Calibration of spring gravimeter using absolute gravity measurements

Results of parallel observations using LCR-ET and FG5 gravimeters during 2007-2010 in Józefoslaw Observatory

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Abstract

COMPARISON of gravimeters relative to absolute measurements is frequently used method for determination of gravimeters scale factors. This technique as completely non-invasive is especially important in periodic control of continuously recording gravimeters. We used 30 repeated parallel observations of LaCoste&Romberg spring gravimeter with FG5 ballistic gravimeter in Jozefoslaw Observatory carried out in last 40 months. Long series of repeated measurements allows us for comprehensive study on utility of calibration with this procedure. Different computational approaches was performed. Temporary variation of LCR scale factor with accuracy assessment are considered. Discussion concerning reliability of calibration dependent on measurements length was also given.

Introduction

JÓZEFOSŁAW observatory (near Warszawa) is equipped in spring LCR-ET26 (Bogusz, 2002) and ballistic FG5230 (since 2005) gravimeters. After serious repair in summer 2006 spring gravimeter is operated continuously and serves for determination of tidal gravity factor, studying air pressure influence on gravity and investigation is other phenomena i.e. ocean loading. Frequently ballistic gravimeter measurements (once monthly) are using to study long term non-tidal gravity variation (hydrology, tectonic and other).
We combined both types of measurements for determination of spring gravimeter scale factor. We also investigated in its variation, unfortunately the length of measurements are insufficient for this study.

Figure 1: *LCR and FG5 gravimeters in Józefosław.*

Observations

THE raw observations of LCR are presented in the fig. 2 along with FG5 periodic measurements. We used almost all FG5 measurements conducted within considered period in Józefosłam. Those are of different length, number of sets and number of drops. We present the results of every single drop in the fig. 3 from an example measurements. For comparison we put it together with records from LCR using raw and filtered data. The records for spring gravimeter are 1 min sampled and simple filter using moving average window 400s length is used. In the fig. 4 we present the same data for one set only.

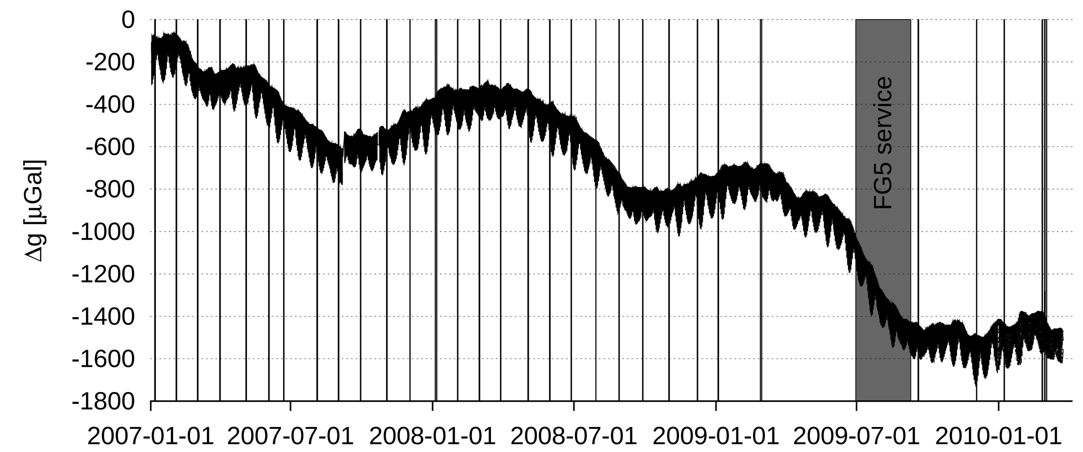

Figure 2: *Raw observations of LCR gravimeter. Vertical bars represents FG5 measurements.*

