.9±2.3
B1		-287.2±1.3		-288.1±1.9
B2		-276.2±1.4		-277.6±2.0
B3	-275.2±2.2		-271.8±1.2	-274.6±1.8
B4				-264.5±2.0
B5				-267.7±2.0
C1	-276.6±2.2			-275.7±1.9
C2		-271.5±1.2		-273.0±1.7
C3				-271.9±1.0
C4			-257.7±0.7	-261.6±1.0
C5				-264.2±1.0

Table 5. Vertical gravity gradient used to transfer the g-values from the observed height to 1.30 m. The uncertainties are on average less than 2 μGal/m.

Site	Vertical Gravity Gradient		
	from 0.55 m to 1.30 m μGal/m	from 0.70 m to 1.30 m μGal/m	from 0.84 m to 1.30 m μGal/m
A1	-256.7	-249.1	-270.9
A2		-272.2	
A3		-269.6	
A4			
A5			
B1		-284.5	
B2		-272.2	
B3	-270.8		-269.1
B4			
B5			
C1	-269.5		
C2		-266.9	
C3			
C4			-254.0
C5			

Table 6. Calibration values of the clock and barometer of each gravity meter (calibration made by M. Van Camp and R. Falk). The precision is about 0.1 mHz. For the A10#006, the manufacturer specified an instrument offset that should be applied to the observations.

Instrument	Clock Frequency $/s^{-1}$	Barometer offset /mbar	Barometer Multiplier mbar/volt	Instrument Offset* /μGal	Interferometer Type
A10#006	10 000 000.00066	1.5000	1.0000	5	N/A
A10#008	10 000 000.00180	0.7900	1.0000	0	N/A
FG5#103	10 000 000.00790	-0.3000	1.0000	0	Bulk
FG5#202	10 000 000.00410	1.0272	0.9983	0	Bulk
FG5#206	9 999 999.99700	-1.4500	1.0000	0	Fiber
FG5#209	10 000 000.01055	-5.2464	1.0047	0	Fiber
FG5#211	9 999 999.98400	1.4000	1.0000	0	Fiber
FG5#215	10 000 000.00087	0.4100	1.0000	0	Bulk
FG5#216	10 000 000.00810	0.3400	1.0000	0	Fiber
FG5#220	10 000 000.00600	-1.2600	1.0000	0	Fiber
FG5#221	10 000 000.01030	0.9300	1.0000	0	Fiber
FG5#223	10 000 000.00350	0.7000	1.0000	0	Fiber
FG5#301	10 000 000.00220	0.0000	1.0000	0	Fiber
JILAg#6	10 000 000.02320	0.0000	1.0000	0	Bulk

* This is a correction determined by the manufacturer.

Table 7. Results of the absolute gravity measurements during ICAG-2003 (expressed in μGal after subtraction of the reference value g_r = 980 960 000 μGal).

