



ABSOLUTE GRAVITY MEASUREMENTS AT THE CONRAD OBSERVATORIUM IN AUSTRIA IN JUNE 2012

Final Report

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Foreword

This report contains the results of absolute gravity measurements carried out at the Conrad Observatory in Austria in June 2012. It has been exactly four years since our last measurements in August 2008. The absolute gravimeter FG5X-216 was operated by Olivier Francis and Marc Seil from the University of Luxembourg.

The main objective of this experiment was to calibrate the superconducting gravimeter CT-025: the absolute gravimeter operated simultaneously side-by-side with the superconducting gravimeter on the same pillar as in 2008 for approximately 4 days. The comparison between the times series from both instruments allows us to determine the scale or calibration factor of the superconducting gravimeter CT-025. In addition, the first determination of the SG instrumental drift is now possible using the AG observations of 2008 and 2012.

During the experiment, the absolute gravimeter FG5-242 from the Federal Office of Metrology and Surveying (BEV) occupied a site on the same pillar (see Figure 1). There was also the absolute gravimeter Jilag-6 but it did not operate the all-time.



Figure 1. Picture showing from the front to the back the absolute gravimeters FG5-242 and FG5X-216 and the superconducting gravimeter CT-025 on the same pillar.

We would like to thank Bruno Meurers and Norbert Blaumoser for their warm hospitality and help during our measurements.

This absolute gravity measurements campaign was funded by the University of Luxembourg.

Data processing

Raw data from the absolute gravimeters consist of vectors of time and position of the falling object during the drops. To obtain the gravity value, a linear equation representing the equation of motion is fit to the raw data including the gravity gradient which has been measured with relative meters.

The data processing follows the protocol adopted during absolute gravimeters comparisons at the BIPM in Sèvres (Francis and van Dam, 2003). Geophysical corrections are applied to the raw gravity data: Earth tides using modelled tidal parameters, atmospheric pressure effect using a constant admittance, and the polar motion effect using pole positions from IERS.

The g-soft version 9.120423 software from Microg-LaCoste Inc. was used for the processing. Text outputs as well as some figures are also compiled in this report for future reference.

Vertical Gravity Gradient

The vertical gravity gradient is needed to linearize the equation of motion but also to transfer the measured absolute gravity value from the reference height around 1.3 m to the floor. Bruno Meurers measured the vertical gravity gradient with his Scintrex CG5. He obtained a value -2.710 microGal/cm that we used to process the absolute gravity observations.

Results of the absolute gravity measurements

The FG5X-216 operated from Monday 4th of June 2012 at 00:45:02 until Friday 8th of June 2012 at 06:29:40. The first day (June 4th), we adopted our usual sampling procedure of hourly sets of 200 drops with a time interval of 5 second. The second day, we changed the time sampling according to the wish of Prof Bruno Meurers: continuous measurements with a drop interval of 15 second. The set values and their associated uncertainties are displayed in Figure 2. Each of the 94 hourly sets contains 239 drops. It represents a total of 22066 drops.

In the table hereafter, the absolute gravity values for 2012 are compared with the values of 2008. For this latter, the 2008 raw data have been reprocessed to insure that the same tides corrections are applied as well as the reference height is taken from the top of the rivet on the floor which was put after the measurements in 2008.

Gravimeter	Date	Gravity value /microgal	Set Standard Deviation /microgal
FG5-216	01-05/06/2008	980 647 604.62	0.85
FG5X-216	04/06/2012	980 647 603.18	1.18
FG5X-216	04-08/06/2012	980 647 600.77	2.41

In conclusion, we would like to draw attention to two features of these measurements:

1. The FG5X-216 is the upgraded version of the FG5-216: the dropping length has been increased by one third, the drive system has been redesigned, and the electronics has been modernized.
2. The time interval between the drops was 15 seconds. This is not ideal as the microseismic noise is between 5 and 15 seconds. This noise could be aliased to lower frequencies. This could explain the few outliers of the Figure 2

3. During this experiment, a large gravity change of 8.5 microgal was measured. It would be interesting to compare it with the SG CT-025.

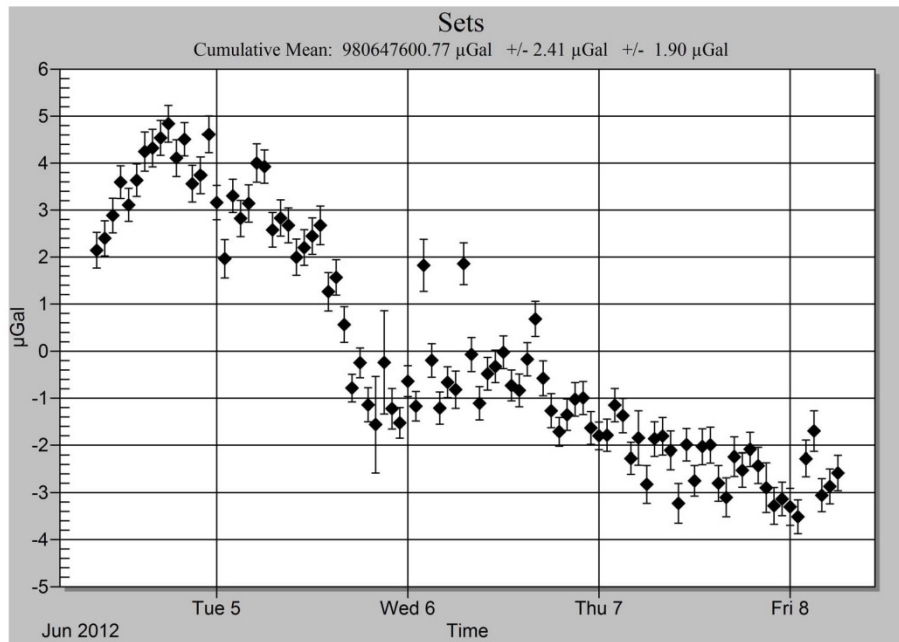


Figure 2. Results of the absolute measurements from the 4th to the 8th of June 2012.

