



**ABSOLUTE GRAVITY MEASUREMENTS AT THE ALPINE
RESEARCH CENTRE IN OBERGUGL (AUSTRIA)
IN SEPTEMBER 2021**

Final Report

June 2022

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Foreword

This report contains the results of absolute gravity measurements carried out at Alpine Research Centre (University of Innsbruck) in Obergurgl. The measurements took place on the pier 0-173-02 (Figure 1) in September 2021.

The absolute gravimeter FG5X#216 was operated by Olivier Francis and Raquel Navarro Buendía from the University of Luxembourg.

The measurements are part of an on-going research collaboration between the Geophysics Laboratory of the University of Luxembourg and Christian Ullrich and Helmut Titz from the Bundesamt für Eich- und Vermessungswesen (BEV, Federal Office of Metrology and Surveying) in Vienna, Austria.

It is the fourth time we measured at this site. Measurements were previously performed in June, September 2018 and 2019. Due to the COVID-19 pandemic, we could not take measurements in 2020.



Figure 1. Pier at the Alpine Research Centre (University of Innsbruck) in Obergurgl

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 v9.12.04.23 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 desired height (1.22 in the present report). Its determination requires relative measurements using a smaller and portable relative gravimeter. We used $-1.82 \mu\text{Gal}/\text{cm}$. The value was provided by Christian Ullrich.

Results of the absolute gravity measurements

The FG5X#216 operated from the 29th of September 2021 at 17:00 UTC until the 30th of September 2021 at 16:00 UTC. A total of 42 sets of 100 drops (1 drop every 10 sec) were taken at a rate of 2 sets per hour. It represents a total of 4200 drops. For the final result, the first set of data is eliminated as the electronics of the gravimeter was still warming up.

Site	Gravity value/ μGal	Mean Set Standard Deviation/ μGal
AGM @ 1.22 m	980 239 672.59	0.65

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: Alpine Research Centre (University of Innsbruck) in Obergurgl			
City:	Obergurgl	Country:	Austria
Location:	Alpine Research Centre	Particularity:	
Situation:	Pier 0-173-02	Remarks:	
Date:	29-30 September 2021		
Code number:	0-173-02		
Latitude:	46.86709 degrees		
Longitude:	11.02489 degrees		
Elevation:	1935.40 m		
Gradient:	-1.82 μ gal/cm		
Reference height	0.1290 m + 1.2579 m = 1.3869 m		
Meter:	FG5X		
S/N:	216		
Tidal corrections using observed tidal parameters			
Polar motion correction		Air pressure correction	
X-coordinate	0.2206	Arc seconds	Nominal air pressure: 801.35 mbar
Y-coordinate	0.2813	Arc seconds	Barometric admittance factor 0.3 μ gal/mbar
Gravity			
Set gravity mean:	980 239 672.59	microgal	
Set std. dev.:	0.65	microgal	
Mean std. dev.:	5.90	microgal	
Number of sets:	41		
Number of drops per set:	100		
Drop interval:	10 seconds		
Set interval:	30 minutes		
Nominal/datum height:	1.22 m		
Author: O. Francis	University of Luxembourg		
Date: 8 June 2022			

Project file

Micro-g LaCoste g Processing Report
File Created: 07/08/22, 08:27:57

Project Name: OB202109
g Acquisition Version: 9.160516
g Processing Version: 9.120423

Company/Institution: University of Luxembourg
Operator: Olivier FRANCIS
Station Data

Name: OBERGURL

Site Code:

Lat: 46.86709 Long: 11.02489 Elev: 1935.40 m

Setup Height: 12.90 cm

Transfer Height: 122.00 cm

Actual Height: 138.69 cm

Gradient: -1.820 $\mu\text{Gal}/\text{cm}$

Nominal Air Pressure: 801.35 mBar

Barometric Admittance Factor: 0.30

Polar Motion Coord: 0.2206 " 0.2813 "

Earth Tide (ETGTAB) Selected

Potential Filename: C:\gData\gWavefiles\ETCPOT.dat

Delta Factor Filename: C:\Users\olivier.francis\Desktop\REPORTS-ABSOLU\INI\OceanLoad-OBERGURL.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:\Users\olivier.francis\Desktop\REPORTS-ABSOLU\INI\OceanLoad-OBERGURLP.olf

