CALIBRATION OF SPRING GRAVIMETER USING ABSOLUTE GRAVITY MEASUREMENTS

RESULTS OF PARALLEL OBSERVATIONS USING LCR-ET AND FG5 GRAVIMETERS DURING 2007-2010 IN JÓZEFOSŁAW 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 Józefosław 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.

1 INTRODUCTION

Józefosław observatory (near Warszawa) is equipped with spring LCR-ET26 (since 2001) and ballistic FG5230 (since 2005) gravimeters (Barlik et al., 2010). Spring gravimeter is operated continuously and serves for determination of tidal gravity factor, studying air pressure influence on gravity and ocean loading (Rajner, 2010). Frequently ballistic gravimeter measurements (once monthly) are using to study long term non-tidal gravity variation (hydrology, tectonic and other, Barlik, 2010).

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.

2 OBSERVATIONS

The raw observations of LCR are presented in Fig. 1 along with FG5 periodic measurements. We used almost all FG5 measurements conducted within considered period in Józefosław. Those are of different length, number of sets and number of drops. We present the results of every single drop in Fig. 2 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 400 s length is used. In Fig. 3 we present the same data for one set only.

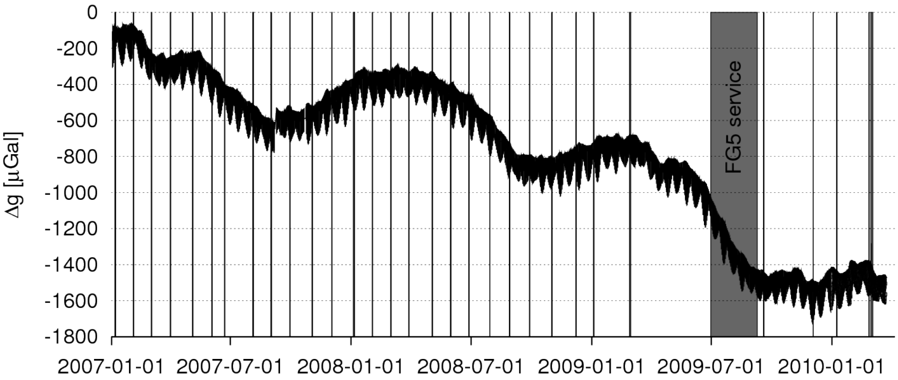

Fig. 1. Raw observations of LCR gravimeter. Vertical bars represents FG5 measurements.

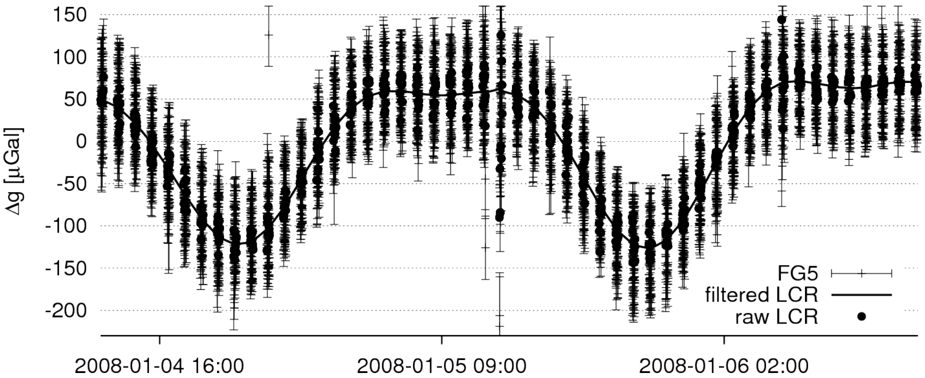

Fig. 2. Gravimeters scatter during parallel measurements (centered values).

