Observed secular gravity trend at Onsala station with the FG5 gravimeters from Gävle and Hannover

L. Timmen (LUH), A. Engfeldt (LM), O. Gitlein (LUH), H.-G. Scherneck (OSO)

Motivation

Onsala Space Observatory (OSO) is one of the key reference stations for absolute gravimetric measurements in the Fennoscandian land uplift area. It provides excellent conditions for testing and comparing absolute gravimeters (offset determination), for monitoring non-tectonic gravity variations on the highest accuracy level with the superconducting gravimeter GWR#54, and for observing secular tectonic variation as a geodynamics observatory within GIA research. For this report, the joint research is driven by the following questions:

1. Is it possible to derive reliably the gravity effect of the Fennoscandian land uplift at Onsala from the observations with the Hannover FG5 gravimeter since 2003?
2. Can we already combine the shorter time series of the gravimeter from Gävle (LM) with the Hannover results (LUH)?
3. Will simultaneous measurements (direct comparisons) with FG5-220 (LUH) and FG5-233 (LM) reveal a significant bias (long-term offset) between both meters?
4. What is the improvement for absolute gravimetry in Onsala gained by continuous gravity monitoring with the superconducting gravimeter GWR#54 since 2009?

Fig. 1:The gravity stations at Onsala Space Observatory: (left) the old site (points AS, AN) has been occupied by FG5-220 until 2011; (right) the new lab (points AA, AC etc.) is available since 2009.

1. Gravity trend from FG5(X)-220

The observational trend is derived from absolute gravity determinations at points AA (new lab) and AS / AN (old site, AN centered to AS, later to AA). Since 2012, the upgraded Hannover meter FG5X-220 has a free-fall length (about 30 cm instead of 20 cm) and a different measuring segment along the vertical (from 138 cm to 108 cm above floor level instead of 128 cm to 108 cm). The difference between AS and AA is 323.2 µGal and has been determined by relative measurements in 2010 and absolute observations in 2010 and in 2011.

For the Fennoscandian land uplift a linear trend is assumed. Due to the number of g-determinations, seasonal and short periodic variations as well as instrumental errors are averaged out to a certain extend. Within the measurement uncertainty, the observational trend agrees with glacial rebound models predicting –0.4 µGal/yr.