Reference

Francis O., van Dam T.M., Processing of the Absolute data of the ICAG01, Cahiers du Centre Européen de Géodynamique et de Séismologie, vol.22, 45-48, 2003. <https://doi.org/10.5281/zenodo.7890604>

ABSOLUTE MEASUREMENTS IN 2012

STATION: CONRAD OBSERVATORIUM			
City:	PERNITZ	Country:	Austria
Location:	Conrad Observatorium	Particularity:	
Situation:	Gravity Room	Remarks:	Site next to the SG CT025
Date:	4 June 2012		
Code number:	0-075-03		
Latitude:	47.92876 degrees		
Longitude:	15.86090 degrees		
Elevation:	1045.0 m		
Gradient:	-2.710 µgal/cm		
Reference height:	0.1260 m + 1.2583 m = 1.3843 m		
Meter:	FG5X		
S/N:	216		
Tidal corrections using observed tidal parameters			
Polar motion correction		Air pressure correction	
X-coordinate	0.0504 Arc seconds	Nominal air pressure:	983.85 mbar
Y-coordinate	0.3974 Arc seconds	Barometric admittance factor:	0.3 µgal/mbar
Gravity			
Set gravity mean:	980 647 603.18		microgal
Set std. dev.:	1.18		microgal
Mean std. dev.:	8.26		microgal
Number of sets:	8		
Number of drops per set:	200		
Drop interval:	5 seconds		
Set interval:	60 minutes		
Nominal/datum height:	1.30 m		
Author: O. Francis			University of Luxembourg
Date: July 25, 2012			

Project file

Micro-g LaCoste g Processing Report
File Created: 07/05/12, 15:37:44

Project Name: CO20120603
g Acquisition Version: 9.110914
g Processing Version: 9.120423

Company/Institution: University of Luxembourg
Operator: Olivier Francis

Station Data

Name: PERNITZ - CONRAD OBSERVATORY
Site Code: B13
Lat: 47.92876 Long: 15.86090 Elev: 1045.00 m
Setup Height: 12.60 cm
Transfer Height: 130.00 cm
Actual Height: 138.43 cm
Gradient: -2.710 μ Gal/cm
Nominal Air Pressure: 893.85 mBar
Barometric Admittance Factor: 0.30
Polar Motion Coord: 0.0504 " 0.3974 "
Earth Tide (ETGTAB) Selected
Potential Filename: C:\gData\gWavefiles\ETCPOT.dat
Delta Factor Filename: C:\DATA\ABSOLU\DATA\INI\OceanLoad-PERNITZ - CONRAD
OBSERVATORY.dff

Delta Factors

Start	Stop	Amplitude	Phase	Term
0.000000	0.000001	1.000000	0.0000	DC
0.000002	0.249951	1.160000	0.0000	Long
0.721500	0.906315	1.154250	0.0000	Q1
0.921941	0.974188	1.154240	0.0000	O1
0.989049	0.998028	1.149150	0.0000	P1
0.999853	1.216397	1.134890	0.0000	K1
1.719381	1.906462	1.161720	0.0000	N2
1.923766	1.976926	1.161720	0.0000	M2
1.991787	2.002885	1.161720	0.0000	S2
2.003032	2.182843	1.161720	0.0000	K2
2.753244	3.081254	1.07338	0.0000	M3
3.791964	3.937897	1.03900	0.0000	M4

Ocean Load ON, Filename: C:\DATA\ABSOLU\DATA\INI\OceanLoad-PERNITZ - CONRAD
OBSERVATORY.olf

Waves: M2 S2 K1 O1 N2 P1 K2 Q1 Mf Mm Ssa
Amplitude (μ Gal): 1.110 0.365 0.096 0.129 0.224 0.035 0.095 0.034 0.000 0.000 0.000
Phase (deg): 45.6 17.9 73.7 161.2 62.5 86.7 15.0 -146.8 0.0 0.0 0.0

Instrument Data

Meter Type: FG5
Meter S/N: X216
Factory Height: 125.83 cm
Rubidium Frequency: 10000000.00000 Hz
Laser: WEO100 (000000)
ID: 632.99117754 nm (0.45 V)
IE: 632.99119473 nm (0.00 V)
IF: 632.99121259 nm (-0.40 V)
IG: 632.99123023 nm (-0.86 V)
IH: 632.99136890 nm (0.00 V)
II: 632.99139822 nm (0.00 V)
IJ: 632.99142704 nm (0.00 V)
Modulation Frequency: 8333.420 Hz

Processing Results

Date: 06/04/12
Time: 04:23:18
DOY: 156
Year: 2012
Time Offset (D h:m:s): 0 0:0:0
Gravity: 980647603.18 μGal
Set Scatter: 1.18 μGal
Measurement Precision: 0.42 μGal
Total Uncertainty: 1.93 μGal
Number of Sets Collected: 11
Number of Sets Processed: 8
Set #s Processed: 4,5,6,7,8,9,10,11
Number of Sets NOT Processed: 3
Set #s NOT Processed: 1,2,3
Number of Drops/Set: 200
Total Drops Accepted: 1578
Total Drops Rejected: 22
Total Fringes Acquired: 1100
Fringe Start: 6
Processed Fringes: 994
GuideCard Multiplex: 4
GuideCard Scale Factor: 250

Acquisition Settings

Set Interval: 60 min
Drop Interval: 5 sec
Number of Sets: 48
Number of Drops: 200

Gravity Corrections

Earth Tide (ETGTAB): -51.28 μGal
Ocean Load: -0.54 μGal
Polar Motion: 1.14 μGal
Barometric Pressure: -0.52 μGal
Transfer Height: 22.85 μGal
Reference Xo: 0.00 μGal