Date (2003)	Gravimeter	Site	#sets/ #drops	Z_{int}	Z_{ref}	Gradient	Z_{top}	g at Z_{top}	Gradient from Z_{top} to 1.30 m	g at 1.30 m	Standard Deviation	Polar Motion X	Polar Motion Y	Start fringe/ # of fringes
				/m	/m	/μgal/cm	/m	/μgal	/μgal/cm	/μgal	/μgal	arsec	arcsec	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3-4 nov.	A10#006	B2	42/200	0,0000	0,6980	-2,762	70	4229,57	-2,722	4066,25	12,45	0,203	0,217	45-650
4-5 nov.	"	C2	12/100	0,0000	0,6980	-2,715	70	4004,73	-2,669	3844,59	13,59	0,200	0,214	45-600
6-7 nov.	"	A3	48/100	0,0000	0,6980	-2,639	70	4201,26	-2,696	4039,50	10,29	0,198	0,211	45-650
4-5 nov.	A10#008	B1	44/100	-0,0060	0,7040	-2,872	70	4253,29	-2,845	4082,59	7,81	0,200	0,214	10-180
5-6 nov.	"	C2	40/100	-0,0060	0,7040	-2,715	70	4114,23	-2,669	3954,09	9,19	0,198	0,211	10-180
6-7 nov.	"	C2	24/200	-0,0060	0,7040	-2,715	70	4114,56	-2,669	3954,42	1,78	0,196	0,208	10-190
7 nov.	"	A1	24/200	-0,0060	0,7040	-2,795	70	4397,83	-2,491	4248,37	2,47	0,195	0,206	10-190
3-4 nov.	FG5#103	B5	15/200	0,5040	0,8087	-2,677				4054,32	1,25	0,203	0,217	20-600
4-5 nov.	"	C5	17/200	0,5000	0,8087	-2,642				3943,85	2,80	0,200	0,214	20-600
5-6 nov.	"	A1	16/200	0,4980	0,8087	-2,897				4229,96	0,52	0,198	0,211	20-600
6-7 nov.	"	A1	13/100	0,4980	0,8087	-2,897				4230,86	1,53	0,196	0,208	20-600
30-31 oct.	FG5#202	B3	14/100	0,5032	0,8071	-2,746				4069,87	1,81	0,211	0,225	34-640
1-2 nov.	"	C5	43/100	0,4995	0,8071	-2,642				3943,81	0,91	0,207	0,222	34-640
3-4 nov.	"	C4	21/100	0,5009	0,8071	-2,616				3949,86	1,23	0,203	0,217	34-640
4-5 nov.	"	B4	18/100	0,5030	0,8071	-2,645				4065,60	1,82	0,200	0,214	34-640
5-6 nov.	"	B1	20/100	0,5010	0,8071	-2,881				4079,51	1,63	0,198	0,211	34-640
6-7 nov.	"	B1	9/100	0,5010	0,8071	-2,881				4079,23	0,84	0,196	0,208	34-640
3-4 nov.	FG5#206	B3	17/100	0,1455	1,1645	-2,746				4072,18	0,80	0,203	0,217	18-610
4-5 nov.	"	C3	17/100	0,1415	1,1645	-2,719				3951,48	1,20	0,200	0,214	18-610
5-6 nov.	"	A4	22/100	0,1430	1,1645	-2,677				4192,38	1,54	0,198	0,211	18-610
6-7 nov.	"	A4	12/100	0,1430	1,1645	-2,677				4193,63	0,75	0,196	0,208	18-610
31 oct.-1 nov.	FG5#209	C4	25/100	0,1345	1,1625	-2,616				3944,73	0,70	0,209	0,223	30-600
2-3 nov.	"	B3	19/100	0,1378	1,1625	-2,746				4068,87	0,77	0,205	0,220	30-600
3-4 nov.	"	C2	18/100	0,1360	1,1625	-2,730				3947,28	1,51	0,203	0,217	30-600
4-5 nov.	"	A2	7/100	0,1380	1,1625	-2,715				4215,15	0,79	0,200	0,214	30-600
5-6 nov.	"	B4	13/100	0,1385	1,1625	-2,645				4061,39	1,07	0,198	0,211	30-600
6-7 nov.	"	B4	12/100	0,1385	1,1625	-2,645				4060,17	0,70	0,196	0,208	30-600
3-4 nov.	FG5#211	B4	12/100	0,1360	1,1638	-2,645				4060,46	0,83	0,203	0,217	30-600
4-5 nov.	"	C4	12/100	0,1367	1,1638	-2,616				3951,61	0,62	0,200	0,214	30-600
5-6 nov.	"	A5	13/100	0,1355	1,1638	-2,629				4179,19	0,65	0,198	0,211	30-600
6-7 nov.	"	A5	13/100	0,1355	1,1638	-2,629				4185,43	0,61	0,196	0,208	30-600
7-8 nov.	"	A4	12/100	0,1335	1,1638	-2,677				4191,96	0,67	0,195	0,206	30-600
3-4 nov.	FG5#215	A5	14/150	0,4966	0,8075	-2,629				4184,20	0,94	0,203	0,217	20-610