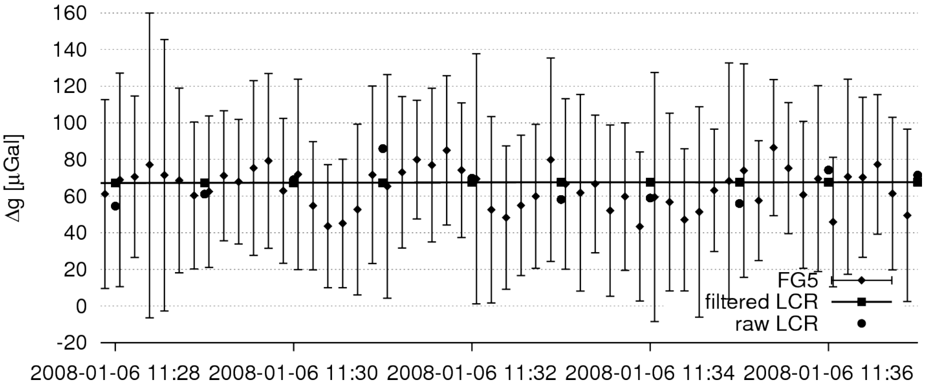

Fig. 3. Gravimeters scatter during one set.

3 ANALYSIS

3.1 DATA

For determination of the 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 the same for both gravimeters we used uncorrected, centered data for further analysis. The results from example session are presented in Fig. 4.

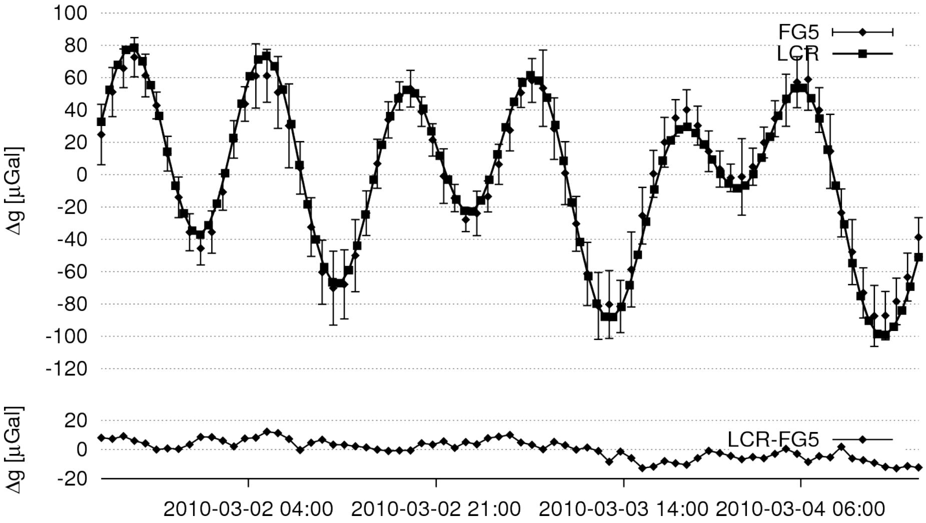

Fig. 4. FG5 mean set value with LCR records.

3.2 RESULTS

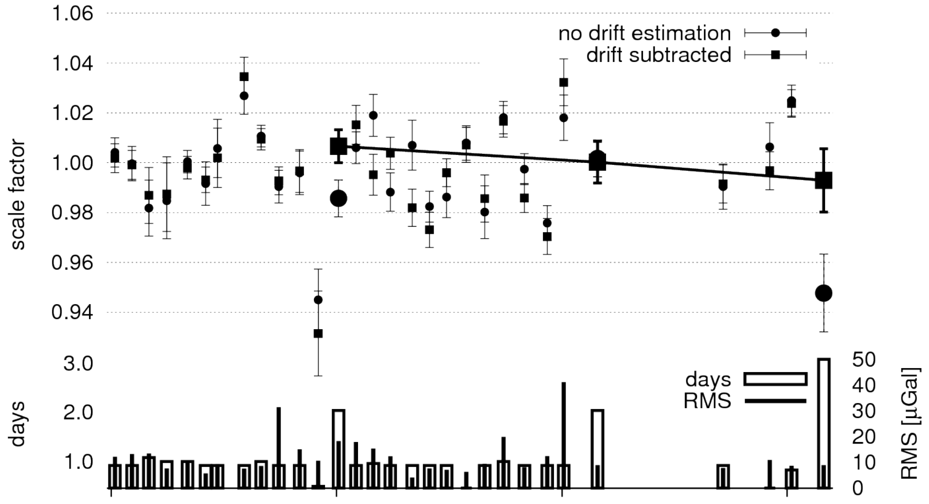

Fig. 5. Scale factor values - upper graph, for sessions of minimum 2 days length has bigger marks. Number of FG5 measurements days and RMS of LCR residuals – bottom graph.

