Comparison between a superconducting gravimeter (GWR-T020) and an absolute gravimeter (FG5-221) at Metsähovi

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Metsähovi

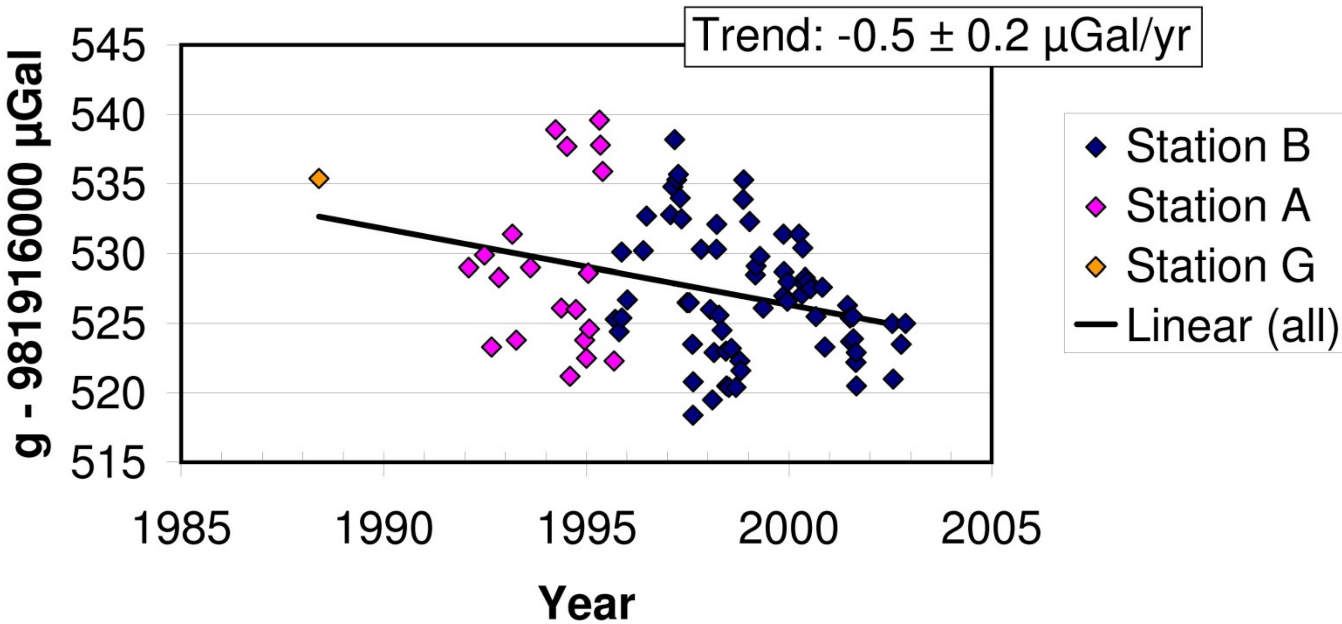
Fundamental Station

Absolute gravity

JILAg-5   1987-2003
FG5-221   2003-2009

Figs. M. Bilker-Koivula

Absolute gravity at Metsähovi measured with JILAg-5 at 120 cm



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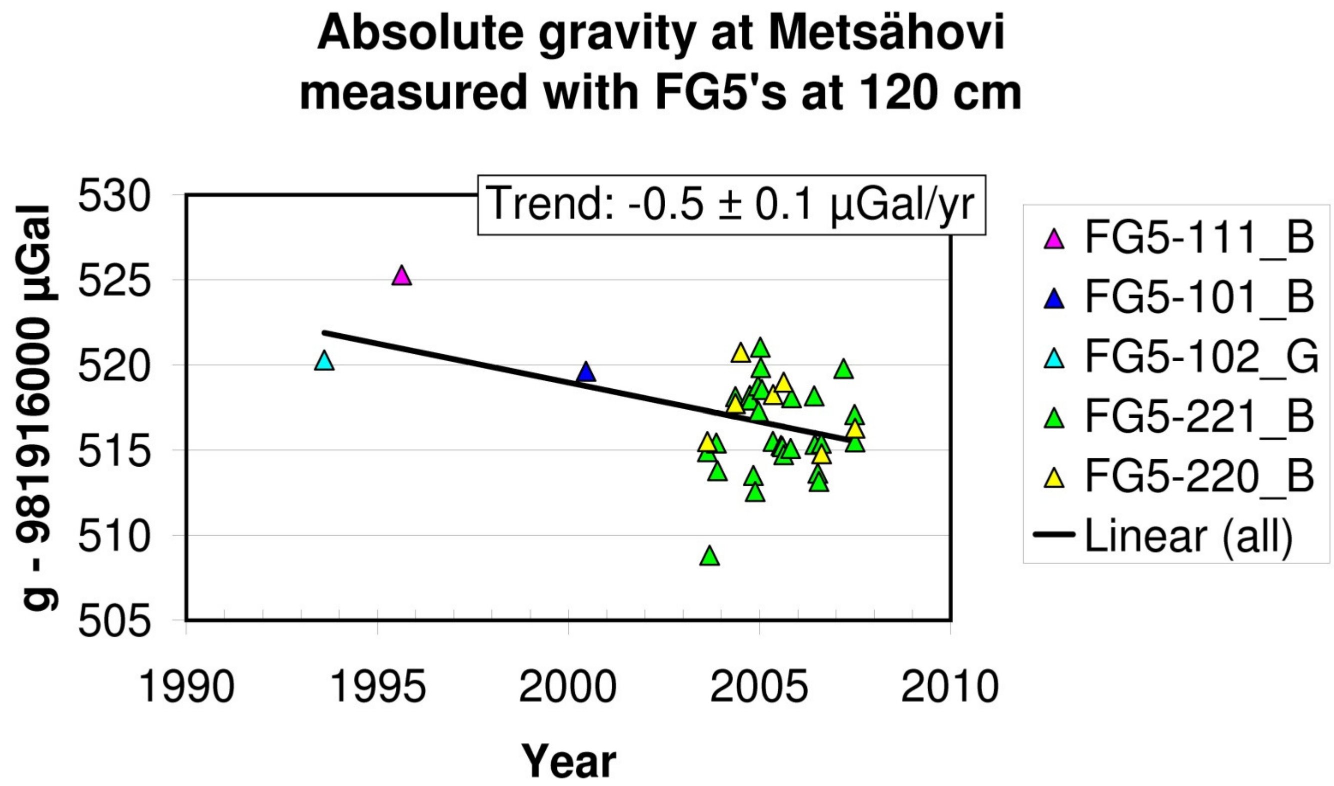


M. Bilker-Koivula

Superconducting gravimeter T020

1994 - 2010

M Poutanen

SUPERCONDUCTING GRAVIMETER (SG)

- Not movable
- High accuracy, 0.1 μgal (precision 1 – 10 ngal)
- 1 second samples, continuos registration
- Relative instrument (calibration needed)
- Offsets (mechanical, LHe, lightning)
- Drift (almost linear)
- Unmodelled drift (mechanical disturbancies due to cooling)

ABSOLUTE GRAVIMETER (AG)

- Movable
- Accuracy 1 – 2 μgal
- No drift, trend determination (land uplift)
- Unknown offsets (maintenance)
- Need comparisons and/or frequent measurements at the site
- 3–5 days measurements

Both instruments are influenced by same environmental effects

Metsähovi is a unique fundamental station, AG is tied to SG

DATA of FG5 and SG

FG5-221:
20030818 – 20080814, 110 datasets (1-6 days),
mean AB 1.4 d (61) and mean AC 0.9 d (49) + 3.03 μgal
Datasets: 50 drops (10s) at every half hour.

SG T020:
20031105 – 20081231 (daily data), common 106 datasets (3d mean).

For comparisons same corrections applied:
Airpressure (0.3μgal/hPa), Pole tide, Tide (neglible difference)

For calibration: 19 sessions*, 1.3 – 6.0 days (mean 2.8 days)
Total of 2560 sets including 128000 drops (only 4 sets rejected).
SG: 1s data, mean of 500 seconds centered to mean time of set
None corrections applied to both timeseries

GSG=CF*SGV+CONST , by linear regression (SVDFIT)

* It is interesting to note that the calibration is independent of whether individual drop means or set means are used (Crossley & Hinderer, 2009)