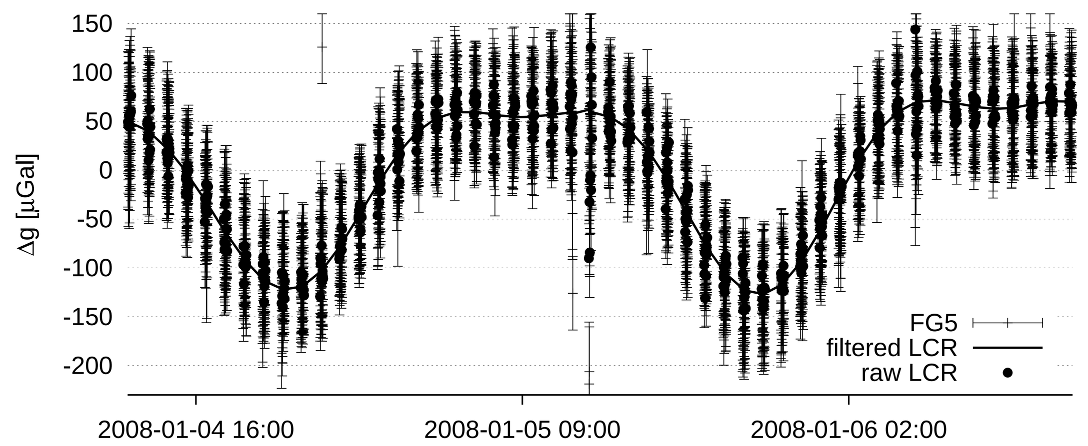

Figure 3: *Gravimeters scatter during parallel measurements (centered values).*

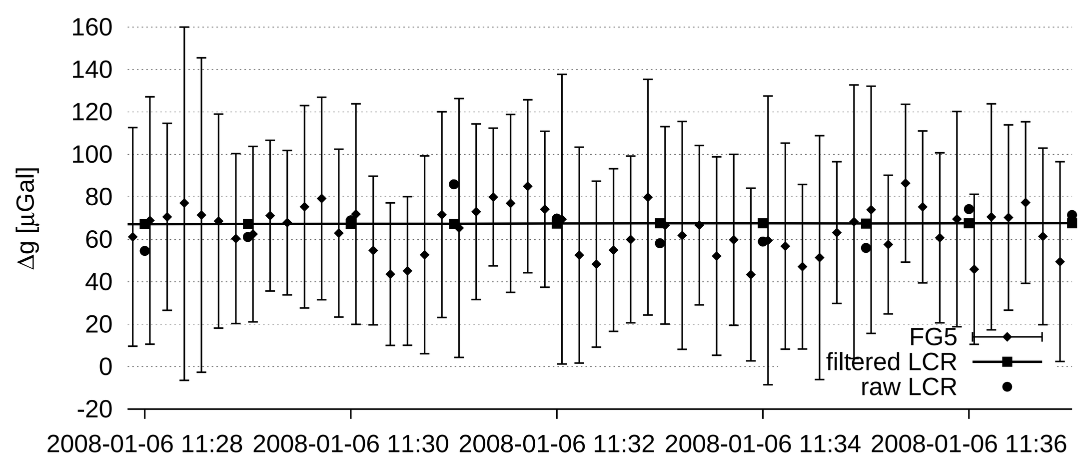

Figure 4: *Gravimeters scatter during one set.*

Analysis

Data

For determining of scale factor we used mean set FG5 values and filtered LCR data. Assuming that impact of environmental disturbances (atmospheric, hydrological) and tides (body tide,ocean loading) is exact for both gravimeters we used uncorrected, centered data for further analysis. The results from example session are presented in the fig. 5.