4-5 nov.	"	B5	20/150	0,4974	0,8075	-2,677				4051,62	0,69	0,200	0,214	20-610
5-6 nov.	"	C1	19/150	0,4993	0,8075	-2,757				3952,56	0,87	0,198	0,211	20-610
6-7 nov.	"	C1	12/100	0,4993	0,8075	-2,757				3952,56	0,64	0,196	0,208	20-610
29-30 oct.	FG5#216	B3	12/100	0,1275	1,1640	-2,746				4067,38	0,80	0,212	0,227	20-600
31 oct.-1 nov.	"	B5	12/100	0,1250	1,1640	-2,677				4047,73	0,69	0,211	0,225	20-600
2-3 nov.	"	C2	12/100	0,1245	1,1640	-2,730				3948,01	0,94	0,205	0,220	20-600
3-4 nov.	"	C5	16/100	0,1220	1,1640	-2,642				3939,90	0,86	0,203	0,217	20-600
4-5 nov.	"	A5	16/100	0,1260	1,1640	-2,629				4182,27	0,67	0,200	0,214	20-600
5-6 nov.	"	B2	14/100	0,1225	1,1640	-2,776				4072,07	0,46	0,198	0,211	20-600
6-7 nov.	"	B2	12/100	0,1225	1,1640	-2,776				4069,62	0,46	0,196	0,208	20-600
7-8 nov.	"	C3	17/100	0,1215	1,1640	-2,719				3949,15	0,85	0,195	0,206	20-600
8-9 nov.	"	C1	24/100	0,1235	1,1640	-2,757				3951,89	1,03	0,193	0,203	20-600
3-4 nov.	FG5#220	A2	14/100	0,1203	1,1640	-2,715				4211,52	1,16	0,203	0,217	15-600
4-5 nov.	"	B2	14/100	0,1188	1,1640	-2,776				4069,04	2,43	0,200	0,214	15-600
5-6 nov.	"	C3	15/100	0,1175	1,1640	-2,719				3949,08	1,55	0,198	0,211	15-600
6-7 nov.	"	C3	12/100	0,1175	1,1640	-2,719				3949,11	1,25	0,196	0,208	15-600
3-4 nov.	FG5#221	C3	15/100	0,1185	1,1629	-2,719				3951,23	1,01	0,205	0,220	30-600
4-5 nov.	"	A3	19/100	0,1200	1,1629	-2,620				4209,14	1,61	0,200	0,214	30-600
5-6 nov.	"	B5	16/100	0,1210	1,1629	-2,677				4052,79	1,33	0,198	0,211	30-600
6-7 nov.	"	B5	14/100	0,1210	1,1629	-2,677				4053,44	1,03	0,196	0,208	30-600
7-8 nov.	"	B1	16/100	0,1205	1,1629	-2,881				4077,66	1,74	0,195	0,206	30-600
8 nov.	"	C1	9/100	0,1205	1,1629	-2,757				3952,88	1,66	0,193	0,203	30-600
8-9 nov.	"	A2	21/100	0,1220	1,1629	-2,715				4218,70	1,25	0,193	0,203	30-600
6-7 nov.	FG5#223	C5	11/100	0,1265	1,1640	-2,642				3943,83	1,17	0,196	0,208	20-600
7-8 nov.	"	B4	15/100	0,1240	1,1640	-2,645				4061,70	1,25	0,195	0,206	20-600
8-9 nov.	"	A4	14/100	0,1220	1,1640	-2,677				4195,22	1,34	0,193	0,203	20-600
3-4 nov.	FG5#301	B1	13/100	0,1387	1,1635	-2,881				4076,06	1,44	0,203	0,217	30-600
4-5 nov.	"	C1	22/100	0,1370	1,1635	-2,757				3949,73	1,39	0,200	0,214	30-600
5-6 nov.	"	A2	9/100	0,1363	1,1635	-2,715				4214,59	1,48	0,198	0,211	30-600
6-7 nov.	"	A2	12/100	0,1363	1,1635	-2,715				4215,43	0,90	0,196	0,208	30-600
3 nov.	IMGC#02	C1	299	0,2269	0,3240	-2,766	55	4101,70	-2,695	3899,56	2,50	0,203	0,217	
4 nov.	"	A1	325	0,2277	0,3240	-2,948	55	4382,80	-2,567	4190,30	2,20	0,200	0,214	
5-6 nov.	"	B3	410	0,2283	0,3240	-2,752	55	4231,90	-2,708	4028,80	1,90	0,198	0,211	
3-4 nov.	JILAg#6	A3	12/100	0,9710	-0,0549	-2,665	84	4336,60	-2,709	4211,99	1,69	0,203	0,217	20-680
4-5 nov.	"	B3	12/100	0,9800	-0,0549	-2,718	84	4195,30	-2,691	4071,51	1,83	0,200	0,214	20-680
5-6 nov.	"	C4	12/100	0,9710	-0,0549	-2,577	84	4062,40	-2,540	3945,56	2,06	0,198	0,211	20-680
6-7 nov.	"	C4	12/100	0,9710	-0,0549	-2,577	84	4070,50	-2,540	3953,66	3,83	0,196	0,208	20-680