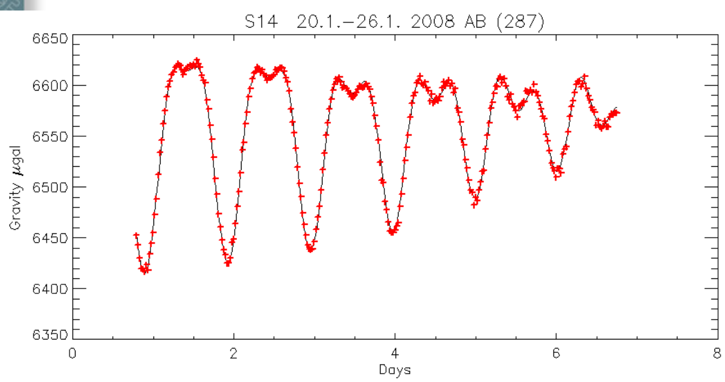
Calibration data sets and results:

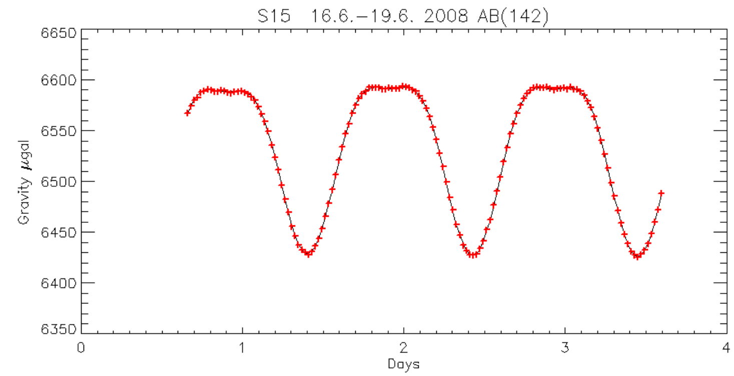
							sets	dur.	ampl.	const	cal.f.	error	corr.
1	2003	11	15	22	4	5	96	2.0	139.9	699.958	-109.797	1.475	-0.99929
2	2003	11	25	13	19	5	70	1.5	208.2	699.105	-111.046	1.263	-0.99971
3	2004	10	7	21	1	56	86	1.8	115.5	697.869	-108.886	3.068	-0.99676
4	2004	11	2	22	39	5	96	2.0	140.4	698.200	-111.568	2.090	-0.99908
5	2004	12	16	18	39	5	95	2.0	158.7	702.361	-111.819	3.857	-0.99851
6	2005	1	8	4	2	5	239	5.0	**230.6**	698.438	-109.761	1.437	-0.99944
7	2005	1	12	16	2	9	193	4.0	213.0	698.225	-110.534	2.021	-0.99924
8	2005	1	23	16	24	5	205	4.3	170.5	697.484	-109.837	1.209	-0.99940
9	2005	8	5	4	39	5	64	1.3	136.6	696.552	-109.004	2.074	-0.99886
10	2006	6	6	7	29	35	90	1.9	91.6	698.945	-109.343	2.678	-0.99699
11	2006	6	14	7	9	5	186	3.9	202.1	699.421	-110.227	0.871	-0.99948
12	2006	7	12	8	36	5	165	3.4	200.9	688.193	-109.981	0.896	-0.99943
13	2007	12	25	2	56	5	143	3.0	**220.2**	693.446	-110.719	2.759	-0.99900
14	2008	1	23	17	57	5	286	6.0	202.2	693.925	-109.495	1.605	-0.99838
15	2008	6	18	2	49	5	142	3.0	166.5	686.699	-110.423	0.580	-0.99993
16	2004	4	10	13	54	5	96	2.0	161.6	704.585	-110.321	1.907	-0.99943
17	2004	5	4	21	24	5	96	2.0	177.3	702.455	-109.892	1.221	-0.99969
18	2004	8	21	14	44	6	96	2.0	105.6	698.347	-111.331	2.590	-0.99842
19	2005	6	7	17	41	40	126	2.6	175.9	697.045	-110.836	0.876	-0.99957

