ABSOLUTE GRAVITY MEASUREMENTS AT THE GEODYNAMIC OBSERVATORY IN MOXA (GERMANY)

APPLIED GEOPHYSICS, FRIEDRICH-SCHILLER-UNIVERSITY JENA

Final Report

February 27, 2012

Prof. Dr. Olivier Francis

University of Luxembourg
Faculty of Sciences, Technology and Communication
Campus Kirchberg
6, rue Coudenhove-Kalergi
L-1359 Luxembourg
Grand-Duché de Luxembourg

Tel. : +352 46 66 44 6264, Email : Olivier.francis@uni.lu

Foreword

This report contains the results of absolute gravity measurements carried out at the Geodynamic Observatory in Moxa on the pier AGM (Figure 1) in January 2012. The absolute gravimeter FG5X#216 was operated by Olivier Francis and Gilbert Klein from the University of Luxembourg.

We would like to thank Dr. Thomas Jahr, Wernfrid Kuhnel and Matthias Meininger for their warm hospitality and help during our measurements.

Figure 1. The absolute gravimeter FG5X#216 on the pier AGM, at the Geodynamic Observatory in Moxa.

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 the International Earth Rotation Service (http://hpiers.obspm.fr).

The g-soft version 7.0 software from Microg-LaCoste Inc. was used for the processing. All the text outputs as well as some figures are compiled in the annexes of 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. Its determination requires relative measurements using a smaller and portable relative gravimeter. We used -2.542 +/- 0.017 μGal/cm. This value was provided by the local team.

Results of the absolute gravity measurements

The FG5X#216 operated from Sunday 15th of January 2012 at 18:30 UTC until Tuesday 17th of January 2012 at 08:45 UTC. A total of 39 sets of 200 drops every 5 seconds were taken with a rate of 1 set per hour. It represents a total of 7800 drops.

Site	Gravity value/ μGal	Mean Set Standard Deviation/ μGal
AGM @ 1.3 m	**981 029 282.66**	**1.23**

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

ANNEXES

STATION: GEODYNAMIC OBSERVATORY MOXA			
City:	Moxa	Country:	Germany
Location:	Observatory	Particularity:	
Situation:	AGM pier	Remarks:	
Date:	15-17 January 2012		

Code number:	
Latitude:	50.6449 degrees
Longitude:	11.6149 degrees
Elevation:	455.0 m
Gradient:	-2.542 μgal/cm
Reference height:	0. 1265 m + 1.1647 m = 1.3848 m
Meter:	FG5
S/N:	X216

Tidal corrections using observed tidal parameters

Polar motion correction			Air pressure correction	
X-coordinate	0.0933	Arc seconds	Nominal air pressure:	959.77 mbar
Y-coordinate	0.2545	Arc seconds	Barometric admittance factor:	0.3 μgal/mbar

Gravity

Set gravity mean:	**981 029 282.66**	microgal
Set std. dev.:	**1.23**	microgal
Mean std. dev.:	8.39	microgal
Number of sets:	39	
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: February 27, 2012

Project file

Micro-g Solutions g Processing Report
File Created: 02/24/12, 12:55:38

Project Name: MO201201
g Acquisition Version: 9.110914
g Processing Version: 7.070307

Company/Institution: University of Luxembourg
Operator: Olivier Francis

Station Data
Name: MOXA
Site Code: SITE AGM
Lat: 50.64490 Long: 11.61490 Elev: 455.00 m
Setup Height: 12.65 cm
Transfer Height: 130.00 cm
Actual Height: 138.48 cm
Gradient: -2.542 µGal/cm
Nominal Air Pressure: 959.77 mBar
Barometric Admittance Factor: 0.30
Polar Motion Coord: 0.0933 " 0.2545 "
Earth Tide (ETGTAB) Selected
Potential Filename: C:\Program Files\Micro-g Solutions Inc\gWavefiles\ETCPOT.dat
Delta Factor Filename: G:\ABSOLU\DATA\INI\OceanLoad-MOXA.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: G:\ABSOLU\DATA\INI\OceanLoad-MOXA.olf