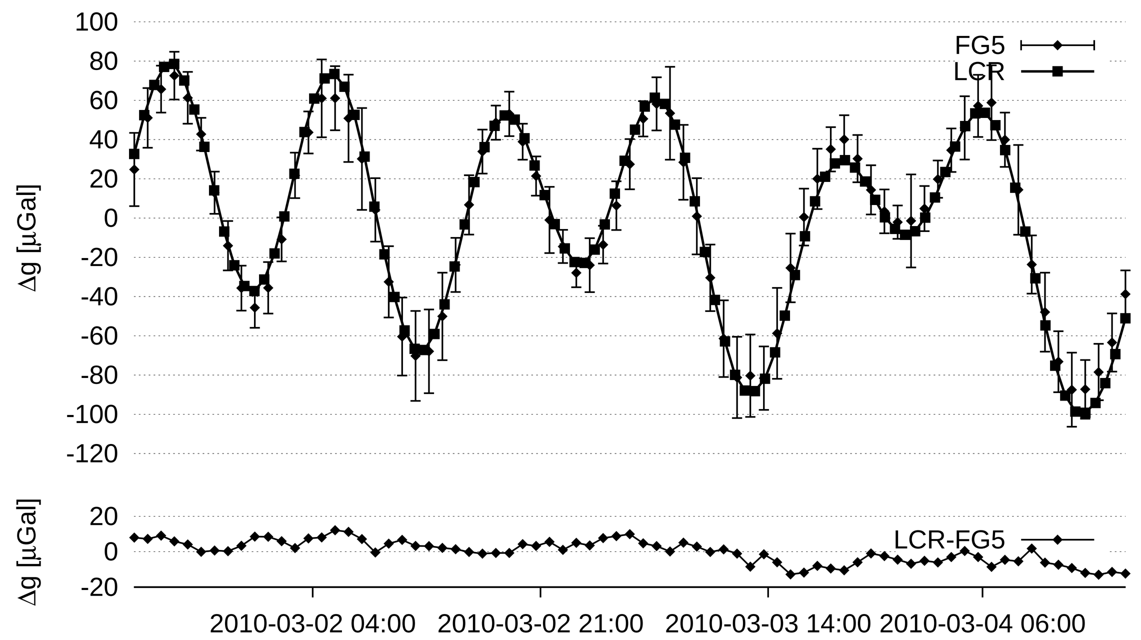

Figure 5: *FG5 mean set value with LCR records.*

Results

We used simple equation,

$$g_{FG} = k \cdot g_{ET} + s,$$

for computing LCR scale factor (k) using Least Square Adjustment. We apply weights for measurements which were proportional to inverse of square of set uncertainty.

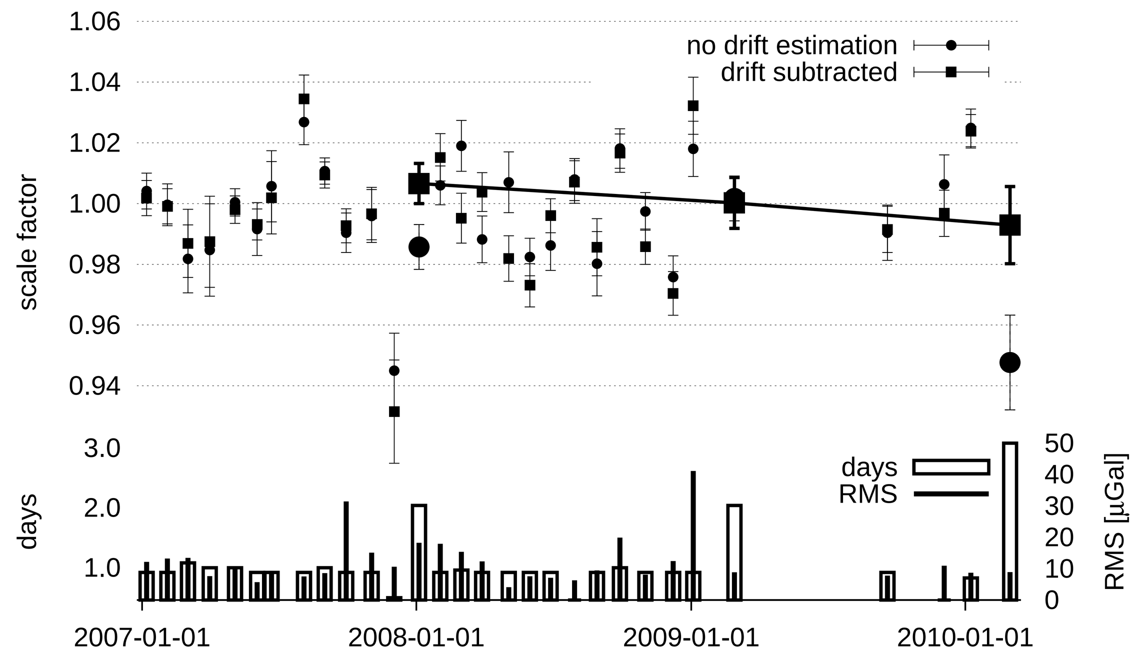

Figure 6: *Scale factor values - upper graph, for sessions of minimum 2 days length has bigger marks. Number of FG5 measurements days and RMS of LCR residuals.*