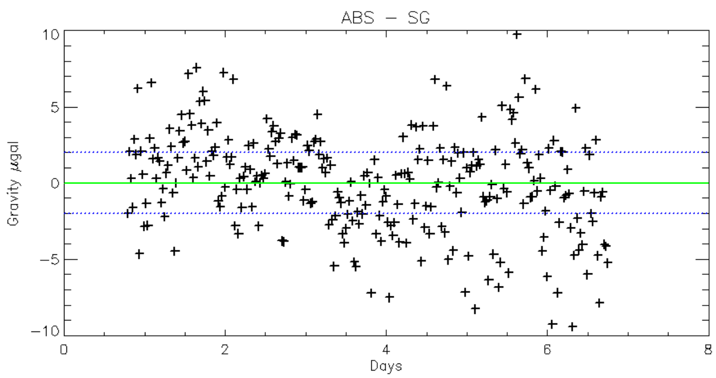
+981016000

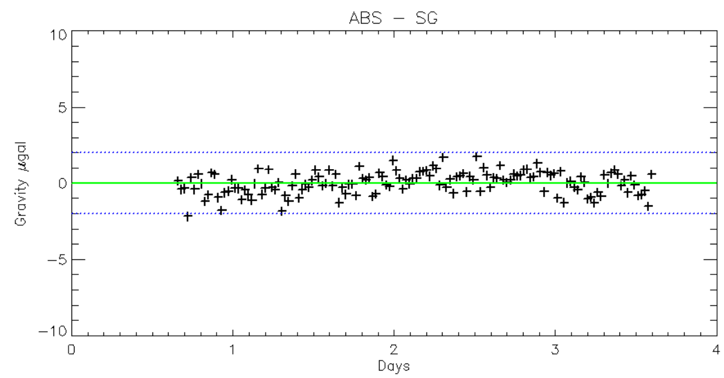
Numbers 1-15 were measured at pillar AB and numbers 16 – 19 at pillar AC.
Total of 2560 sets including 128000 drops.

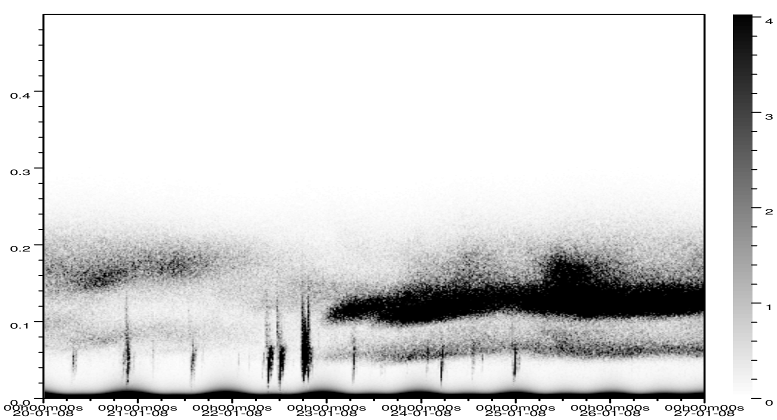
Calibration sessions: high and low microseims