Waves:	M2	S2	K1	O1	N2	P1	K2	Q1	Mf	Mm	Ssa
Amplitude (µGal):	1.302	0.421	0.144	0.139	0.264	0.048	0.108	0.038	0.000	0.000	0.000
Phase (deg):	49.6	21.2	54.9	159.2	66.7	68.8	17.9	-140.7	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 (-0.20 V)
IF: 632.99121259 nm (-0.60 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: 01/16/12
Time: 13:39:54
DOY: 016
Year: 2012
Time Offset (D h:m:s): 0 0:0:0
Gravity: 981029282.66 µGal
Set Scatter: 1.23 µGal
Measurement Precision: 0.20 µGal
Total Uncertainty: 1.89 µGal
Number of Sets Collected: 39
Number of Sets Processed: 39
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
Number of Sets NOT Processed: 0
Set #s NOT Processed:
Number of Drops/Set: 200
Total Drops Accepted: 7753
Total Drops Rejected: 47
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: 39
Number of Drops: 200

Gravity Corrections
Earth Tide (ETGTAB): -28.96 µGal
Ocean Load: -0.01 µGal
Polar Motion: -0.75 µGal
Barometric Pressure: 3.24 µGal
Transfer Height: 21.56 µGal
Reference Xo: 0.00 µGal

Set File

Source Data Filename: MO201201
g Acquisition Version: 9.110914
g Processing Version: 7.070307