Waves:	M2	S2	K1	O1	N2	P1	K2	Q1	Mf	Mm	Ssa
Amplitude (μGal):	1.447	0.478	0.134	0.135	0.294	0.047	0.125	0.037	0.000	0.000	0.000
Phase (deg):	56.2	28.4	71.9	-188.8	73.5	84.3	26.6	-131.8	0.0	0.0	0.0

Instrument Data

Meter Type: FG5

Meter S/N: X216

Factory Height: 125.79 cm

Rubidium Frequency: 10000000.01121 Hz

Laser: WEO100 (242)

ID: 632.99117754 nm (0.01 V)

IE: 632.99119473 nm (-0.49 V)

IF: 632.99121259 nm (-0.91 V)

IG: 632.99123023 nm (-1.29 V)

IH: 632.99136890 nm (-1.66 V)

II: 632.99139822 nm (4.00 V)

IJ: 632.99142704 nm (5.00 V)

Modulation Frequency: 8333.350 Hz

Processing Results

Date: 09/30/21

Time: 04:30:37

DOY: 273

Year: 2021

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

Gravity: 980239672.59 μGal

Set Scatter: 0.65 μGal

Measurement Precision: 0.10 μGal

Total Uncertainty: 1.59 μGal

Number of Sets Collected: 42

Number of Sets Processed: 41

Set #s Processed:

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

Number of Sets NOT Processed: 1

Set #s NOT Processed: 1

Number of Drops/Set: 100

Total Drops Accepted: 4079

Total Drops Rejected: 21

Total Fringes Acquired: 1100

Fringe Start: 2

Processed Fringes: 1030

GuideCard Multiplex: 4

GuideCard Scale Factor: 250

Acquisition Settings

Set Interval: 30 min

Drop Interval: 10 sec

Number of Sets: 42

Number of Drops: 100

Gravity Corrections

Earth Tide (ETGTAB): -18.75 μGal

Ocean Load: -0.11 μGal

Polar Motion: -3.11 μGal

Barometric Pressure: 3.10 μGal

Transfer Height: 30.38 μGal

Reference Xo: -0.02 μGal

Uncertainties

Sigma Reject: 3.00

Earth Tide Factor: 0.000

Average Earth Tide Uncertainty: 0.00 μGal

Ocean Load Factor: 0.00

Average Ocean Load Uncertainty: 0.00 μGal

Barometric: 0.00 μGal

Polar Motion: 0.00 μGal

Laser: 0.00 μGal

Clock: 0.10 μGal

System Type: 1.50 μGal

Tidal Swell: 0.00 μGal

Water Table: 0.00 μGal

Unmodeled: 0.00 μGal

System Setup: 0.50 μGal

Gradient: 0.000 μGal (0.000 $\mu\text{Gal/cm}$)

Files Merged:

