

Gravimetric effects induced by vertical air mass shifts at
Medicina (1998-2005), Wettzell, Bad Homburg, Moxa, Pecny and Wien (1998-2004)

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Abstract

The gravimetric effects of vertical air mass displacements were computed at the locations of six European stations, where superconducting gravimeters are recording. The modelling was made based on radiosonde data using the AMACON software of SIMON (2003). The length of the $g_c(t)$ model curves is 8 years (1998/01/01–2005/12/31) for Medicina station / Italy and 7 years (1998/01/01–2004/12/30), respectively, for the five other stations Bad Homburg/Germany, Wettzell/Germany, Moxa/Germany, Pecny/Czech Republic and at Vienna/Austria. As before the modelling was made with a general sampling rate of 24 hours (12 h of any day). Some examples of $g_c(t)$ model curves are given where the sampling rates are shorter.

1. Background of the modelling

Four years ago the existence of a gravimetric component $g_c(t)$ induced by vertical air mass shifts in the case of a constant ground air pressure was firstly shown by SIMON (2002). The effect is caused by an unaccelerated rising of warmed (lighter) and the sinking of colder (heavier) air particles, respectively. The air mass attraction varies due to these vertical air mass shifts according to

$$A_c(t) = A(t) - A_p(t) = A(t) - r_{AP}^* P(t) \quad (1)$$

$A(t)$: air mass attraction at the measuring point G,

$P(t)$: surface pressure at the measuring point G

$A_p(t)$, $A_c(t)$: surface pressure-dependent and independent component of $A(t)$

$r_{AP} = 0.40 \mu\text{Gal/hPa}$: regression coefficient (SIMON, 2003).

The corresponding component $g_c(t)$ of the gravity variation has the opposite sign. It is obtained from

$$g_c(t) = - A_c(t) + C, \quad C = \text{constant} \quad (2)$$

The seasonal warming /cooling of air masses is an effect of low regional variability. As a consequence the data of a network of eight radiosonde stations located in Germany, Austria, Poland and Italy were enough for the calculation of the $g_c(t)$ – variations at the mentioned six European gravimeter stations. The radiosonde stations were seldom situated in the direct vicinity of a gravimeter location, as for instance at Medicina and Vienna. Therefore the $g_c(t)$ modelling was made in most cases according the so-called 3 stations method (SIMON, 2003).

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2. Results

The results of the computations are shown in the following figures:

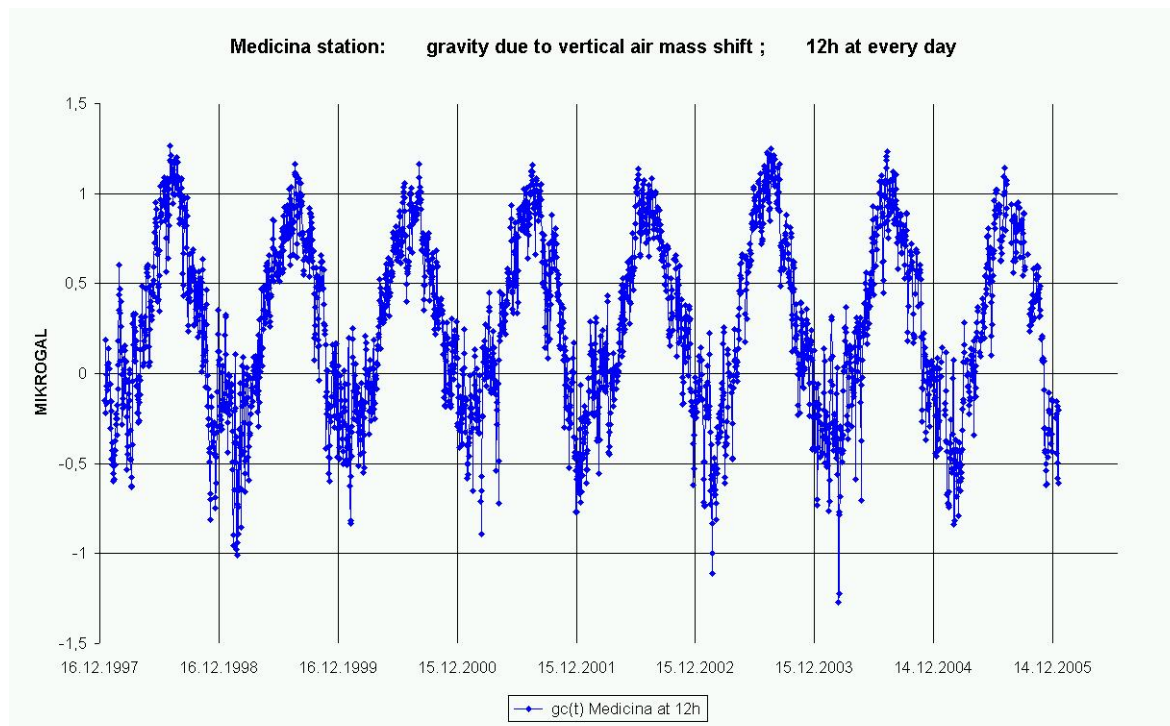


Fig.1: Medicina station 1998-2005: The $g_c(t)$ model curve, calculated from data of the neighbouring radiosonde station (distance: about 2 km).

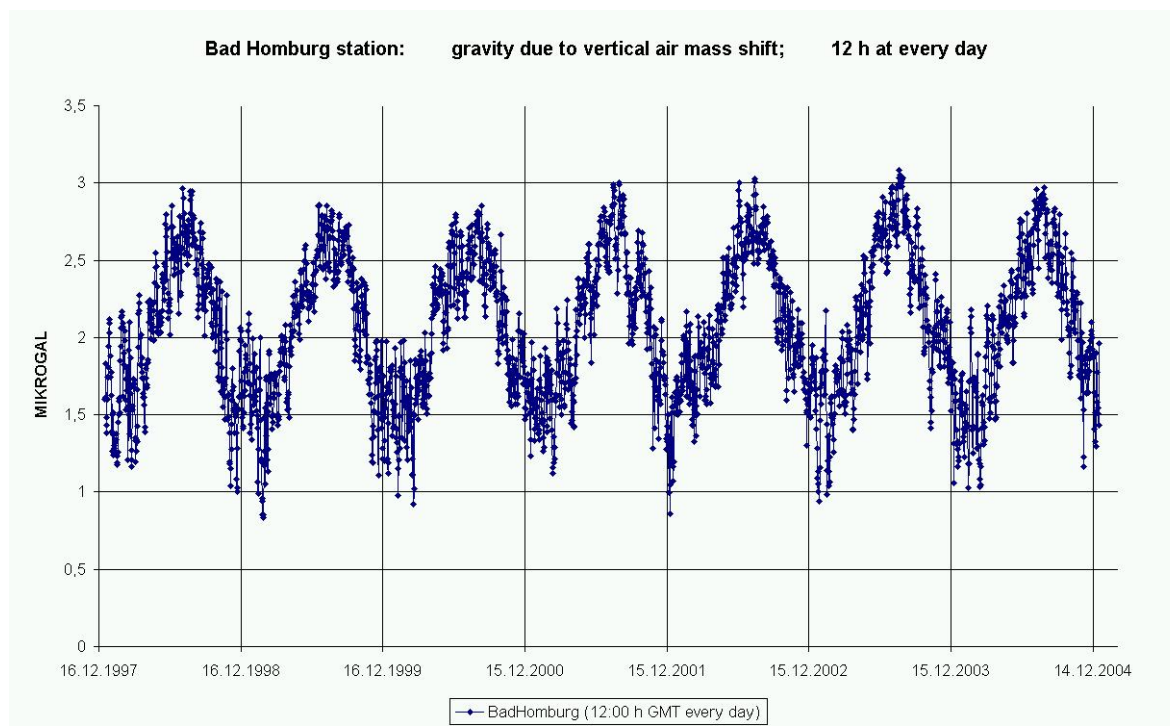


Fig.2: Bad Homburg station 1998-2004: The $g_c(t)$ model curve, calculated from data of the radiosonde stations at Stuttgart, Essen, and Meiningen, respectively.