Set	Time	DOY	Year	Gravity	Sigma	Error	Uncert	Tide	Load	Baro	Polar	Transfer		Refxo	Temp	Pres	Chan5	Chan6	Chan7	Accept	Reject		
1	18:42:26	015	2012	981029283.091		9.559	0.709	2.009	18.505	-0.650	2.771	-0.753	21.556	0.003	34.775	969.008		-0.024	2247.385	2923.747	182	18
2	19:42:25	015	2012	981029284.242		11.485	0.812	2.049	6.733	-1.048	2.881	-0.753	21.556	0.003	36.746	969.374		-0.021	2151.660	2893.835	200	0
3	20:42:27	015	2012	981029284.254		11.237	0.807	2.048	-6.017	-1.144	3.053	-0.753	21.556	0.003	36.668	969.947		-0.021	2147.871	2876.515	194	6
4	21:42:25	015	2012	981029284.897		9.944	0.703	2.008	-17.166	-0.915	3.107	-0.753	21.556	0.003	36.602	970.125		-0.021	2151.295	2859.275	200	0
5	22:42:21	015	2012	981029281.844		10.155	0.724	2.014	-25.018	-0.423	3.113	-0.753	21.556	0.003	36.739	970.148		-0.021	2137.848	2844.310	197	3
6	23:42:25	015	2012	981029280.721		10.358	0.732	2.017	-29.100	0.211	2.966	-0.753	21.556	0.003	36.779	969.658		-0.021	2131.325	2832.075	200	0
7	00:42:25	016	2012	981029281.951		9.349	0.661	1.994	-30.167	0.821	2.955	-0.753	21.556	0.003	36.804	969.620		-0.021	2127.265	2827.380	200	0
8	01:42:27	016	2012	981029283.326		9.520	0.675	2.000	-29.999	1.252	2.975	-0.753	21.556	0.003	36.781	969.687		-0.021	2119.759	2817.492	199	1
9	02:42:25	016	2012	981029283.744		9.675	0.684	2.004	-30.816	1.391	3.018	-0.753	21.556	0.003	36.813	969.831		-0.021	2120.900	2819.835	200	0
10	03:42:27	016	2012	981029284.699		9.600	0.681	2.002	-34.585	1.197	3.022	-0.753	21.556	0.003	36.854	969.843		-0.021	2116.181	2818.075	199	1
11	04:42:26	016	2012	981029286.258		8.777	0.622	1.981	-42.343	0.710	3.067	-0.753	21.556	0.003	36.784	969.994		-0.021	2117.779	2812.965	199	1
12	05:42:24	016	2012	981029283.563		9.080	0.644	1.987	-53.784	0.041	3.078	-0.753	21.556	0.003	36.747	970.031		-0.021	2118.528	2817.940	199	1
13	06:42:26	016	2012	981029285.013		8.351	0.592	1.972	-67.224	-0.653	3.132	-0.753	21.556	0.003	36.765	970.211		-0.021	2117.588	2815.382	199	1
14	07:42:24	016	2012	981029282.576		8.567	0.609	1.980	-79.874	-1.210	3.213	-0.753	21.556	0.003	36.757	970.479		-0.021	2122.227	2821.323	198	2
15	08:42:25	016	2012	981029282.776		7.788	0.551	1.966	-88.637	-1.502	3.310	-0.753	21.556	0.003	36.741	970.802		-0.021	2117.085	2825.775	200	0
16	09:38:20	016	2012	981029283.539		7.937	0.564	1.969	-90.879	-1.475	3.405	-0.753	21.556	0.003	37.196	971.120		-0.020	2060.551	2784.333	198	2
17	10:38:19	016	2012	981029283.443		8.969	0.634	1.988	-85.372	-1.137	3.375	-0.753	21.556	0.003	36.843	971.019		-0.021	2098.685	2805.890	200	0
18	11:38:19	016	2012	981029282.424		8.349	0.590	1.971	-71.504	-0.560	3.325	-0.753	21.556	0.003	36.864	970.853		-0.021	2106.920	2813.320	200	0
19	12:38:19	016	2012	981029282.356		6.944	0.491	1.943	-50.659	0.116	3.197	-0.753	21.556	0.003	36.805	970.427		-0.021	2103.320	2816.910	200	0