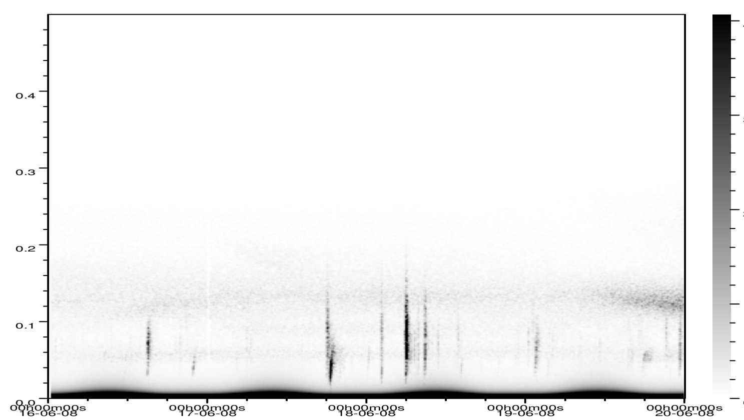


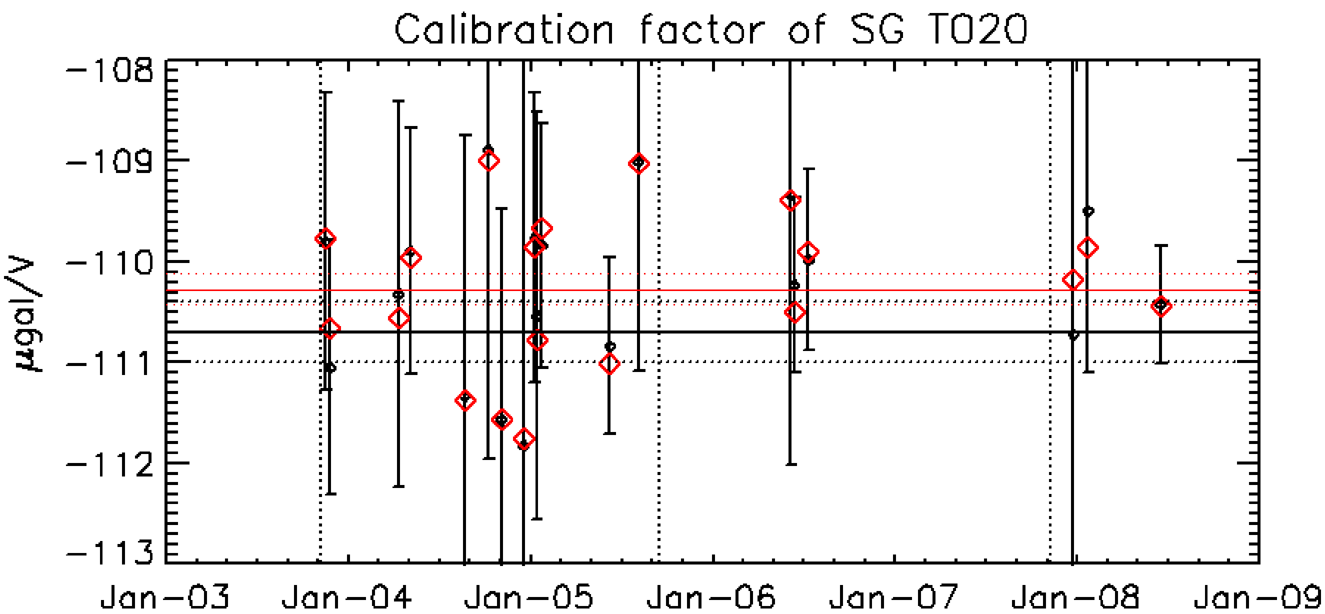


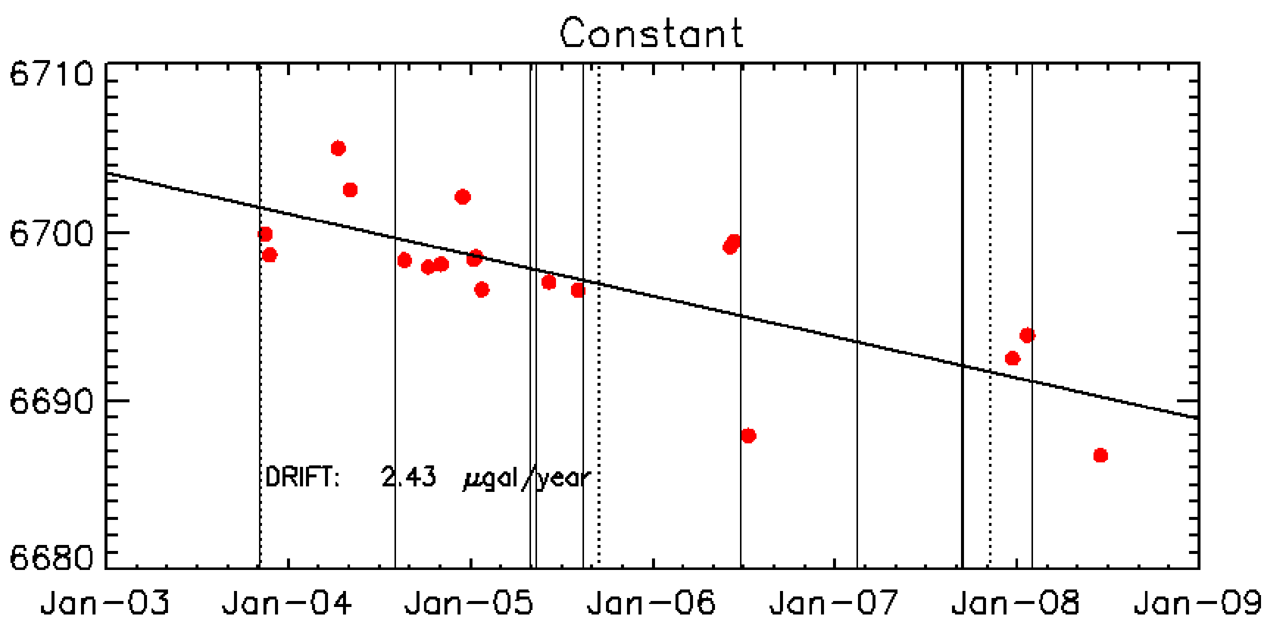









Calibration factor of SG T020
μgal/V
−108
−109
−110
−111
−112
−113
Jan−03 Jan−04 Jan−05 Jan−06 Jan−07 Jan−08 Jan−09