OB20210929.fg5

OB20210930.fg5

Set File

Source Data Filename: OB202109

g Acquisition Version: 9.160516

g Processing Version: 9.120423

	Time	DOY	Year	Gravity	Sigma	Error	Uncert	Tide	Load	Baro	Polar	Transfer	Refxo	Tilt	Diffraction	SelfAttract	Temp	Pres	Chan5	Chan6	Chan7	Chan8	Chan9	Chan10	Accept	Reject
2	17:08:44	272	2021	980239671.991	5.357	0.538	1.673	-66.457	0.349	2.564	-3.109	30.376	-0.016	0.000	0.000	0.000	34.591809.897	-0.013	108.30392.778	0.000	0.000	0.000	99	1		
3	17:38:42	272	2021	980239672.597	5.259	0.526	1.669	-64.455	0.224	2.640	-3.109	30.376	-0.016	0.000	0.000	0.000	34.952810.149	-0.013	96.240	75.910	0.000	0.000	0.000	100	0	
4	18:08:43	272	2021	980239671.613	5.560	0.565	1.682	-62.138	0.090	2.702	-3.109	30.376	-0.015	0.000	0.000	0.000	35.032810.358	-0.013	90.567	66.340	0.000	0.000	0.000	97	3	
5	18:38:45	272	2021	980239672.240	5.337	0.542	1.674	-59.626	-0.044	2.756	-3.109	30.376	-0.016	0.000	0.000	0.000	35.027810.538	-0.013	86.711	57.402	0.000	0.000	0.000	97	3	
6	19:08:43	272	2021	980239672.459	5.595	0.562	1.681	-57.024	-0.170	2.794	-3.109	30.376	-0.016	0.000	0.000	0.000	35.106810.662	-0.013	84.091	54.697	0.000	0.000	0.000	99	1	
7	19:38:42	272	2021	980239671.848	6.007	0.601	1.694	-54.387	-0.278	2.819	-3.109	30.376	-0.016	0.000	0.000	0.000	35.162810.747	-0.013	76.400	52.850	0.000	0.000	0.000	100	0	
8	20:08:42	272	2021	980239672.525	5.013	0.501	1.662	-51.737	-0.363	2.885	-3.109	30.376	-0.016	0.000	0.000	0.000	35.153810.967	-0.013	76.620	48.690	0.000	0.000	0.000	100	0	
9	20:38:42	272	2021	980239671.477	6.112	0.611	1.698	-49.058	-0.418	2.904	-3.109	30.376	-0.016	0.000	0.000	0.000	35.074811.029	-0.012	74.630	42.070	0.000	0.000	0.000	100	0	
10	21:08:42	272	2021	980239672.953	5.670	0.567	1.683	-46.295	-0.440	2.985	-3.109	30.376	-0.016	0.000	0.000	0.000	34.478811.299	-0.013	69.200	34.560	0.000	0.000	0.000	100	0	
11	21:38:42	272	2021	980239672.502	5.924	0.592	1.691	-43.359	-0.428	2.986	-3.109	30.376	-0.016	0.000	0.000	0.000	34.477811.303	-0.013	66.660	38.250	0.000	0.000	0.000	100	0	
12	22:08:48	272	2021	980239671.503	4.732	0.478	1.655	-40.123	-0.383	2.963	-3.109	30.376	-0.016	0.000	0.000	0.000	34.499811.227	-0.013	62.653	34.592	0.000	0.000	0.000	98	2	
13	22:38:44	272	2021	980239672.361	5.185	0.524	1.669	-36.483	-0.307	2.953	-3.109	30.376	-0.016	0.000	0.000	0.000	34.464811.193	-0.013	65.408	30.143	0.000	0.000	0.000	98	2	
14	23:08:42	272	2021	980239672.595	5.167	0.517	1.666	-32.287	-0.206	2.955	-3.109	30.376	-0.016	0.000	0.000	0.000	34.485811.200	-0.012	64.140	30.540	0.000	0.000	0.000	100	0	
15	23:38:42	272	2021	980239672.853	6.729	0.673	1.721	-27.408	-0.086	2.972	-3.109	30.376	-0.016	0.000	0.000	0.000	34.417811.256	-0.012	61.960	30.080	0.000	0.000	0.000	100	0	
16	00:08:44	273	2021	980239671.832	4.874	0.490	1.658	-21.748	0.045	3.033	-3.109	30.376	-0.016	0.000	0.000	0.000	34.500811.461	-0.012	59.848	32.333	0.000	0.000	0.000	99	1	
17	00:38:42	273	2021	980239672.982	5.271	0.527	1.670	-15.270	0.179	3.058	-3.109	30.376	-0.016	0.000	0.000	0.000	34.471811.543	-0.013	60.250	30.090	0.000	0.000	0.000	100	0	
18	01:08:38	273	2021	980239673.554	5.415	0.544	1.675	-7.971	0.307	3.082	-3.109	30.376	-0.016	0.000	0.000	0.000	34.507811.625	-0.013	60.071	25.030	0.000	0.000	0.000	99	1	
19	01:38:42	273	2021	980239672.427	5.783	0.578	1.687	0.134	0.421	3.090	-3.109	30.376	-0.016	0.000	0.000	0.000	34.551811.651	-0.013	54.890	24.380	0.000	0.000	0.000	100	0	
20	02:08:42	273	2021	980239672.619	5.809	0.581	1.687	8.866	0.512	3.095	-3.109	30.376	-0.016	0.000	0.000	0.000	34.526811.666	-0.013	51.500	26.360	0.000	0.000	0.000	100	0	
21	02:38:42	273	2021	980239672.644	5.970	0.597	1.693	18.049	0.576	3.084	-3.109	30.376	-0.016	0.000	0.000	0.000	34.541811.629	-0.012	53.730	21.430	0.000	0.000	0.000	100	0	