1. Date of the measurements.
2. Gravimeter.
3. Site.
4. Number of sets and number of drops per set.
5. Instrument height as given by the manufacturer.
6. Reference height as measured by the operator.
7. Vertical gravity gradient used in the equation of motion of the gravimeters.
8. Height of the observations (Z_{inst} + Z_{ref}). For the FG5's, the g-value was calculated directly at 1.30 m using the same gradient for the equation of motion and for the transfer from Z_{top} to 1.30 m.
9. The g-value at Z_{top} expressed in μGal.
10. Vertical gravity gradient used to transfer the g-value from Z_{top} to 1.30 m.
11. The g-value at 1.3 m expressed in μGal.
12. Weighted set standard deviation of g-value in μGal.
13. X pole position from the International Earth Rotation Service.
14. Y pole position from the International Earth Rotation Service.
15. Scaled fringes: starting fringe; number of fringes fitted.

Table 8. g-values at the different sites using the 3-day data from the 4th to the 6th of July. No weight was apply to the data. An observational error of 2 μGal has been prescribed for each gravimeter.

Site	Gravity value /μGal
A2	4213.8 +/- 0.8
A3	4210.5 +/- 1.0
A4	4192.4 +/- 1.4
A5	4181.9 +/- 0.8
B1	4079.4 +/- 0.8
B2	4070.5 +/- 1.0
B3	4071.8 +/-1.0
B4	4062.5 +/- 0.8
B5	4052.9 +/- 0.8
C1	3951.1 +/- 1.0
C2	3950.7 +/- 1.0
C3	3950.0 +/- 0.8
C4	3951.7 +/- 0.8
C5	3942.5 +/- 0.8

Table 9. Comparison between the g-values measured by the gravimeters with the adjusted values (Table 8). The mean difference is the offset of the gravimeter. The standard deviation is a measure of the repeatability of each instrument that will help in estimating the uncertainty that will be used to weight the data in the second iteration.

Instrument	Site	g-value measured by the instrument /µGal	Adjusted g-value at the site /µGal	Difference /µGal	Mean Difference /µGal	Standard Deviation /µGal	Uncertainty* /µGal
A10#008	B1	4082.6	4079.4	3.2			
A10#008	C2	3954.1	3950.7	3.4	3.3	0.1	5.0
FG5#103	B5	4054.3	4052.9	1.4			
FG5#103	C5	3943.9	3942.5	1.4	1.4	0	2.0
FG5#202	B1	4079.5	4079.4	0.1			
FG5#202	B4	4065.6	4062.5	3.1	0.5	2.5	3.2
FG5#202	C4	3949.9	3951.7	-1.8			
FG5#206	A4	4192.4	4192.4	0.0			
FG5#206	B3	4072.2	4071.8	0.4	0.0	0.4	2.0
FG5#206	C3	3949.6	3950.0	-0.4			
FG5#209	A2	4215.2	4213.8	1.4			
FG5#209	B4	4061.4	4062.5	-1.1	-1.0	2.4	3.1
FG5#209	C2	3947.3	3950.7	-3.4			
FG5#211	A5	4179.2	4181.9	-2.7			
FG5#211	B4	4060.5	4062.5	-2.0	-1.6	1.3	2.4
FG5#211	C4	3951.6	3951.7	-0.1			
FG5#215	A5	4184.2	4181.9	2.3			
FG5#215	B5	4051.6	4052.9	-1.3	0.8		2.8
FG5#215	C1	3952.6	3951.1	1.5			
FG5#216	A5	4182.3	4181.9	0.4			
FG5#216	B2	4072.1	4070.5	1.6	-0.2	2.2	3.0
FG5#216	C5	3939.9	3942.5	-2.6			
FG5#220	A2	4211.5	4213.8	-2.3			
FG5#220	B2	4069.0	4070.5	-1.5	-1.6	0.7	2.1
FG5#220	C3	3949.1	3950.0	-0.9			
FG5#221	A3	4209.1	4210.5	-1.4			
FG5#221	B5	4052.8	4052.9	-0.1	-0.1	1.3	2.4
FG5#221	C3	3951.2	3950.0	1.2			
FG5#223	C5	3943.8	3942.5	1.3	1.3	1.3	2.4
FG5#301	A2	4214.6	4213.8	0.8			
FG5#301	B1	4076.1	4079.4	-3.3	-1.3	2.1	2.9
FG5#301	C1	3949.7	3951.1	-1.4			