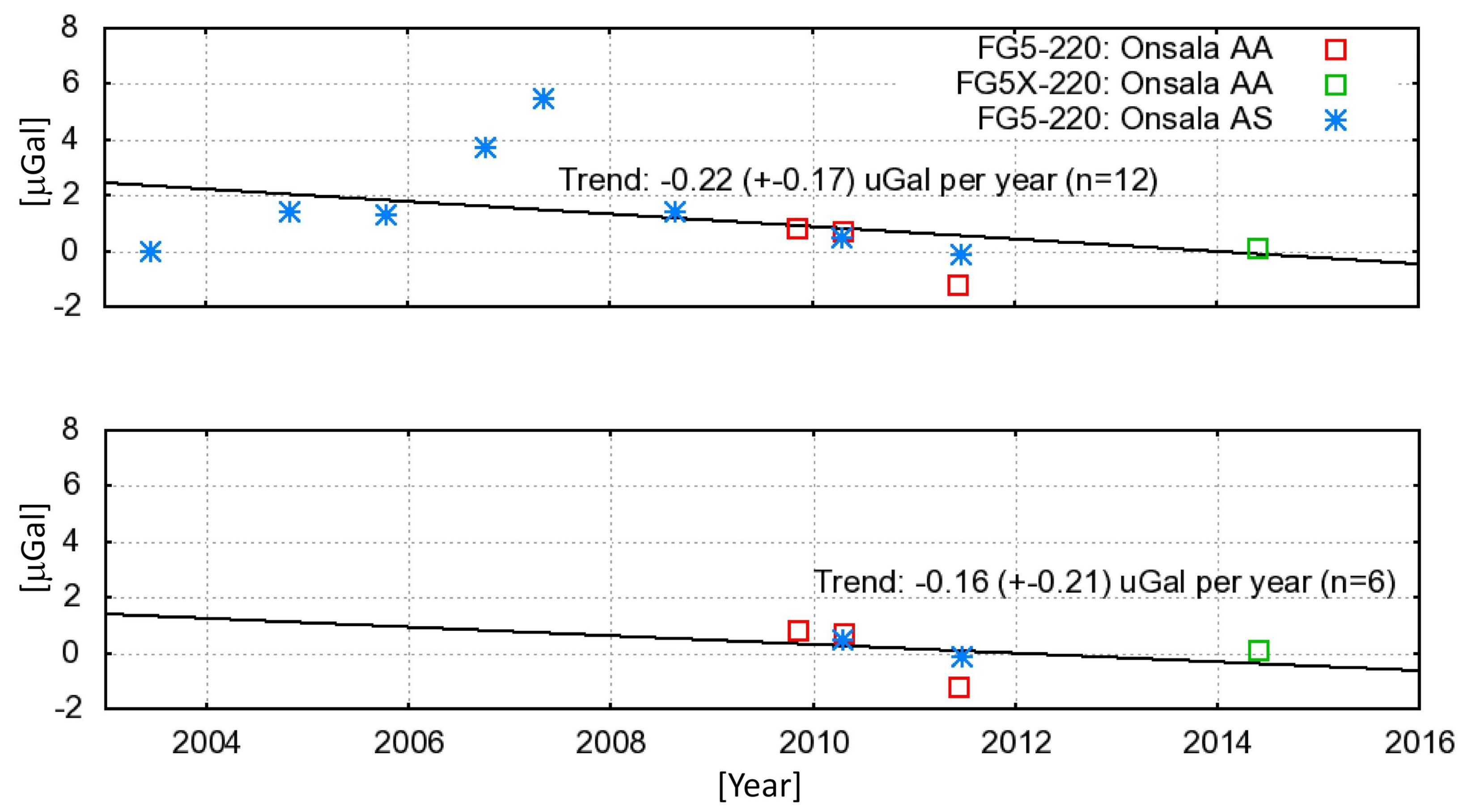

Fig. 2: (top) Gravity variations for Onsala as obtained with the Hannover FG5 gravimeter in combination with the measurements of the superconducting gravimeter GWR#54 at OSO (since 2009); (bottom) g-trend since the availability of the new laboratory.

2. Combining g-results of 2 FG5s (LM / LUH)

Fig. 3 shows the FG5 results of LUH together with 3 determinations of LM, all reduced by the SCG analysis result. Obviously no improvement is achieved. The g-results of a single meter should already show a reliable trend before combining the different meters.