Constant
6710
6700
6690
6680
DRIFT: 2.43 μgal/year
Jan−03 Jan−04 Jan−05 Jan−06 Jan−07 Jan−08 Jan−09

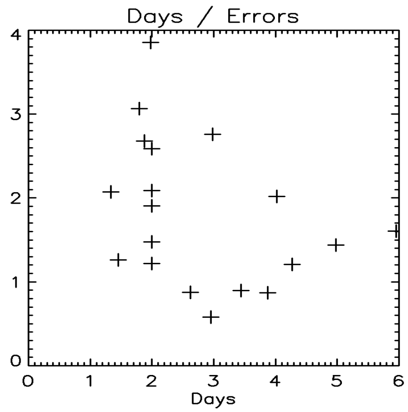
Results of calibration factors:

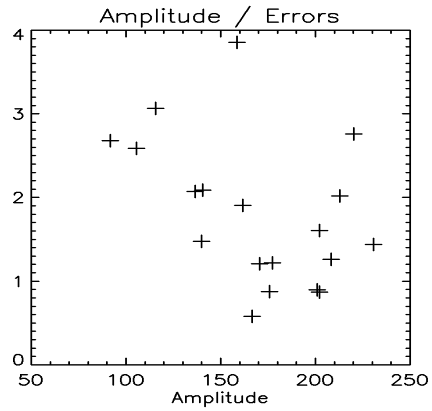
There are several possibilities to weighting:

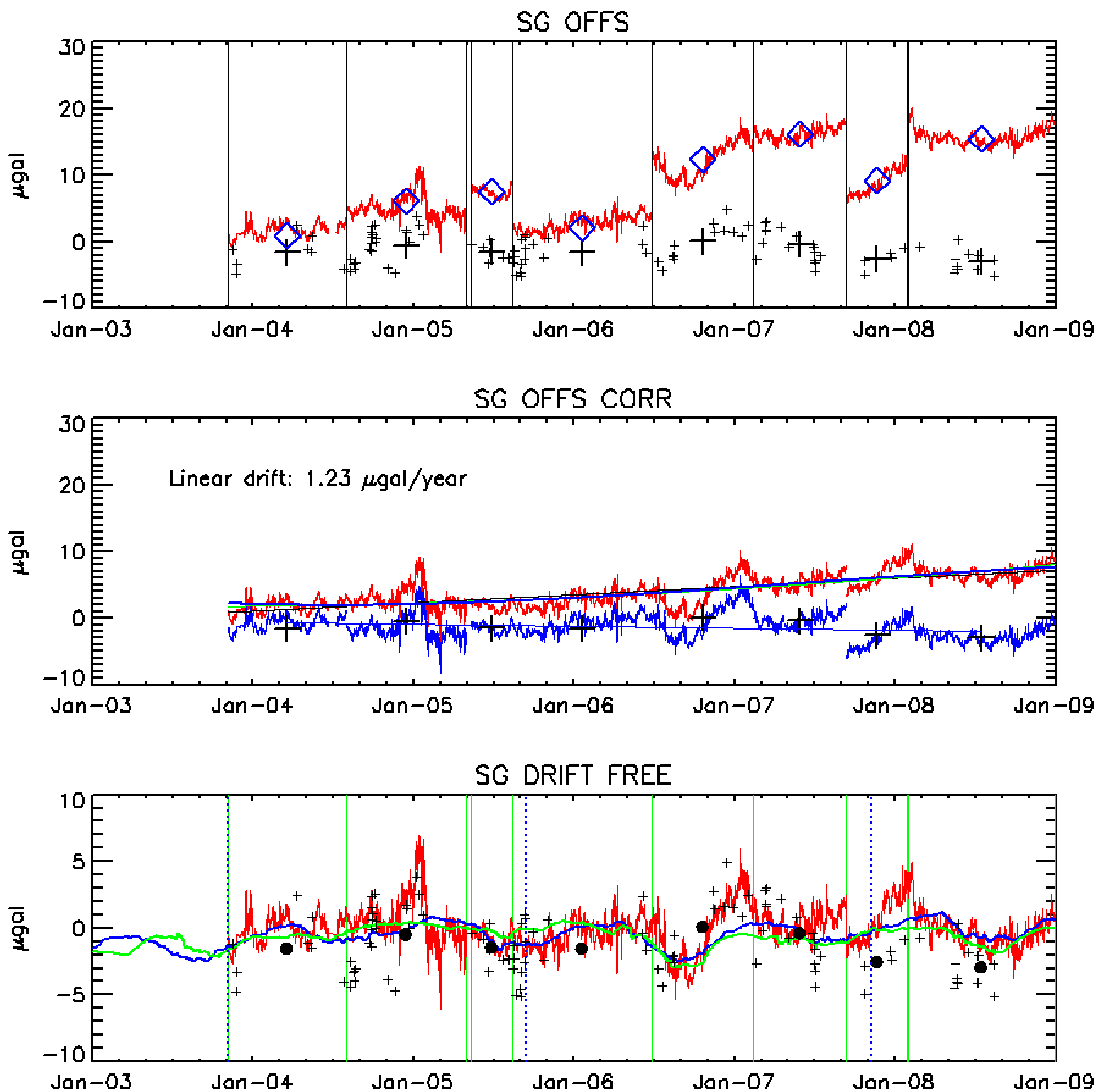
- No weights
- Scatter
- Precision (scatter/ 7), sqrt(50)
- Uncertainty