22	03:08:42	273	2021	980239673.340	6.228	0.623	1.702	27.423	0.606	3.126	-3.109	30.376	-0.016	0.000	0.000	0.000	34.550811.771	-0.012	49.480	24.020	0.000	0.000	0.000	100	0	
23	06:26:40	273	2021	980239673.767	5.229	0.526	1.669	69.829	-0.000	3.393	-3.109	30.376	-0.016	0.000	0.000	0.000	35.189812.661	-0.012	51.283	18.828	0.000	0.000	0.000	99	1	
24	06:56:35	273	2021	980239672.473	6.772	0.681	1.724	69.830	-0.161	3.427	-3.109	30.376	-0.016	0.000	0.000	0.000	34.557812.772	-0.012	43.758	12.394	0.000	0.000	0.000	99	1	
25	07:26:33	273	2021	980239673.589	5.782	0.581	1.688	67.575	-0.318	3.503	-3.109	30.376	-0.016	0.000	0.000	0.000	34.443813.026	-0.012	38.242	5.717	0.000	0.000	0.000	99	1	
26	07:56:37	273	2021	980239672.888	6.206	0.621	1.702	63.044	-0.462	3.534	-3.109	30.376	-0.016	0.000	0.000	0.000	34.407813.130	-0.013	40.160	8.270	0.000	0.000	0.000	100	0	
27	08:26:37	273	2021	980239672.459	6.382	0.638	1.708	56.357	-0.585	3.480	-3.109	30.376	-0.016	0.000	0.000	0.000	34.341812.949	-0.013	36.070	8.070	0.000	0.000	0.000	100	0	
28	08:56:37	273	2021	980239671.818	6.237	0.624	1.703	47.704	-0.679	3.481	-3.109	30.376	-0.016	0.000	0.000	0.000	34.302812.952	-0.012	36.660	12.210	0.000	0.000	0.000	100	0	
29	09:26:42	273	2021	980239672.332	5.082	0.511	1.665	37.339	-0.739	3.463	-3.109	30.376	-0.017	0.000	0.000	0.000	34.322812.892	-0.012	29.515	12.515	0.000	0.000	0.000	99	1	
30	09:56:37	273	2021	980239673.173	6.560	0.656	1.715	25.703	-0.762	3.415	-3.109	30.376	-0.017	0.000	0.000	0.000	34.417812.732	-0.013	33.160	8.840	0.000	0.000	0.000	100	0	
31	10:26:37	273	2021	980239671.513	6.339	0.634	1.706	13.123	-0.747	3.410	-3.109	30.376	-0.017	0.000	0.000	0.000	34.412812.718	-0.013	33.740	5.460	0.000	0.000	0.000	100	0	
32	10:56:37	273	2021	980239671.895	7.186	0.719	1.740	0.072	-0.693	3.403	-3.109	30.376	-0.017	0.000	0.000	0.000	34.294812.695	-0.013	31.670	5.640	0.000	0.000	0.000	100	0	
33	11:26:34	273	2021	980239672.848	5.758	0.579	1.687	-12.970	-0.606	3.366	-3.109	30.376	-0.017	0.000	0.000	0.000	34.196812.569	-0.012	28.606	4.747	0.000	0.000	0.000	99	1	
34	11:56:35	273	2021	980239672.893	6.462	0.649	1.712	-25.599	-0.488	3.283	-3.109	30.376	-0.017	0.000	0.000	0.000	34.151812.293	-0.012	27.424	1.202	0.000	0.000	0.000	99	1	
35	12:26:37	273	2021	980239673.536	6.562	0.656	1.715	-37.382	-0.347	3.190	-3.109	30.376	-0.016	0.000	0.000	0.000	34.120811.982	-0.012	28.990	-1.810	0.000	0.000	0.000	100	0	
36	12:56:37	273	2021	980239674.108	5.846	0.585	1.689	-47.931	-0.191	3.100	-3.109	30.376	-0.017	0.000	0.000	0.000	34.197811.682	-0.012	30.840	-2.070	0.000	0.000	0.000	100	0	
37	13:26:37	273	2021	980239673.247	6.260	0.626	1.703	-56.962	-0.028	3.016	-3.109	30.376	-0.016	0.000	0.000	0.000	34.274811.405	-0.012	29.850	-5.040	0.000	0.000	0.000	100	0	
38	13:56:32	273	2021	980239673.123	5.923	0.595	1.692	-64.243	0.131	2.998	-3.109	30.376	-0.017	0.000	0.000	0.000	34.268811.344	-0.012	32.121	-2.273	0.000	0.000	0.000	99	1	
39	14:26:37	273	2021	980239671.765	6.097	0.610	1.698	-69.695	0.280	2.973	-3.109	30.376	-0.017	0.000	0.000	0.000	34.261811.260	-0.012	34.860	1.520	0.000	0.000	0.000	100	0	
40	14:56:37	273	2021	980239672.659	7.026	0.703	1.733	-73.233	0.408	2.969	-3.109	30.376	-0.017	0.000	0.000	0.000	34.240811.245	-0.012	35.070	1.530	0.000	0.000	0.000	100	0	
41	15:26:37	273	2021	980239673.121	7.259	0.726	1.743	-74.931	0.510	3.034	-3.109	30.376	-0.017	0.000	0.000	0.000	34.214811.463	-0.012	33.310	1.910	0.000	0.000	0.000	100	0	
42	15:56:37	273	2021	980239672.736	5.794	0.579	1.687	-74.929	0.580	3.142	-3.109	30.376	-0.017	0.000	0.000	0.000	34.201811.822	-0.012	33.240	0.700	0.000	0.000	0.000	100	0	