20	13:38:19	016	2012	981029283.589		7.932	0.561	1.962	-25.522	0.732	3.171	-0.753	21.556	0.003	36.801	970.339		-0.021	2110.915	2819.440	200	0
21	14:38:21	016	2012	981029283.995		7.080	0.503	1.948	0.463	1.145	3.207	-0.753	21.556	0.003	36.746	970.460		-0.021	2102.960	2809.384	198	2
22	15:38:19	016	2012	981029283.637		8.185	0.579	1.970	23.684	1.266	3.232	-0.753	21.556	0.003	36.780	970.545		-0.021	2102.985	2811.730	200	0
23	16:38:19	016	2012	981029283.711		7.871	0.557	1.963	41.120	1.075	3.230	-0.753	21.556	0.003	36.691	970.536		-0.021	2109.655	2809.140	200	0
24	17:38:19	016	2012	981029282.135		7.242	0.512	1.949	50.703	0.630	3.238	-0.753	21.556	0.003	36.628	970.565		-0.021	2106.475	2806.780	200	0
25	18:38:19	016	2012	981029281.372		7.686	0.543	1.956	51.674	0.049	3.358	-0.753	21.556	0.003	36.672	970.965		-0.021	2108.270	2808.565	200	0
26	19:38:18	016	2012	981029282.522		7.896	0.560	1.962	44.626	-0.519	3.378	-0.753	21.556	0.003	36.766	971.031		-0.021	2104.417	2801.769	199	1
27	20:38:19	016	2012	981029280.981		7.746	0.548	1.959	31.302	-0.933	3.426	-0.753	21.556	0.003	36.779	971.190		-0.021	2100.640	2800.330	200	0
28	21:38:22	016	2012	981029281.381		7.441	0.527	1.954	14.238	-1.088	3.388	-0.753	21.556	0.003	36.704	971.063		-0.021	2104.392	2804.402	199	1
29	22:38:20	016	2012	981029281.984		7.248	0.514	1.950	-3.750	-0.949	3.450	-0.753	21.556	0.003	36.713	971.269		-0.021	2104.523	2803.266	199	1
30	23:38:18	016	2012	981029281.282		7.555	0.537	1.955	-20.192	-0.550	3.375	-0.753	21.556	0.003	36.723	971.019		-0.021	2107.399	2806.985	198	2
31	00:38:19	017	2012	981029281.200		7.419	0.525	1.951	-33.424	0.007	3.434	-0.753	21.556	0.003	36.685	971.216		-0.021	2103.540	2804.785	200	0
32	01:38:19	017	2012	981029282.669		7.944	0.563	1.963	-42.844	0.583	3.351	-0.753	21.556	0.003	36.743	970.939		-0.021	2098.281	2798.402	199	1
33	02:38:19	017	2012	981029280.427		8.043	0.569	1.966	-49.004	1.033	3.314	-0.753	21.556	0.003	36.671	970.815		-0.021	2097.680	2799.830	200	0
34	03:38:21	017	2012	981029281.786		6.990	0.495	1.948	-53.274	1.244	3.330	-0.753	21.556	0.003	36.734	970.871		-0.021	2094.176	2800.121	199	1
35	04:38:19	017	2012	981029282.658		7.864	0.556	1.964	-57.332	1.158	3.349	-0.753	21.556	0.003	36.661	970.934		-0.021	2096.315	2796.150	200	0
36	05:38:19	017	2012	981029282.913		7.694	0.544	1.959	-62.547	0.792	3.329	-0.753	21.556	0.003	36.738	970.867		-0.021	2092.955	2795.500	200	0
37	06:38:19	017	2012	981029281.780		7.994	0.565	1.963	-69.430	0.229	3.434	-0.753	21.556	0.003	36.758	971.216		-0.021	2090.405	2797.245	200	0
38	07:38:21	017	2012	981029282.089		6.495	0.460	1.936	-77.375	-0.400	3.581	-0.753	21.556	0.003	36.743	971.708		-0.021	2085.769	2793.035	199	1
39	08:38:17	017	2012	981029281.904		7.247	0.514	1.952	-84.704	-0.946	3.740	-0.753	21.556	0.003	36.870	972.236		-0.021	2060.633	2774.879	199	1