Uncertainties

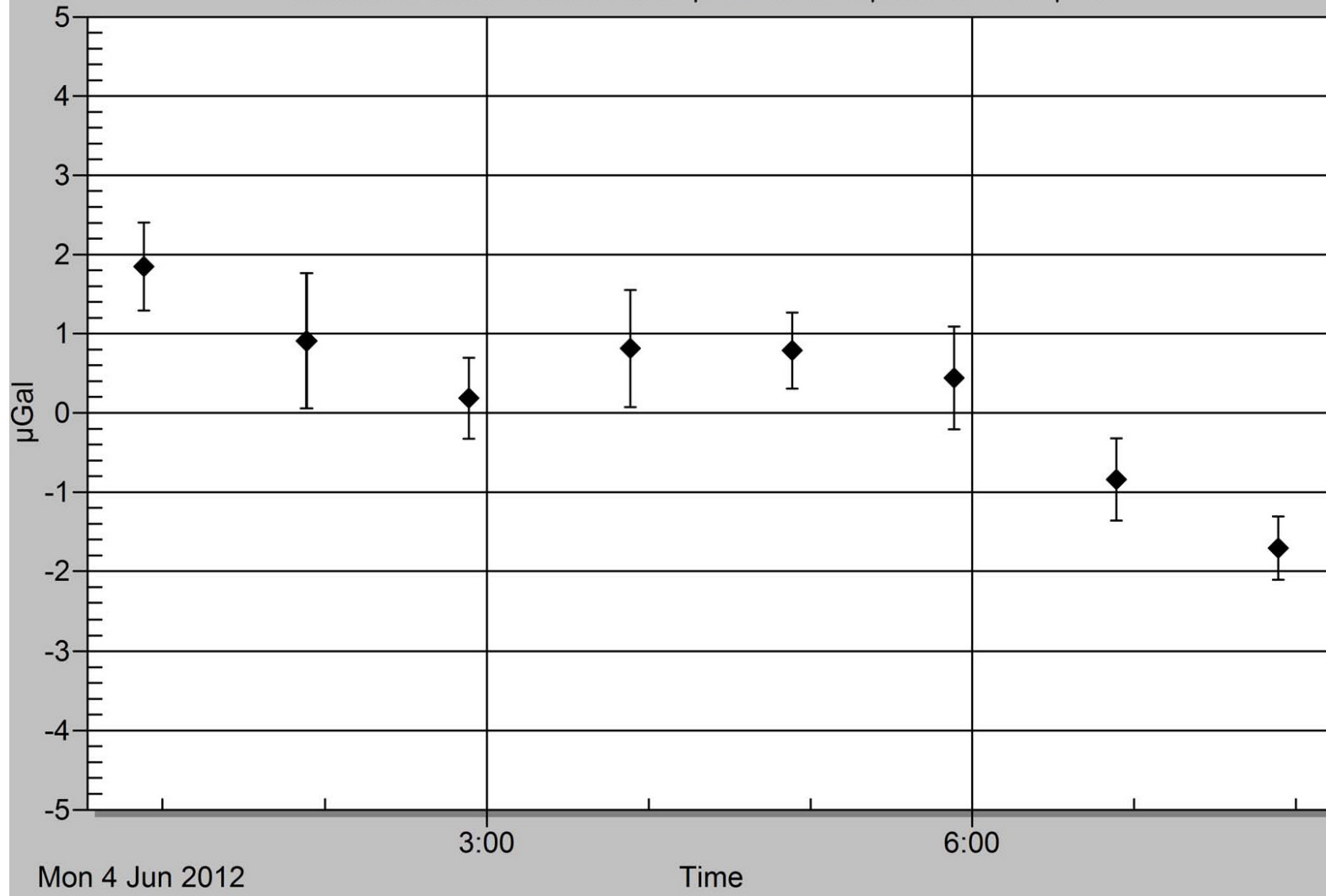
Sigma Reject: 3.00
Earth Tide Factor: 0.001
Average Earth Tide Uncertainty: 0.05 μGal
Ocean Load Factor: 0.10
Average Ocean Load Uncertainty: 0.05 μGal
Barometric: 1.00 μGal
Polar Motion: 0.05 μGal
Laser: 0.05 μGal
Clock: 0.50 μGal
System Type: 1.10 μGal
Tidal Swell: 0.00 μGal
Water Table: 0.00 μGal
Unmodeled: 0.00 μGal
System Setup: 1.00 μGal
Gradient: 0.253 μGal (0.030 $\mu\text{Gal}/\text{cm}$)

Comments

The reference height is taken from the top of the rivet at the floor (height = 3mm)
GPS ON