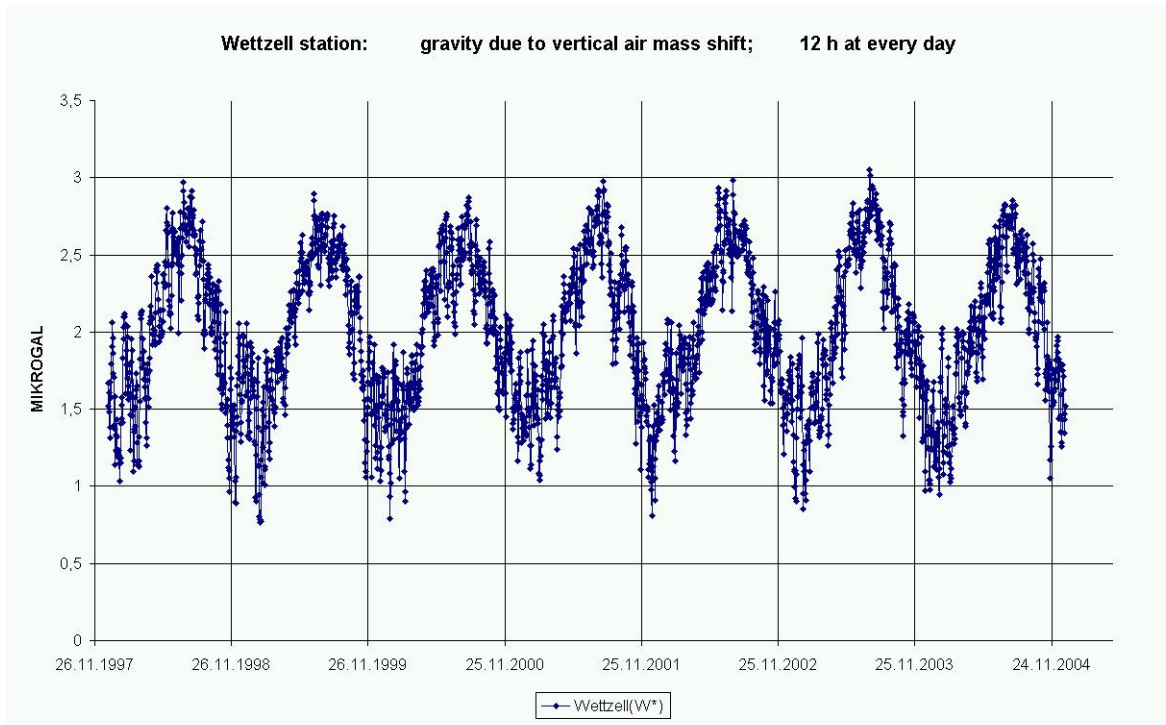


Fig.3: Wetzell station 1998-2004: The $g_c(t)$ model curve, calculated from data of the radiosonde stations at Munic, Lindenberg, and Meiningen, respectively.