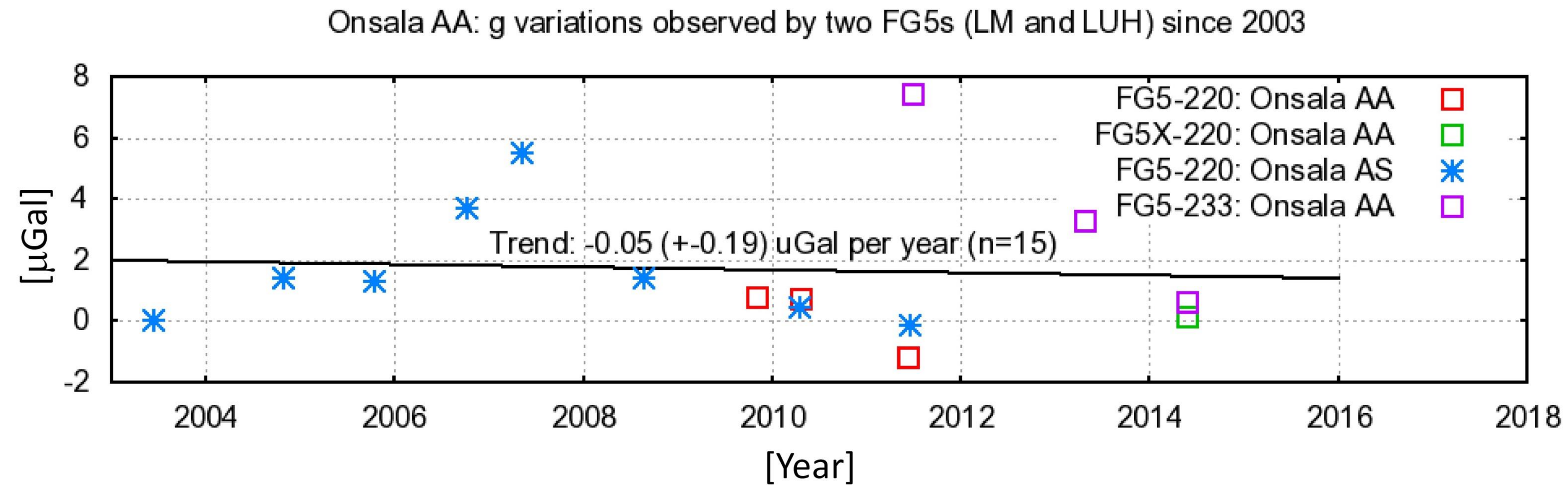

Fig. 3: Gravity variations for Onsala as obtained with the FG5 gravimeters of LM and LUH, after applying reductions from SCG GWR#54 (available since 2009).

3. Simultaneous measurements with FG5-233 and FG5(X)-220

For the period 2007 to 2014 a negligible long-term bias of 0.1µGal is obtained.

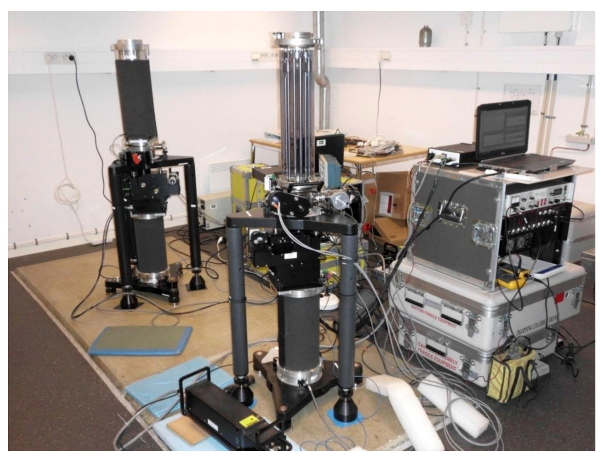

Fig. 4: OSO absolute gravity site with the Hannover absolute gravimeter FG5X-220 (AA, room center) and the gravimeter FG5-233 (AC) from Lantmateriet, Gävle.

International and local comparisons	No. of meters	Epoch	Δg [µGal] (FG5#220 – CRVs)		Δg [µGal] (FG5#233 – CRVs)		Δg [µGal] FG5#220–#233
ECAG2003	13	Nov. 2003	–1.9	±1.4	FG5 not available		
Mårtsbo (unpublished)	2	May 2007					**+2.1**
ECAG2007	19	Nov. 2007	+2.4		+1.0		**+1.4**
ICAG2009	21	Oct. 2009	+1.7	±0.9	+1.0	±0.3	**+0.7**
RICAG_WET2010 (unpublished)	5	Nov. 2010	+3.3		+5.8		**–2.5**
ECAG2011	21	Nov. 2011	+1.8	±0.3	+4.7	±0.9	**–2.9**
ICAG2013 (with FG5X-220)	25	Nov. 2013	+2.3	±0.8	+2.2	±1.3	**+0.1**
RICAG_WET2013 (unpubl., FG5X-220)	5	Jan. 2013	+6.3		+6.9		**–0.6**
Onsala (unpubl., FG5X-220)	2	May 2014					**+0.7**
CRVs: Comparison Reference Values as defined by all participating gravimeters (ICAG, ECAG) or by the reference gravimeters (RICAG); statistical values are partly not available							**mean = –0.1 (rms = 1.7)**

Tab. 1: Compilation of differences between the 2 FG5s within international and local comparisons.