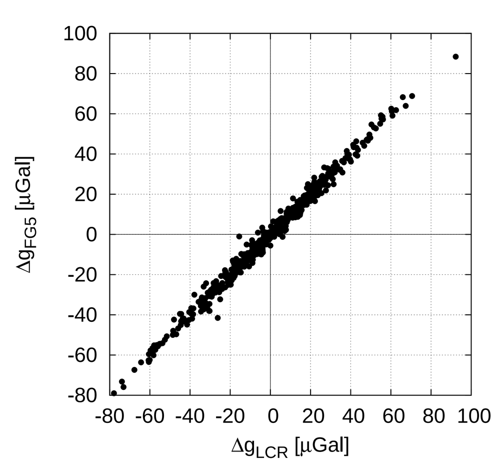

Figure 7. *Correlation.*

The results for particular series are presented in the fig. 6. It is clear that variation of factor is due insufficient length of AG measurements or due increased background noise. The level of noise (RMS) during session is computed as standard deviation of raw minute data with subtracted synthetic tides and fitted 9^{th} degree polynomial. For every session we computed scale factor twice, with LCR drift-less assumption and removing linear drift from LCR results. Drift was computed by fitting linear trend for detided time series. Theoretical tides was computed using `predict` (Wenzel, 1996) with potential catalog HW95 (Hartmann and Wenzel, 1995) using local tidal factor estimated from LCR measurements.
Fig. 8 presents importance of accuracy of scale factor determination depending on AG measurements length computed from the longest session of parallel observations.

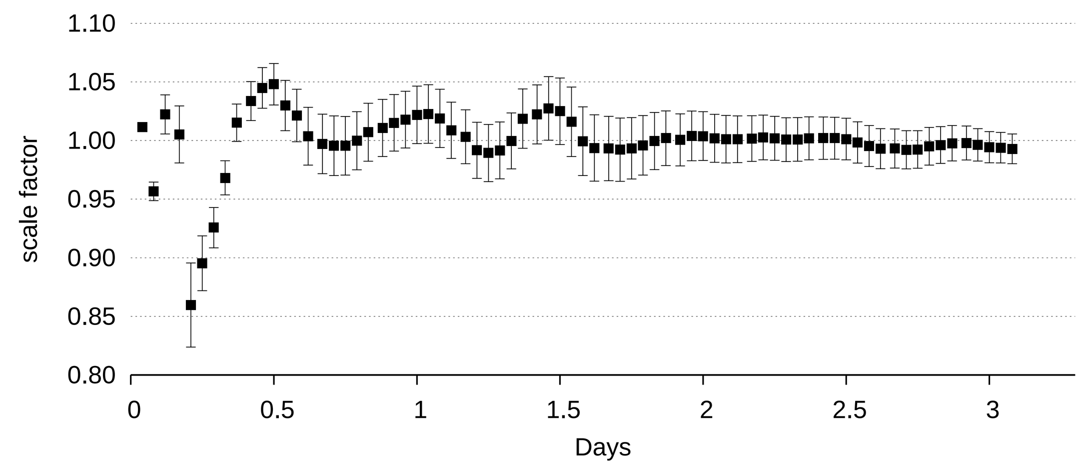

Figure 8: *Scale factor depending on measurement time.*

Table 1: *Calibration results.*

Date	$\Delta t [days]$	Number of set	$\Delta g\ [\mu Gal]$	k	m_k
2008-01-04	2.04	202	50	1.0066	0.0066
2009-02-27	2.04	146	50	1.0002	0.0084
2010-03-01	3.08	160	75	0.9929	0.0127

Conclusions

DETERMINING scale factor for relative gravimeters is important and crucial for all further measurements. From all known methods comparison with absolute gravimeters, despite high cost, has the advantage that is non-invasive and automatic. It is routinely used for superconducting gravimeters where relative accuracy is achieved with minimum 5 days of observation (Rosat and others, 2009). This method can be used for spring gravimeters as well (Pálinkáš, 2006; Bogusz and Kłek, 2008). Unfortunately lengths of measurements allows for confirming manufacturer scale factor at 1% level.

Acknowledgments

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