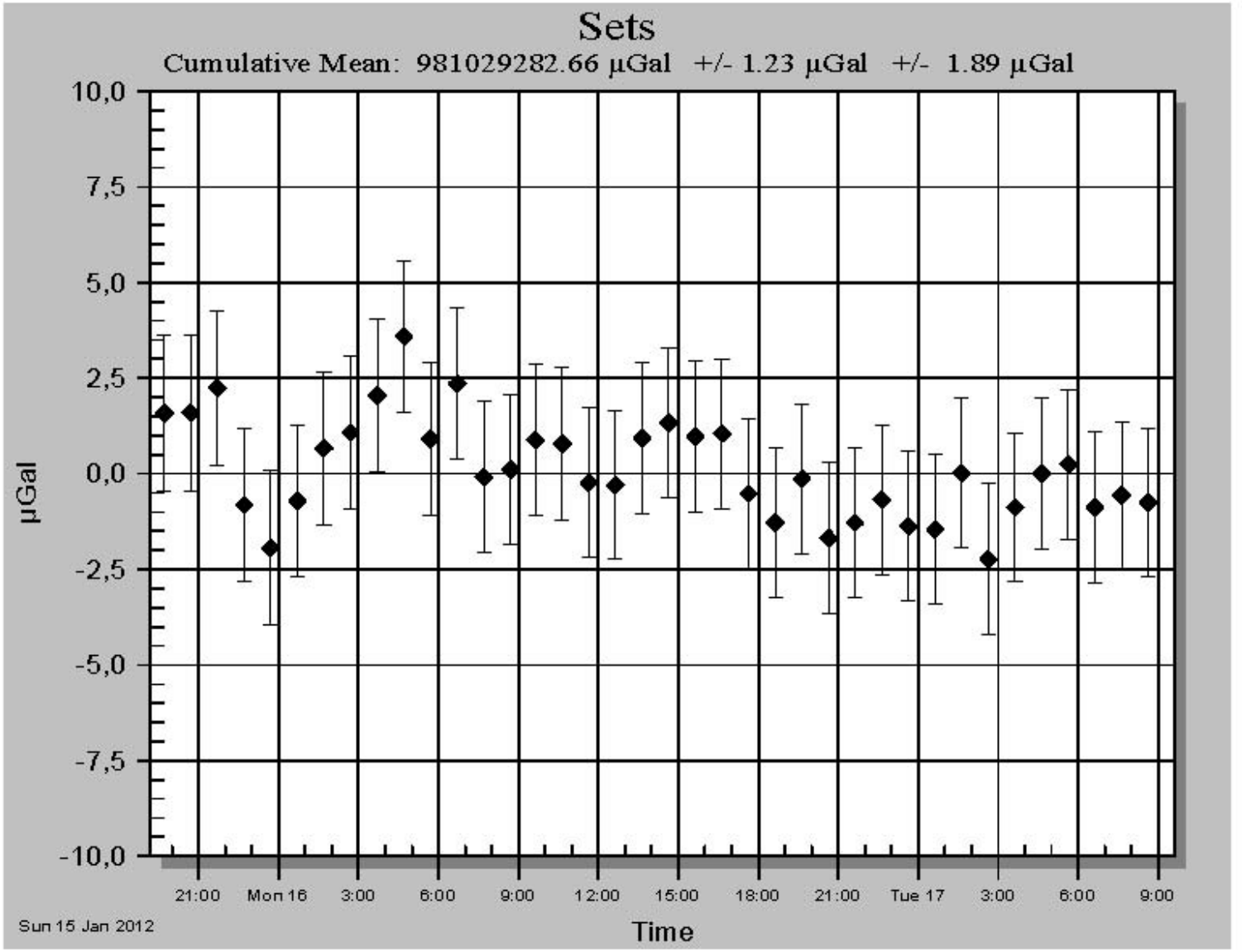

Figure 2. Plot of the set gravity values (1 set = 200 dr7ops).

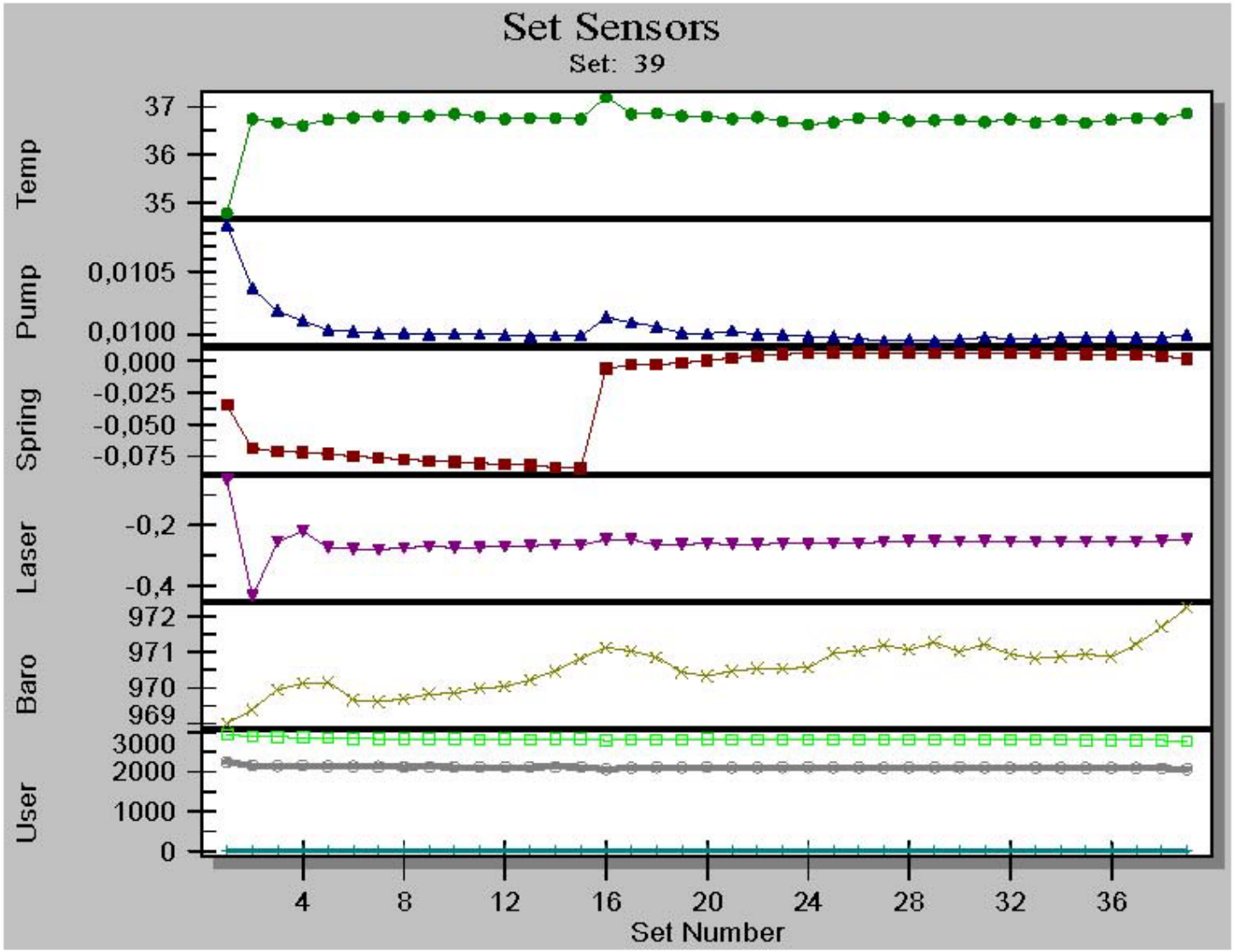

Figure 3. Plot of the set sensor parameters (1 set = 200 drops).