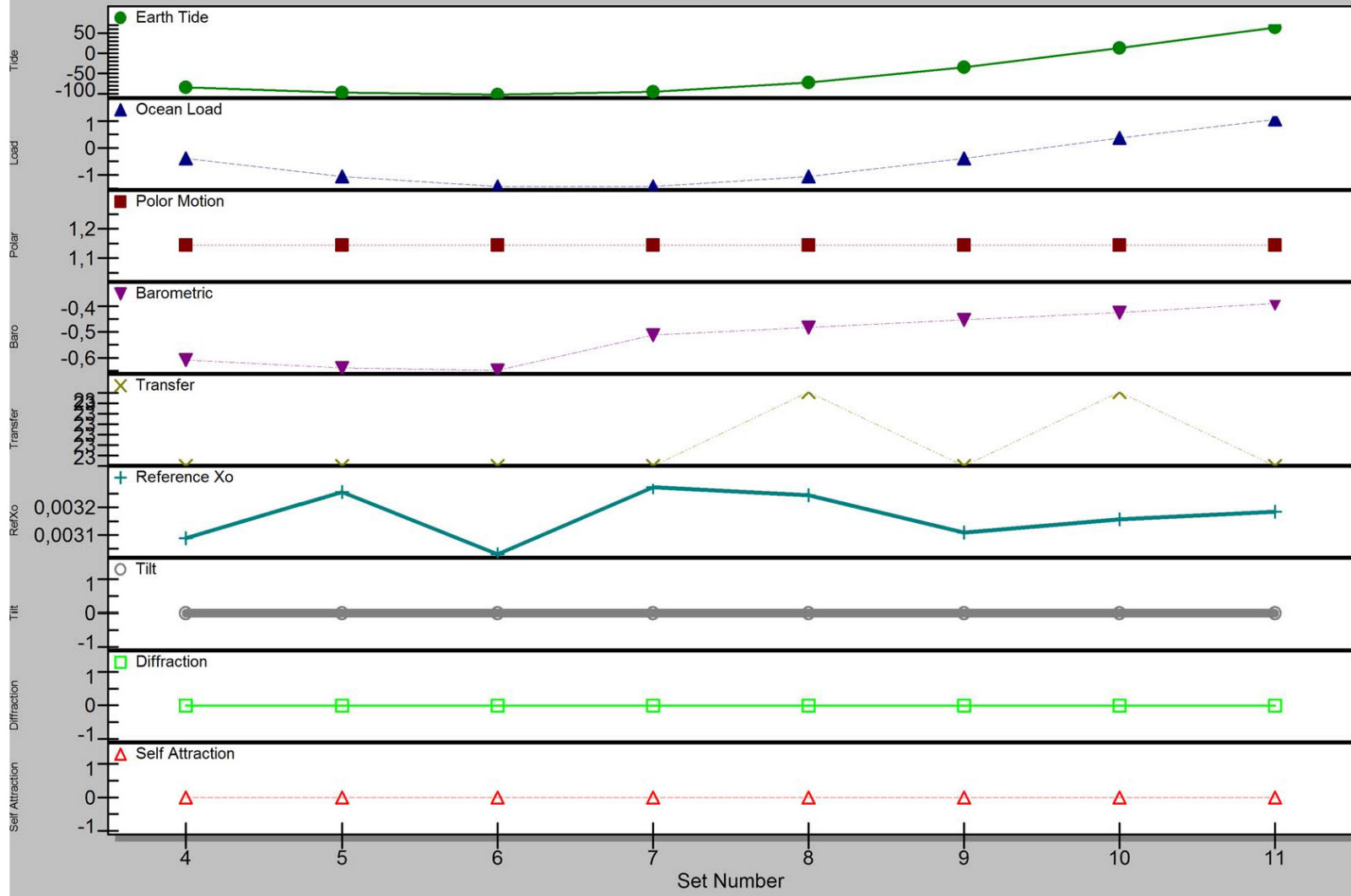
Sets

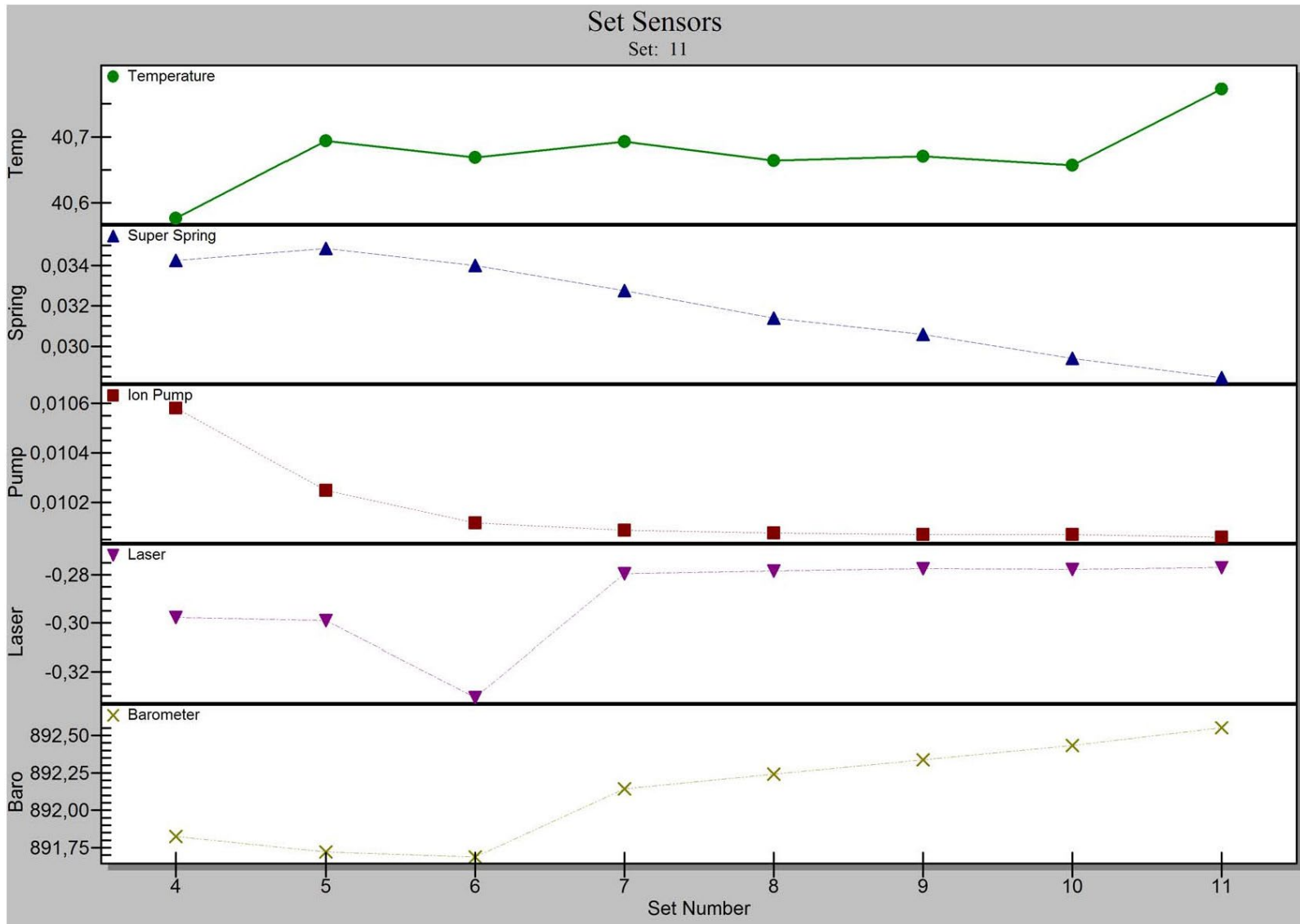
Cumulative Mean: 980647603.18 μGal $\pm 1.18 \mu\text{Gal}$ $\pm 1.93 \mu\text{Gal}$