IMGC#02	B3	4028.8	4071.8	-43			
IMGC#02	C1	3899.6	3951.1	-51.5	-47.2	6.0	N/A
JILAg#6	A3	4212.0	4210.5	1.5			
JILAg#6	B3	4071.5	4071.8	-0.3	1.1	1.2	2.3
JILAg#6	C4	3953.7	3951.7	2.0			

*The uncertainties are calculated by taking the root mean square of the sum of the square of the systematic error (2 μgal for the FG5's and JILAg and 5 μgal for the A10) and the standard deviation. For example: A10#008 weight = sqrt(5.0**^{2}+0.1**^{2}) = 5.0; FG5#301 weight = sqrt(2.0**^{2}+2.1**^{2}) = 2.9.

Table 10. g-values at the different sites using the 3-day data from the 4th to the 6th of July obtained by a weighted adjustment. The weights are the uncertainties of the last column of table 9.

Site	Gravity value /μGal
A2	4213.8 +/- 1.5
A3	4210.5 +/- 1.7
A4	4192.4 +/- 2.0
A5	4181.9 +/- 1.5
B1	4079.4 +/- 2.0
B2	4070.5 +/- 1.7
B3	4071.8 +/-1.5
B4	4062.5 +/- 1.6
B5	4052.9 +/- 1.3
C1	3951.1 +/- 2.0
C2	3950.7 +/- 2.6
C3	3950.0 +/- 1.3
C4	3951.7 +/- 1.5
C5	3942.5 +/- 1.4

Table 11. Comparison between the g-values measured by the gravimeters with the weighted adjusted g-values (Table 10). The mean difference is the offset of the gravimeter. The standard deviation is a measure of the repeatability of each instrument. The final uncertainties are calculated by combining the standard deviation with a systematic error of 2 μGal for the FG5s and JILAg and 5 μGal for the A10.

Instrument	Site	g-value measured by the instrument /μGal	Adjusted g-value at the site /μGal	Difference /μGal	Mean Difference /μGal	Standard Deviation /μGal	Uncertainty* /μGal
A10#008	B1	4082.6	4078.4	4.2			
A10#008	C2	3954.1	3949.2	4.9	4.5	0.5	5.0
FG5#103	B5	4054.3	4053.2	1.1			
FG5#103	C5	3943.9	3943.0	0.9	1.0	0.1	2.0
FG5#202	B1	4079.5	4078.4	1.1			
FG5#202	B4	4065.6	4062.1	3.5	0.8	2.9	3.5
FG5#202	C4	3949.9	3952.1	-2.2			
FG5#206	A4	4192.4	4192.4	0.0			
FG5#206	B3	4072.2	4071.9	0.3	0.0	0.3	2.0
FG5#206	C3	3949.6	3949.9	-0.3			
FG5#209	A2	4215.2	4213.2	2.0			
FG5#209	B4	4061.4	4062.1	-0.7	-0.2	2.0	2.8
FG5#209	C2	3947.3	3949.2	-1.9			
FG5#211	A5	4179.2	4181.6	-2.4			
FG5#211	B4	4060.5	4062.1	-1.6	-1.5	1.0	2.2
FG5#211	C4	3951.6	3952.1	-0.5			
FG5#215	A5	4184.2	4181.6	2.6			
FG5#215	B5	4051.6	4053.2	-1.6	0.8	2.2	3.0
FG5#215	C1	3952.6	3951.2	1.4			
FG5#216	A5	4182.3	4181.6	0.7			
FG5#216	B2	4072.1	4070.0	2.1	-0.1	2.7	3.4
FG5#216	C5	3939.9	3943.0	-3.1			
FG5#220	A2	4211.5	4213.2	-1.7			
FG5#220	B2	4069.0	4070.0	-1.0	-1.2	0.5	2.1
FG5#220	C3	3949.1	3949.9	-0.8			
FG5#221	A3	4209.1	4210.6	-1.5			
FG5#221	B5	4052.8	4053.2	-0.4	-0.2	1.4	2.4
FG5#221	C3	3951.2	3949.9	1.3			
FG5#223	C5	3943.8	3943.0	0.8	0.8	0.8	2.2
FG5#301	A2	4214.6	4213.2	1.4			
FG5#301	B1	4076.1	4078.4	-2.3	-0.8	1.9	2.8
FG5#301	C1	3949.7	3951.2	-1.5			