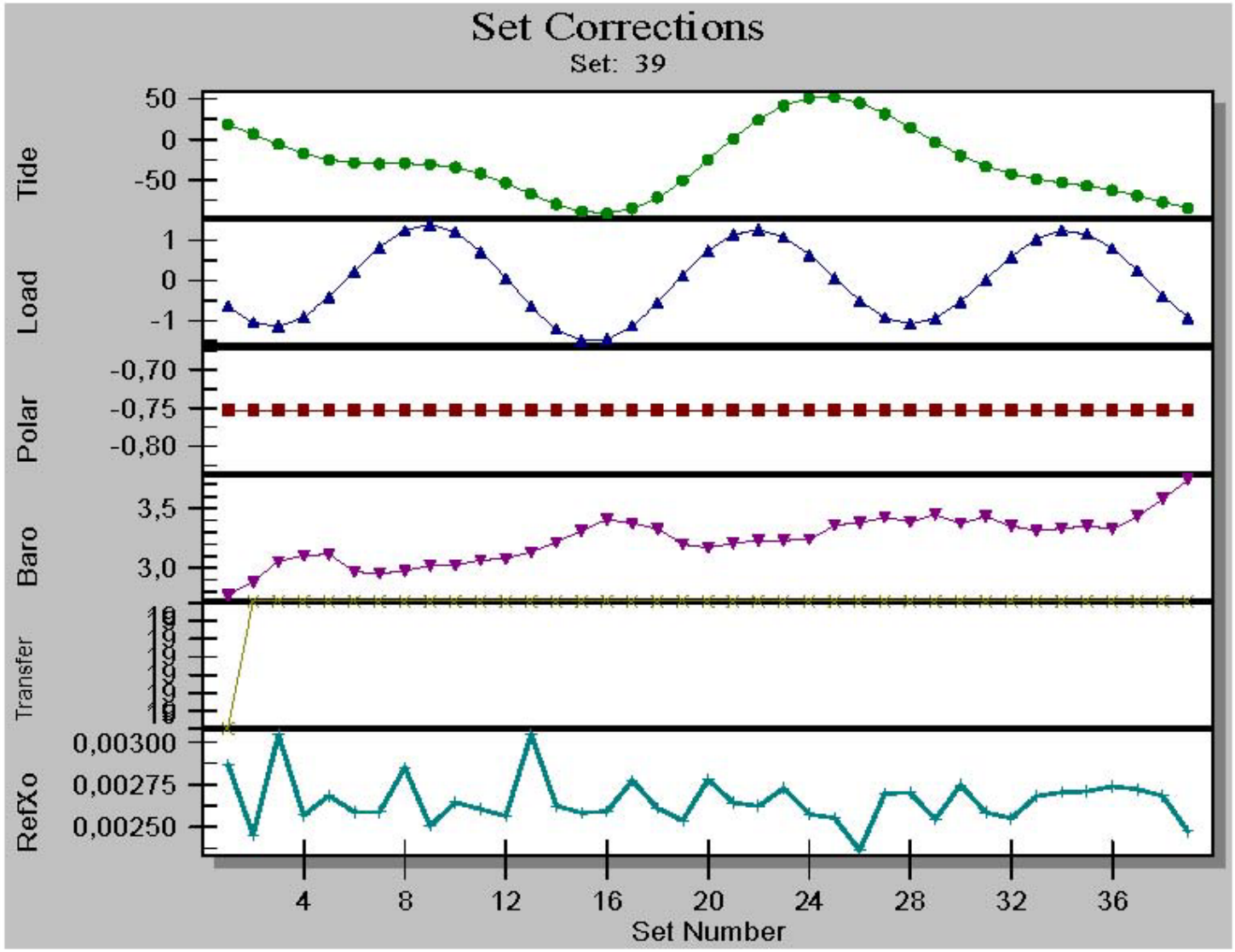

Figure 4. Plot of the set corrections values (1 set = 200 drops).