Set Corrections

Set: 11





STATION: CONRAD OBSERVATORIUM			
City:	PERNITZ	Country:	Austria
Location:	Conrad Observatorium	Particularity:	
Situation:	Gravity Room	Remarks:	Site next to the SG CT025
Date:	04-08 June 2012		
Code number:	0-075-03		
Latitude:	47.92876 degrees		
Longitude:	15.86090 degrees		
Elevation:	1045.0 m		
Gradient:	-2.710 µgal/cm		
Reference height:	0.1260 m + 1.2583 m = 1.3843 m		
Meter:	FG5X		
S/N:	216		
Tidal corrections using observed tidal parameters			
Polar motion correction			Air pressure correction
X-coordinate	0.0549	Arc seconds	Nominal air pressure: 983.85 mbar
Y-coordinate	0.3984	Arc seconds	Barometric admittance factor: 0.3 µgal/mbar
Gravity			
Set gravity mean:	980 647 600.77	microgal	
Set std. dev.:	2.41	microgal	
Mean std. dev.:	5.98	microgal	
Number of sets:	94		
Number of drops per set:	239		
Drop interval:	15 seconds		
Set interval:	60 minutes		
Nominal/datum height:	1.30 m		
Author: O. Francis	University of Luxembourg		
Date: July 25, 2012			

Project file

Micro-g LaCoste g Processing Report
File Created: 07/05/12, 15:47:56

Project Name: CO20120604
g Acquisition Version: 9.110914
g Processing Version: 9.120423

Company/Institution: Universty of Luxembourg
Operator: Olivier Francis

Station Data

Name: PERNITZ - CONRAD OBSERVATORY
Site Code: B13
Lat: 47.92876 Long: 15.86090 Elev: 1045.00 m
Setup Height: 12.60 cm
Transfer Height: 130.00 cm
Actual Height: 138.43 cm
Gradient: -2.710 μ Gal/cm
Nominal Air Pressure: 893.85 mBar
Barometric Admittance Factor: 0.30
Polar Motion Coord: 0.0549 " 0.3984 "
Earth Tide (ETGTAB) Selected
Potential Filename: C:\gData\gWavefiles\ETCPOT.dat
Delta Factor Filename: C:\DATA\ABSOLU\DATA\INI\OceanLoad-PERNITZ-CONRAD

OBSERVATORY.dff

Delta Factors

Start	Stop	Amplitude	Phase	Term
0.000000	0.000001	1.000000	0.0000	DC
0.000002	0.249951	1.160000	0.0000	Long
0.721500	0.906315	1.154250	0.0000	Q1
0.921941	0.974188	1.154240	0.0000	O1
0.989049	0.998028	1.149150	0.0000	P1
0.999853	1.216397	1.134890	0.0000	K1
1.719381	1.906462	1.161720	0.0000	N2
1.923766	1.976926	1.161720	0.0000	M2
1.991787	2.002885	1.161720	0.0000	S2
2.003032	2.182843	1.161720	0.0000	K2
2.753244	3.081254	1.07338	0.0000	M3
3.791964	3.937897	1.03900	0.0000	M4

Ocean Load ON, Filename: C:\DATA\ABSOLU\DATA\INI\OceanLoad-PERNITZ - CONRAD

OBSERVATORY.olf

Waves: M2 S2 K1 O1 N2 P1 K2 Q1 Mf Mm Ssa
Amplitude (μ Gal): 1.110 0.365 0.096 0.129 0.224 0.035 0.095 0.034 0.000 0.000 0.000
Phase (deg): 45.6 17.9 73.7 161.2 62.5 86.7 15.0 -146.8 0.0 0.0 0.0

Instrument Data

Meter Type: FG5
Meter S/N: X216
Factory Height: 125.83 cm
Rubidium Frequency: 10000000.00000 Hz
Laser: WEO100 (000000)
ID: 632.99117754 nm (0.20 V)
IE: 632.99119473 nm (-0.28 V)
IF: 632.99121259 nm (-0.67 V)
IG: 632.99123023 nm (-0.86 V)
IH: 632.99136890 nm (0.00 V)
II: 632.99139822 nm (0.00 V)
IJ: 632.99142704 nm (0.00 V)
Modulation Frequency: 8333.420 Hz

Processing Results

Date: 06/06/12

Time: 07:29:54

DOY: 158

Year: 2012

Time Offset (D h:m:s): 0 0:0:0

Gravity: 980647600.77 μGal

Set Scatter: 2.41 μGal

Measurement Precision: 0.25 μGal

Total Uncertainty: 1.90 μGal

Number of Sets Collected: 94

Number of Sets Processed: 94

Set #s Processed:

1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94

Number of Sets NOT Processed: 0

Set #s NOT Processed:

Number of Drops/Set: 239

Total Drops Accepted: 22255

Total Drops Rejected: 211

Total Fringes Acquired: 1100

Fringe Start: 6

Processed Fringes: 994

GuideCard Multiplex: 4

GuideCard Scale Factor: 250

Acquisition Settings

Set Interval: 60 min

Drop Interval: 15 sec

Number of Sets: 200

Number of Drops: 239

Gravity Corrections

Earth Tide (ETGTAB): -16.53 μGal

Ocean Load: 0.02 μGal

Polar Motion: 1.07 μGal

Barometric Pressure: -0.10 μGal

Transfer Height: 22.85 μGal

Reference Xo: 0.00 μGal

Uncertainties

Sigma Reject: 3.00

Earth Tide Factor: 0.001

Average Earth Tide Uncertainty: 0.02 μGal

Ocean Load Factor: 0.10

Average Ocean Load Uncertainty: 0.00 μGal

Barometric: 1.00 μGal

Polar Motion: 0.05 μGal

Laser: 0.05 μGal

Clock: 0.50 μGal

System Type: 1.10 μGal

System Setup: 1.00 μGal

Gradient: 0.253 μGal (0.030 $\mu\text{Gal}/\text{cm}$)