IMGC#02	B3	4028.8	4071.9	-43.1			
IMGC#02	C1	3899.6	3951.2	-51.6	-47.3	6.0	N/A
JILAg#6	A3	4212.0	4210.6	1.4			
JILAg#6	B3	4071.5	4071.9	-0.4	0.9	1.1	2.3
JILAg#6	C4	3953.7	3952.1	1.6			

Table 12. g-values at the different sites using all the data except the data collected by the Micro-g Solutions Inc. operators on the night between the 6^{th} and 7^{th} of November.. No weight was apply to the data. An observational error of 2 μGal has been prescribed for each gravimeter.

Site	Gravity value /μGal
A2	4215.0 +/- 0.7
A3	4210.5 +/- 1.0
A4	4193.2 +/- 0.8
A5	4181.9 +/- 0.8
B1	4079.0 +/- 0.7
B2	4070.5 +/- 1.0
B3	4070.0 +/- 0.6
B4	4062.3 +/- 0.7
B5	4051.6 +/- 0.7
C1	3951.8 +/- 0.7
C2	3949.8 +/- 0.8
C3	3949.8 +/- 0.7
C4	3950.0 +/- 0.7
C5	3942.8 +/- 0.7

Table 13. Comparison between the g-values measured by the gravimeters with the adjusted values (Table 12). The mean difference is the offset of the gravimeter. The standard deviation is a measure of the repeatability of each instrument that will be used to weight the data in a second iteration.

Instrument	Site	g-value measured by the instrument /µGal	Adjusted g-value at the site /µGal	Difference /µGal	Mean Difference /µGal	Standard Deviation /µGal	Uncertainty* /µGal
A10#008	B1	4082.6	4079.0	3.6			
A10#008	C2	3954.1	3949.8	4.3	3.9	0.5	5.0
FG5#103	B5	4054.3	4051.6	2.7			
FG5#103	C5	3943.9	3942.8	1.1	1.9	1.1	2.3
FG5#202	B1	4079.5	4079.0	0.5			
FG5#202	B3	4069.9	4070.0	-0.1			
FG5#202	B4	4065.6	4062.3	3.3	0.9	1.4	2.4
FG5#202	C4	3949.9	3950.0	-0.1			
FG5#202	C5	3943.8	3942.8	1.0			
FG5#206	A4	4192.4	4193.2	-0.8			
FG5#206	B3	4072.2	4070.0	2.2	0.4	1.6	2.6
FG5#206	C3	3949.6	3949.8	-0.2			
FG5#209	A2	4215.2	4215.0	0.2			
FG5#209	B3	4068.9	4070.0	-1.1			
FG5#209	B4	4061.4	4062.3	-0.9	-1.9	2.1	2.9
FG5#209	C2	3947.3	3949.8	-2.5			
FG5#209	C4	3944.7	3950.0	-5.3			
FG5#211	A4	4192.0	4193.2	-1.2			
FG5#211	A5	4179.2	4181.9	-2.7			
FG5#211	B4	4060.5	4062.3	-1.8	-1.0	1.9	2.8
FG5#211	C4	3951.6	3950.0	1.6			
FG5#215	A5	4184.2	4181.9	2.3			
FG5#215	B5	4051.6	4051.6	0.0	1.0	1.2	2.3
FG5#215	C1	3952.6	3951.8	0.8			
FG5#216	A5	4182.3	4181.9	0.4			
FG5#216	B2	4072.1	4070.5	1.6			
FG5#216	B3	4067.4	4070.0	-2.6			
FG5#216	B5	4047.7	4051.6	-3.9			
FG5#216	C1	3951.9	3951.8	0.1	-1.2	1.9	2.8
FG5#216	C2	3948.0	3949.8	-1.8			
FG5#216	C3	3949.2	3949.8	-0.6			
FG5#216	C5	3939.9	3942.8	-2.9			
FG5#220	A2	4211.5	4215.0	-3.5			
FG5#220	B2	4069.0	4070.5	-1.5	-1.9	1.4	2.4
FG5#220	C3	3949.1	3949.8	-0.7			
FG5#221	A2	4218.7	4215.0	3.7			