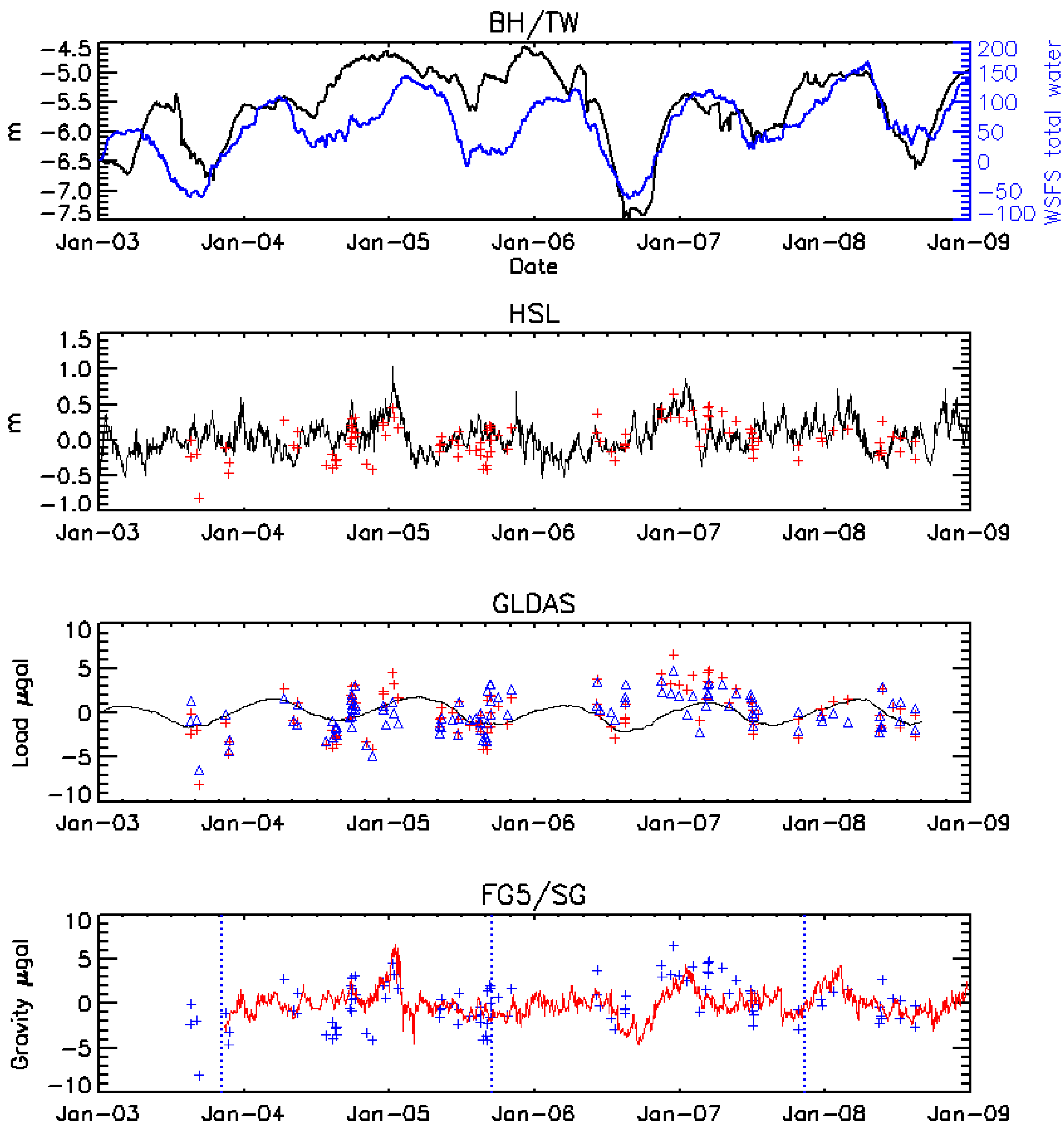
Results:

No weights: -110.27 ± 0.15 μgal/Volts
Scatter: -110.25 ± 0.15 μgal/Volts
Precision: -110.24 ± 0.15 μgal/Volts
Present: -110.70 ± 0.40 μgal/Volts (JILAg-5 1995)






SG OFFS
μgal
30
20
10
0
−10
Jan−03
Jan−04
Jan−05
Jan−06
Jan−07
Jan−08
Jan−09
SG OFFS CORR
Linear drift: 1.23 μgal/year
μgal
SG DRIFT FREE
10
5
0
−5
−10


BH/TW
m
WSFS total water
−4.5
−5.0
−5.5
−6.0
−6.5
−7.0
−7.5
200
150
100
50
0
−50
−100
Jan−03
Jan−04
Jan−05
Jan−06
Jan−07
Jan−08
Jan−09
Date
HSL
m
1.5
1.0
0.5
0.0
−0.5
−1.0
GLDAS
Load µgal
10
5
0
−5
−10
FG5/SG
Gravity µgal

SG/FG5 comparisons results:

FG5 TREND microgal/year: -0.069

SDEV ABS:	2.4808
SDEV SG :	1.7165

BH:	0.5139	0.129	2.4599	1%	
TW:	0.0231	0.448	2.2175	11%	
HSL:	5.0054	0.480	2.1752	12%	
GLDAS:	1.1394	0.439	2.2280	10%	
SG:	0.6562	0.473	2.0982	15%	(variance -28%)

BH	2.4918	0%	(1.1 µgal/m)
TW	2.2439	9%	(0.016 µgal/mm)
HSL	2.2557	9%	(2.5 µgal/m)
GLDAS	2.2320	10%	

FG5-HSL-GLDAS:	2.0261	18%	(variance -33%)
FG5-HSL-GLDAS-TW:	2.1287	14%	
FG5-HSL-BH:	2.3260	6%	
FG5-HSL-TW:	2.0549	17%	
FG5-BH-TW:	2.3779	4%	
FG5-SG:	2.1795	12%	
ALL:	2.4707	1%	

Conclusions I (SG)

Two instrument is necessary to ensure that AG measurements are referencing the mean station gravity and not short-term gravity perturbations due for example to hydrology and meteorology

Hydrological variations – from local to global the largest unmodeled effect on AG measurements

Possible correction parameter due to environmental effects for AG

Long-term changes if measurements spaced few days, SG will significally enhance the quality of observations

Conclusions II (AG)

- Calibration (scale factor) for SG
- Determination offsets size and long data gaps connections
- Drift control for SG
- Enhange of quality in long term studies (hydrology)

SGs and AGs are complementary

They serve to check each other by entrely independent observations

Discrepancies between SG and AG data may indicate problems with one of the instruments

References:

Crossley, D.,Hinderer, J.,2009. The Contribution of GGP Superconducting Gravimeters to GGCOS. M.G. Sideris (ed.),Observing our Changing Earth, International Association of Geodesy Symposia 133, Spinger-Verlag Berlin, pp 841-852.

Bilker-Koivula, M.,Mäkinen, J., Timmen, L., Gitlein, O., Klopping, F., Falk, R., 2008. Repeated Absolute Gravity Measurements in Finland. Proceedings of International Symposium on Terrestrial Gravimetry: Static and mobile Measurements, TG-SMM2007, 20-23 August 2007, Saint Petersburg, Russia.

Hwang, C., kao, R., Cheng, C.-C., Huang, J.-F., Lee, C.-W., Sato, T., 2009. Results from paraler observations of superconducting and absolute gravimeters and GPS at the Hsinchu station of Global Geodynamics Project, Taiwan. J.Geophys.Res. 114, B07406, doi:10.1029/2008JB006195.

Thank you for your attention !