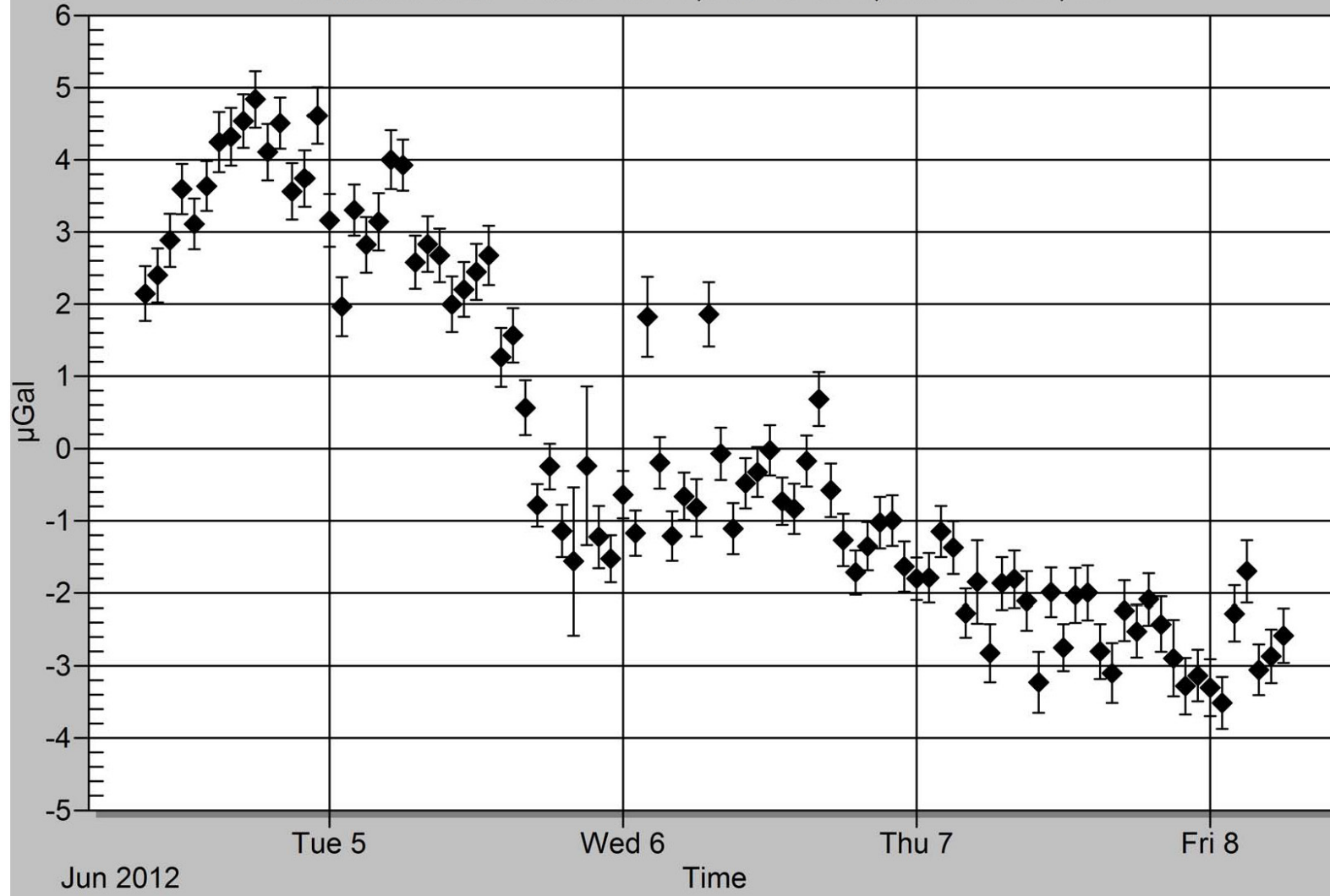
Comments

Reference height from the top of the rivet on the floor (height 3 mm)