FG5#221	A3	4209.1	4210.5	-1.4			
FG5#221	B1	4077.7	4079.0	-1.3			
FG5#221	B5	4052.8	4051.6	1.2	0.8	1.9	2.8
FG5#221	C1	3952.9	3951.8	1.1			
FG5#221	C3	3951.2	3949.8	1.4			
FG5#223	A4	4195.2	4193.2	2.0			
FG5#223	B4	4061.7	4062.3	-0.6	0.8	1.3	2.4
FG5#223	C5	3943.8	3942.8	1.0			
FG5#301	A2	4214.6	4215.0	-0.4			
FG5#301	B1	4076.1	4079.0	-2.9	-1.8	1.3	2.4
FG5#301	C1	3949.7	3951.8	-2.1			
IMGC#02	B3	4028.8	4070.0	-41.2			
IMGC#02	C1	3899.6	3951.8	-52.2	-46.7	7.8	N/A
JILAg#6	A3	4212.0	4210.5	1.5			
JILAg#6	B3	4071.5	4070.0	1.5	2.2	1.3	2.4
JILAg#6	C4	3953.7	3950.0	3.7			

*The uncertainty is calculated by taking the root mean square of the sum of the square of the systematic error (2 μgal for the FG5's and Jilas and 5 μgal for the A10) and the standard deviation. For example: A10#008 weight = sqrt(5.0**^{2}+0.5**^{2}) = 5.0; FG5#301 weight = sqrt(2.0**^{2}+1.3**^{2}) = 2.4.

Table 14. Gravity values at the different sites using the all the data except the data collected by the Micro-g Solutions Inc. operators on the night between the 6th and 7th of November.. The weight from the last column of the table 14 were applied to the data.

Site	Gravity value /μGal
A2	4214.8 +/- 1.3
A3	4210.8 +/- 1.8
A4	4193.4 +/- 1.5
A5	4182.2 +/- 1.5
B1	4078.1 +/- 1.4
B2	4070.4 +/- 1.8
B3	4070.1 +/- 1.2
B4	4062.5 +/- 1.3
B5	4051.9 +/- 1.3
C1	3951.7 +/- 1.3
C2	3948.5 +/- 1.9
C3	3949.7 +/- 1.3
C4	3950.4 +/- 1.3
C5	3943.1 +/- 1.2

Table 15. Comparison between the g-values measured by the gravimeters with the adjusted values (Table 14). The mean difference is the offset of the gravimeter. The standard deviation is a measure of the repeatability of each instrument that will be used to weight the data in a second iteration.

Instrument	Site	g-value measured by the instrument /μGal	Adjusted g-value at the site /μGal	Difference /μGal	Mean Difference /μGal	Standard Deviation /μGal	Uncertainty /μGal
A10#008	B1	4082.6	4078.1	4.5			
A10#008	C2	3954.1	3948.5	5.6	5.0	0.8	5.1
FG5#103	B5	4054.3	4051.9	2.4			
FG5#103	C5	3943.9	3943.1	0.8	1.6	1.1	2.3
FG5#202	B1	4079.5	4078.1	1.4			
FG5#202	B3	4069.9	4070.1	-0.2			
FG5#202	B4	4065.6	4062.5	3.1	0.9	1.4	2.4
FG5#202	C4	3949.9	3950.4	-0.5			
FG5#202	C5	3943.8	3943.1	0.7			
FG5#206	A4	4192.4	4193.4	-1.0			
FG5#206	B3	4072.2	4070.1	2.1	0.3	1.6	2.6
FG5#206	C3	3949.6	3949.7	-0.1			
FG5#209	A2	4215.2	4214.8	0.4			
FG5#209	B3	4068.9	4070.1	-1.2			
FG5#209	B4	4061.4	4062.5	-1.1	-1.8	2.3	3.0
FG5#209	C2	3947.3	3948.5	-1.2			
FG5#209	C4	3944.7	3950.4	-5.7			
FG5#211	A4	4192.0	4193.4	-1.4			
FG5#211	A5	4179.2	4182.2	-3.0			
FG5#211	B4	4060.5	4062.5	-2.0	-1.3	1.8	2.7
FG5#211	C4	3951.6	3950.4	1.2			
FG5#215	A5	4184.2	4182.2	2.0			
FG5#215	B5	4051.6	4051.9	-0.3	0.9	1.2	2.3
FG5#215	C1	3952.6	3951.7	0.9			
FG5#216	A5	4182.3	4182.2	0.1			
FG5#216	B2	4072.1	4070.4	1.7			
FG5#216	B3	4067.4	4070.1	-2.7			
FG5#216	B5	4047.7	4051.9	-4.2			
FG5#216	C1	3951.9	3951.7	0.2	-1.1	2.0	2.8
FG5#216	C2	3948.0	3948.5	-0.5			
FG5#216	C3	3949.2	3949.7	-0.5			
FG5#216	C5	3939.9	3943.1	-3.2			
FG5#220	A2	4211.5	4214.8	-3.3			
FG5#220	B2	4069.0	4070.4	-1.4	-1.8	1.4	2.4
FG5#220	C3	3949.1	3949.7	-0.6			