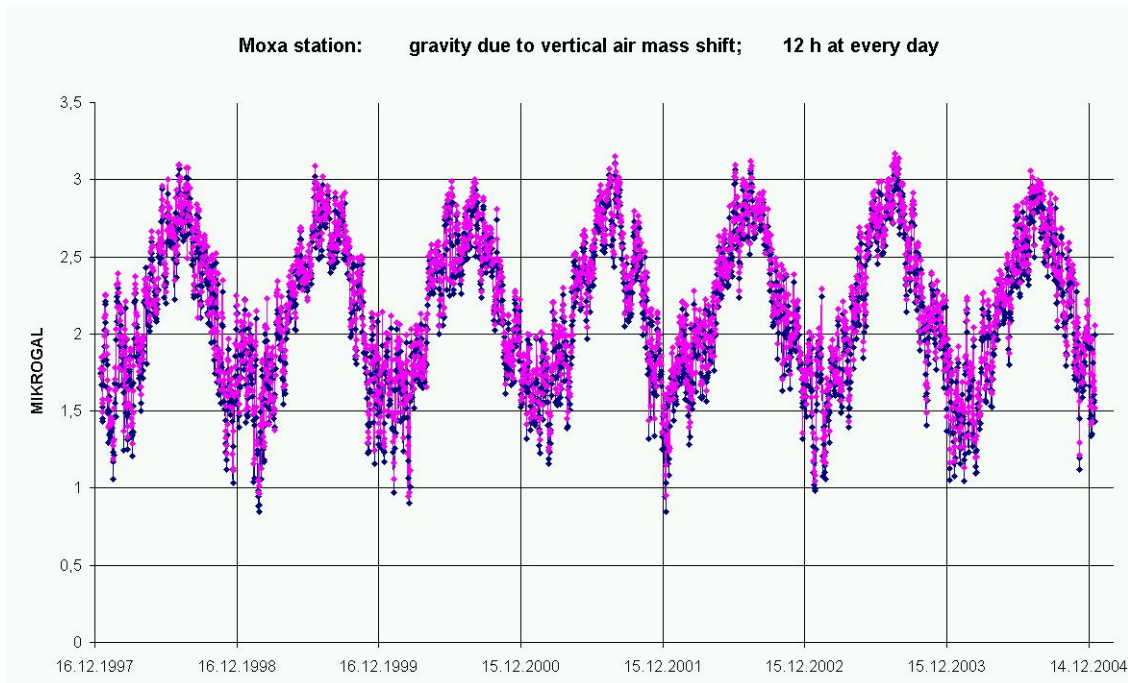


Fig.4: Moxa station 1998-2004: Two variants of $g_c(t)$ model curve, calculated firstly from radiosonde data of Munic, Lindenberg, and Meiningen, respectively, and secondly from radiosonde data of Munic, Wroclaw, and Meiningen.