GPS ON

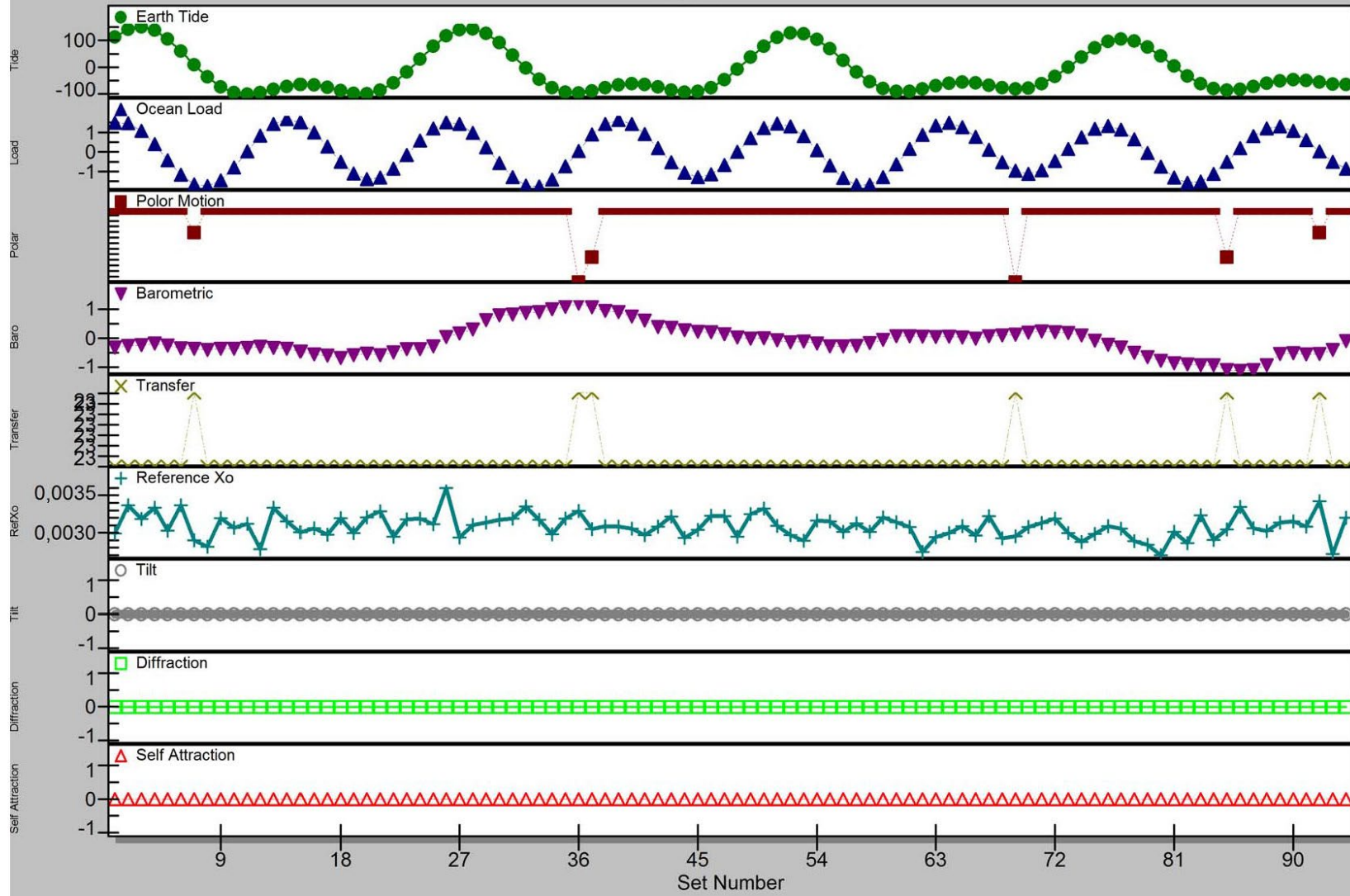
Sets

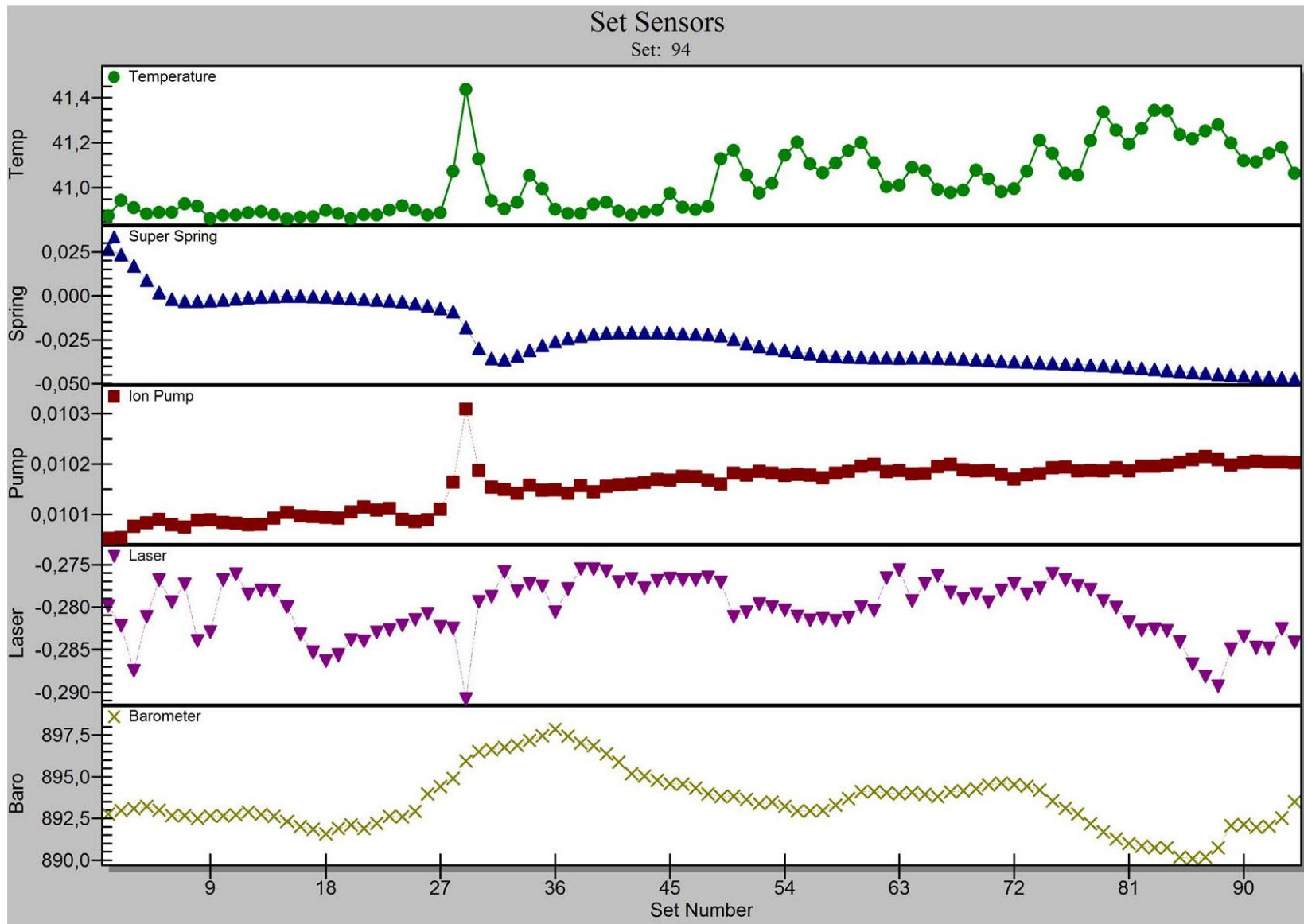
Cumulative Mean: 980647600.77 μGal $\pm 2.41 \mu\text{Gal}$ $\pm 1.90 \mu\text{Gal}$