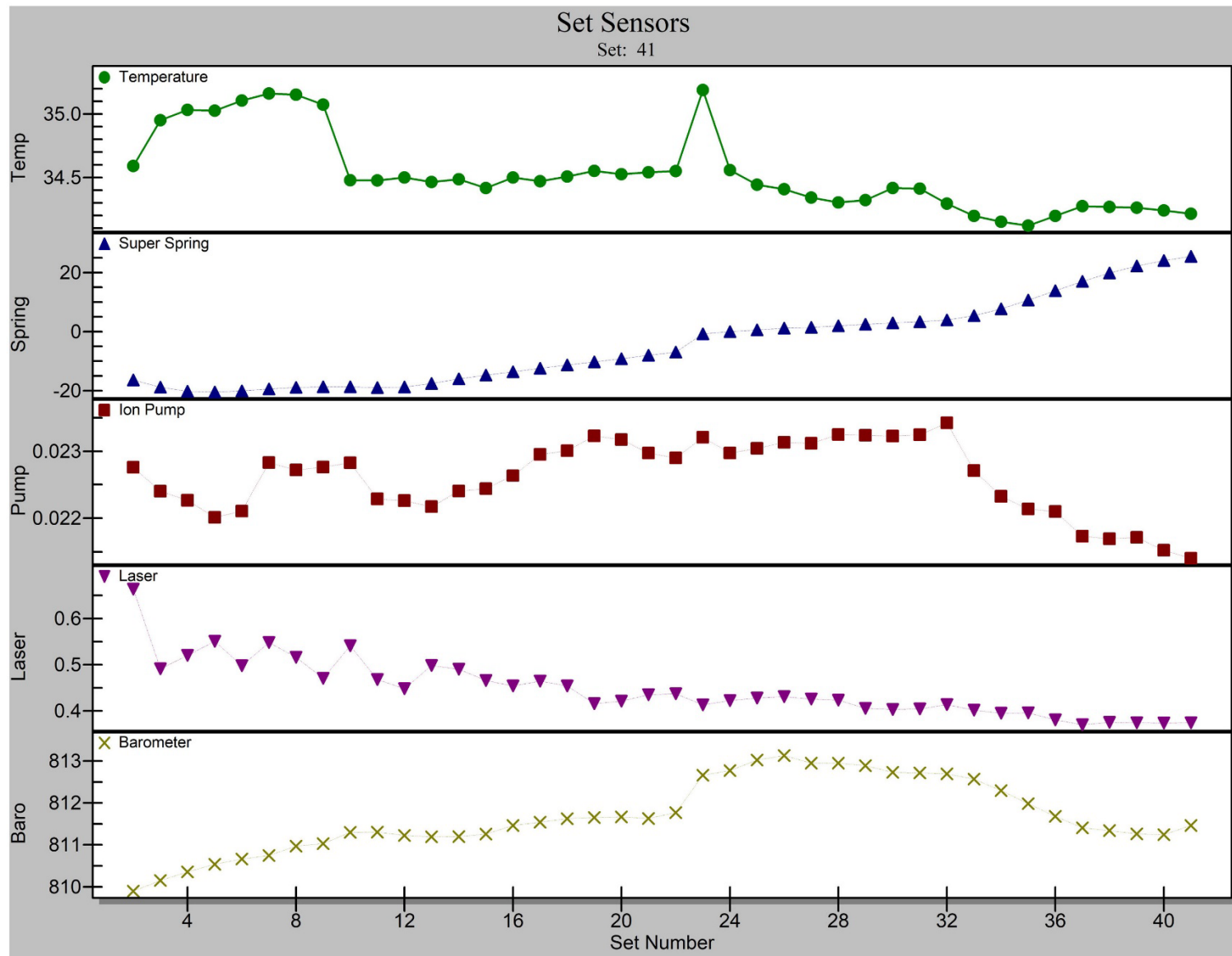


Figure 3. Plot of the set sensor parameters (1 set = 100 drops)