FG5#221	A2	4218.7	4214.8	3.9			
FG5#221	A3	4209.1	4210.8	-1.7			
FG5#221	B1	4077.7	4078.1	-0.4			
FG5#221	B5	4052.8	4051.9	0.9	0.9	1.9	2.8
FG5#221	C1	3952.9	3951.7	1.2			
FG5#221	C3	3951.2	3949.7	1.5			
FG5#223	A4	4195.2	4193.4	1.8			
FG5#223	B4	4061.7	4062.5	-0.8	0.6	1.3	2.4
FG5#223	C5	3943.8	3943.1	0.7			
FG5#301	A2	4214.6	4214.8	-0.2			
FG5#301	B1	4076.1	4078.1	-2.0	-1.4	1.0	2.2
FG5#301	C1	3949.7	3951.7	-2.0			
IMGC#02	B3	4028.8	4070.1	-41.3			
IMGC#02	C1	3899.6	3951.7	-52.1	-46.7	7.6	N/A
JILAg#6	A3	4212.0	4210.8	1.2			
JILAg#6	B3	4071.5	4070.1	1.4	2.0	1.2	2.3
JILAg#6	C4	3953.7	3950.4	3.3			

Table 16. Relative offsets between the gravimeters for the unweighted and weighted adjustments.

Instrument	Unweighted offset		Weighted offset	
	3-day data /μGal	All the data /μGal	3-day data /μGal	All the data /μGal
A10#008	3.3±5.0	3.9±5.0	4.5±5.0	5.0±5.1
FG5#103	1.4±2.0	1.9±2.3	1.0±2.0	1.6±2.3
FG5#202	0.5±3.2	0.9±2.4	0.8±3.5	0.9±2.4
FG5#206	0.0±2.0	0.4±2.6	0.0±2.0	0.3±2.6
FG5#209	-1.0±3.1	-1.9±2.9	-0.2±2.8	-1.8±3.0
FG5#211	-1.6±2.4	-1.0±2.8	-1.5±2.2	-1.3±2.7
FG5#215	0.8±2.8	1.0±2.3	0.8±3.0	0.9±2.3
FG5#216	-0.2±3.0	-1.2±2.8	-0.1±3.4	-1.1±2.8
FG5#220	-1.6±2.1	-1.9±2.4	-1.2±2.1	-1.8±2.4
FG5#221	-0.1±2.4	0.8±2.8	-0.2±2.4	0.9±2.8
FG5#223	1.3±2.4	0.8±2.4	0.8±2.2	0.6±2.4
FG5#301	-1.3±2.9	-1.8±2.4	-0.8±2.8	-1.4±2.2
JILAg#6	1.1±2.3	2.2±2.4	0.9±2.3	2.0±2.3
Standard Deviation	**1.4**	**1.8**	**1.5**	**1.9**
IMGC#02	-47.2±6.0	-46.7±7.8	-47.3±6.0	-46.7±7.6

Table 17. Comparison between the averaged offsets of the FG5s with bulk and fiber interferometer.

Type of gravimeter	Number of Instruments	Mean offset/μGal
Fiber Interferometer	8	-0.6 ± 1.1
Bulk Interferometer	3	1.2 ± 0.5