Set Corrections

Set: 94





ABSOLUTE MEASUREMENTS IN 2008

STATION: CONRAD OBSERVATORIUM			
City:	PERNITZ	Country:	Austria
Location:	Conrad Observatorium	Particularity:	
Situation:	Gravity Room	Remarks:	Site next to the SG CT025
Date:	01-05 June 2008		
Code number:	0-075-03		
Latitude:	47.92876 degrees		
Longitude:	15.86090 degrees		
Elevation:	1045.0 m		
Gradient:	-2.710 µgal/cm		
Reference height:	0.1250 m + 1.1652 m = 1.2902m		
Meter:	FG5		
S/N:	216		
Tidal corrections using observed tidal parameters			
Polar motion correction			Air pressure correction
X-coordinate	0.1290	Arc seconds	Nominal air pressure: 983.85 mbar
Y-coordinate	0.5375	Arc seconds	Barometric admittance factor: 0.3 µgal/mbar
Gravity			
Set gravity mean:	980 647 604.62	microgal	
Set std. dev.:	0.85	microgal	
Mean std. dev.:	4.60	microgal	
Number of sets:	80		
Number of drops per set:	100		
Drop interval:	10 seconds		
Set interval:	30 minutes		
Nominal/datum height:	1.30 m		
Author: O. Francis	University of Luxembourg		
Date: July 25, 2012			

Project file

Micro-g LaCoste g Processing Report
File Created: 07/05/12, 15:31:26

Project Name: CO20080601
g Acquisition Version: 1.082300
g Processing Version: 9.120423

Company/Institution: University of Luxembourg
Operator: Olivier FRANCIS

Station Data

Name: Conrad Observatorium
Site Code: next to SG
Lat: 47.92876 Long: 15.86090 Elev: 1045.00 m
Setup Height: 12.50 cm
Transfer Height: 130.00 cm
Actual Height: 129.02 cm
Gradient: -2.710 μ Gal/cm
Nominal Air Pressure: 893.85 mBar
Barometric Admittance Factor: 0.30
Polar Motion Coord: 0.1290 " 0.5375 "
Earth Tide (ETGTAB) Selected
Potential Filename: C:\gData\gWavefiles\Etcpot.dat
Delta Factor Filename: C:\DATA\ABSOLU\DATA\INI\OceanLoad-Conrad Observatorium-Conrad Observatorium.dff

Delta Factors

Start	Stop	Amplitude	Phase	Term
0.000000	0.000001	1.000000	0.0000	DC
0.000002	0.249951	1.160000	0.0000	Long
0.721500	0.906315	1.154250	0.0000	Q1
0.921941	0.974188	1.154240	0.0000	O1
0.989049	0.998028	1.149150	0.0000	P1
0.999853	1.216397	1.134890	0.0000	K1
1.719381	1.906462	1.161720	0.0000	N2
1.923766	1.976926	1.161720	0.0000	M2
1.991787	2.002885	1.161720	0.0000	S2
2.003032	2.182843	1.161720	0.0000	K2
2.753244	3.081254	1.07338	0.0000	M3
3.791964	3.937897	1.03900	0.0000	M4

Ocean Load ON, Filename: C:\DATA\ABSOLU\DATA\INI\OceanLoad-Conrad Observatorium-Conrad Observatorium.olf

Waves: M2 S2 K1 O1 N2 P1 K2 Q1 Mf Mm Ssa
Amplitude (μ Gal): 1.110 0.365 0.096 0.129 0.224 0.035 0.095 0.034 0.000 0.000 0.000
Phase (deg): 45.6 17.9 73.7 161.2 62.5 86.7 15.0 -146.8 0.0 0.0 0.0

Instrument Data

Meter Type: FG5
Meter S/N: 216
Factory Height: 116.52 cm
Rubidium Frequency: 10000000.00970 Hz
Laser: WEO100 (187)
ID: 632.99117754 nm (0.65 V)
IE: 632.99119473 nm (0.19 V)
IF: 632.99121259 nm (-0.20 V)
IG: 632.99123023 nm (-0.43 V)
IH: 632.99136890 nm (-1.88 V)
II: 632.99139822 nm (-1.58 V)
IJ: 632.99142704 nm (-1.30 V)
Modulation Frequency: 8333.420 Hz

Processing Results

Date: 06/03/08

Time: 12:44:14

DOY: 155

Year: 2008

Time Offset (D h:m:s): 0 0:0:0

Gravity: 980647604.62 μ Gal

Set Scatter: 0.85 μ Gal

Measurement Precision: 0.10 μ Gal

Total Uncertainty: 0.10 μ Gal

Number of Sets Collected: 82

Number of Sets Processed: 80

Set #s Processed:

1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,
41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,7
5,76,77,78,79,80,81,82

Number of Sets NOT Processed: 2

Set #s NOT Processed: 17,18

Number of Drops/Set: 100

Total Drops Accepted: 7932

Total Drops Rejected: 68

Total Fringes Acquired: 700

Fringe Start: 7

Processed Fringes: 613

GuideCard Multiplex: 4

GuideCard Scale Factor: 250

Acquisition Settings

Set Interval: 60 min

Drop Interval: 10 sec

Number of Sets: 100

Number of Drops: 100

Gravity Corrections

Earth Tide (ETGTAB): -22.23 μ Gal

Ocean Load: 0.02 μ Gal

Polar Motion: 0.43 μ Gal

Barometric Pressure: 0.53 μ Gal

Transfer Height: -2.66 μ Gal

Reference Xo: -0.82 μ Gal

Uncertainties

Sigma Reject: 3.00

Earth Tide Factor: 0.000

Average Earth Tide Uncertainty: 0.00 μ Gal

Ocean Load Factor: 0.00

Average Ocean Load Uncertainty: 0.00 μ Gal

Barometric: 0.00 μ Gal

Polar Motion: 0.00 μ Gal

Laser: 0.00 μ Gal

Clock: 0.00 μ Gal

System Type: 0.00 μ Gal

Tidal Swell: 0.00 μ Gal

System Setup: 0.00 μ Gal

Gradient: -0.000 μ Gal (0.000 μ Gal/cm)

Comments

12.80 cm- 0.3 cm fot the rivet