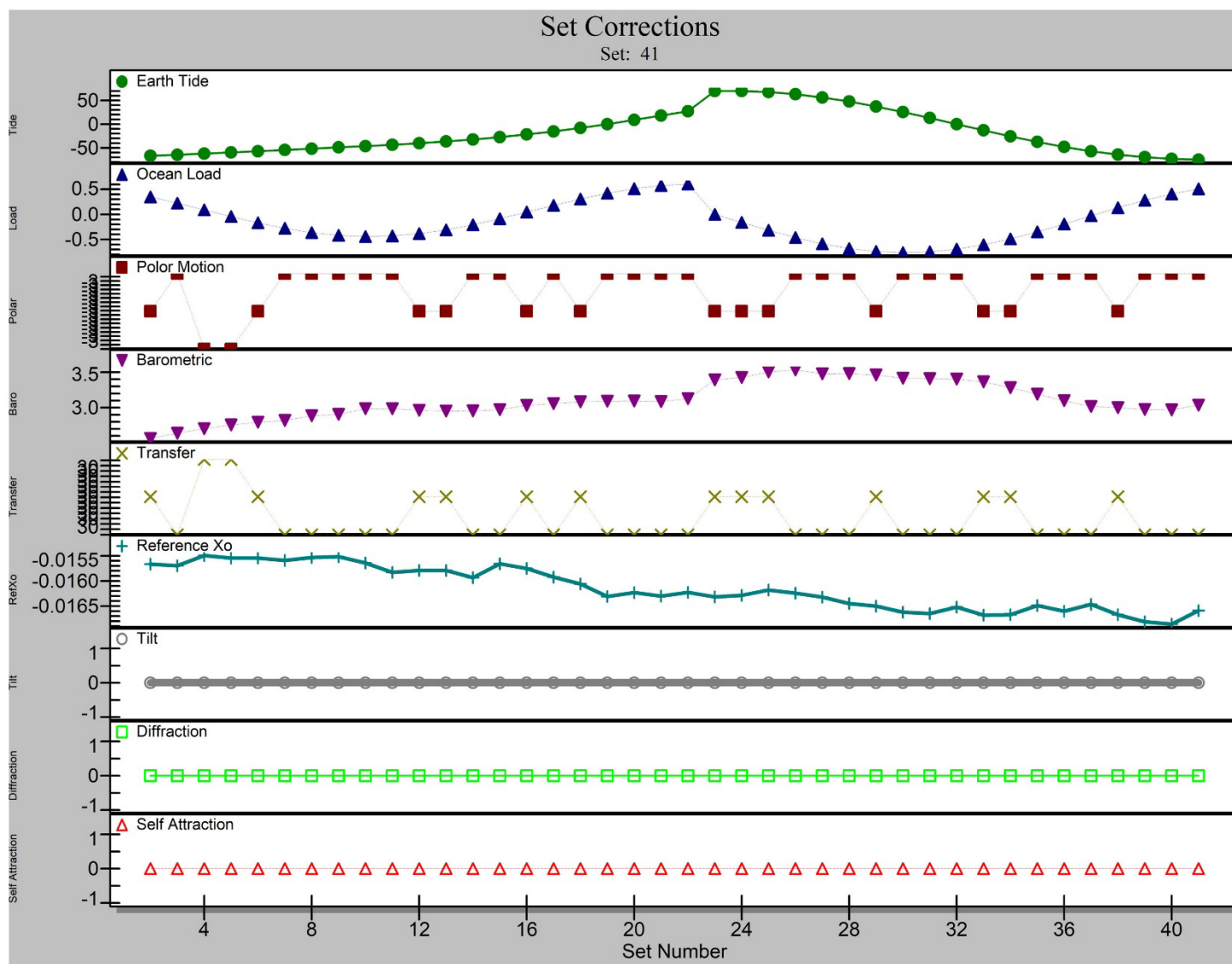


Figure 4. Plot of the set corrections values (1 set = 100 drops)