4. Gain by superconducting gravimetry

From the SCG observations (2009 to 2014), a new tidal model has been derived which is applied to all FG5-220 results since 2003. Additional reductions for g-determinations are provided for epochs since 2009. The full benefit for absolute gravimetry is included in Fig. 2. The first big hit with the new tidal model comprises additional tide effects from the Kattegat.

Fig. 5: GWR#54 at OSO

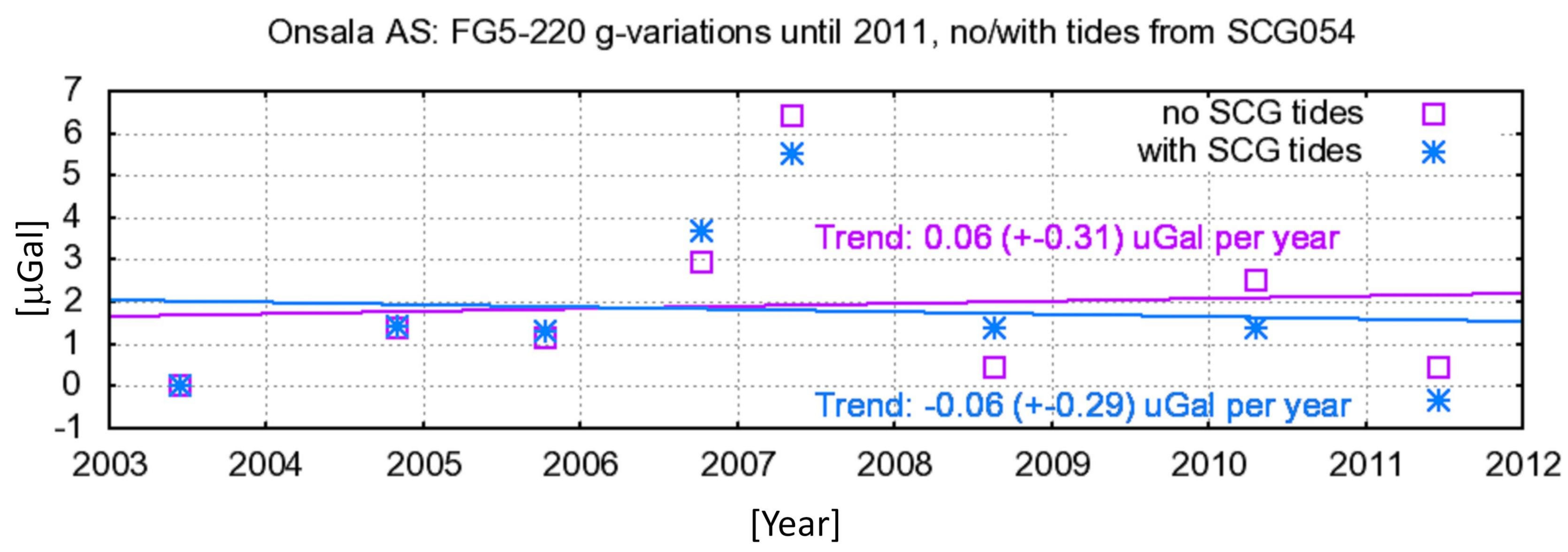

Fig. 6: (top) g-results before applying tides from GWR#54 (just synthetic tides); (bottom) improved results with observational tides.

Absolute gravimetry combined with continuous SCG measurements at Onsala