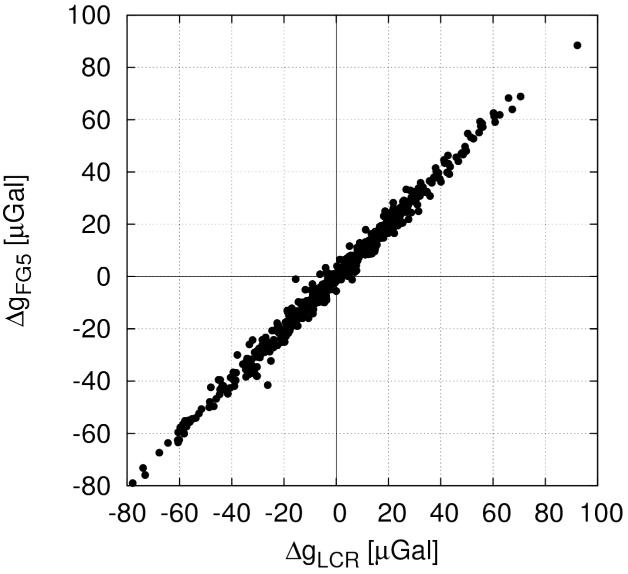

Fig. 6. Correlation of gravity differences for both gravimeters.

We used simple equation,

$$g_{FG5} = g_{ET} \cdot k + s,$$

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.

The results for particular series are presented in Fig. 5. 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 9th 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. 7 presents importance of AG measurements length for scale factor accuracy determination computed from the longest session of parallel observations.

Table 1. Calibration results.

Date	Δt[*days*]	Number of set	Δg [μ*Gal*]	*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

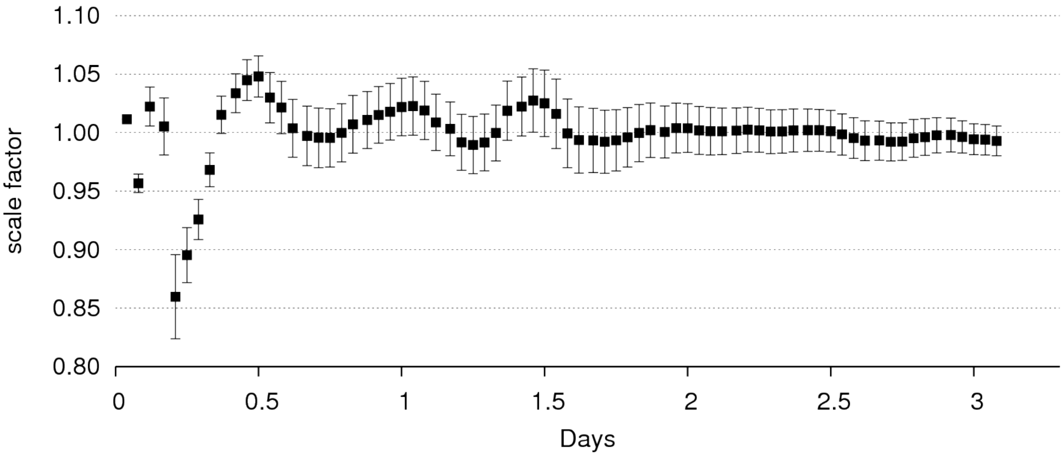

Fig. 7. Scale factor depending on measurement time.

4 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 (Hinderer et al., 1991, Ducarme et al., 1993). It is routinely used for superconducting gravimeters (Amalvict et al., 2002, Francis and van Dam, 2002) where relative accuracy (0.1%) is achieved with minimum 5 days of observation (Rosat et al., 2009). This method can be used for spring gravimeters as well (Pálinkáš, 2006, Bogusz and Kłęk, 2008). In our studies lengths of measurements allowed to confirm the manufacturer scale factor at 1%.

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