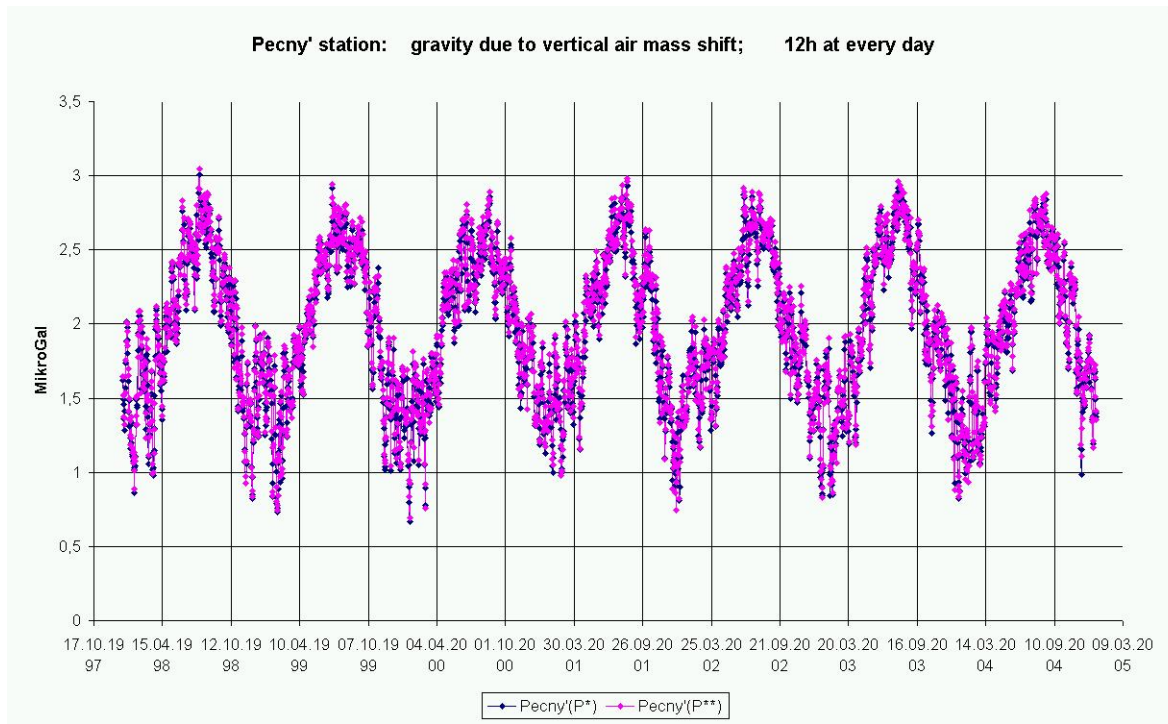


Fig.5: Pecny station 1998-2004: Two variants of $g_c(t)$ model curve, calculated firstly from the radiosonde data of Munic, Lindenberg, Vienna, and Wroclaw, respectively, and secondly by the radiosonde data of Munic, and Wroclaw, respectively.

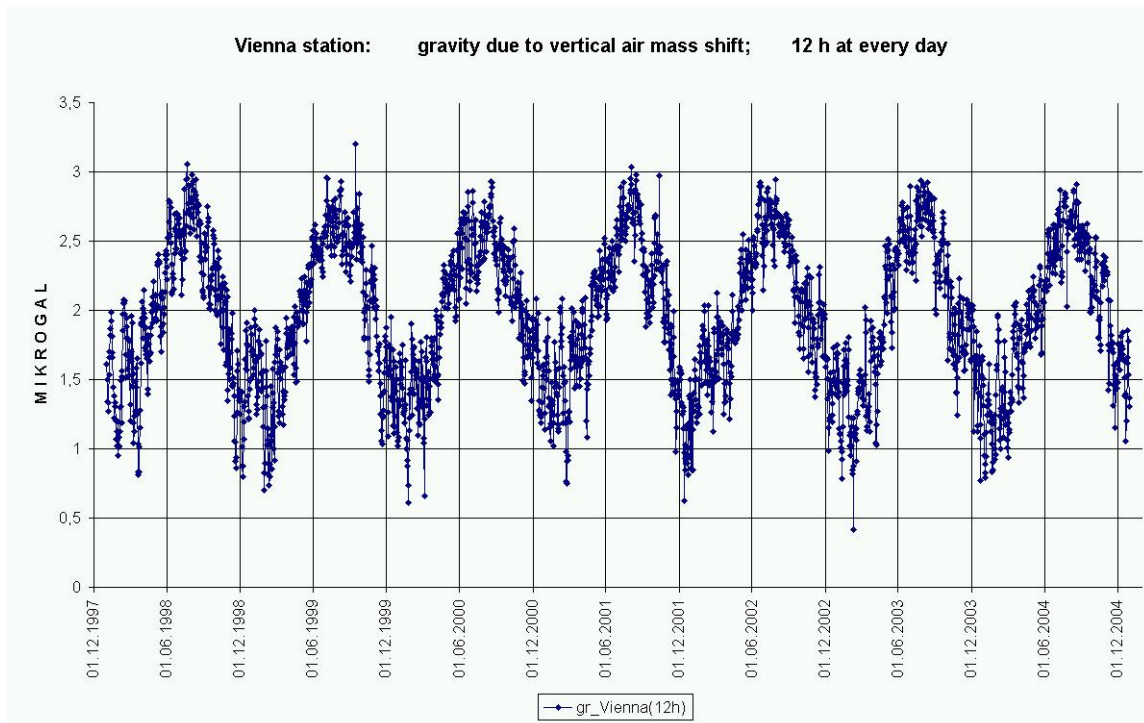


Fig.6: Vienna station 1998-2004: The $g_c(t)$ model curve, calculated from the data of the neighbouring radiosonde station (distance: < 0.2 km).

2. Comparison with the results of other modeling

KLUEGEL (2005) calculated the $g_c(t)$ curves of three of the before mentioned gravimeter stations Bad Homburg, Wetzell and Moxa, too. As 2 years ago (KLUEGEL, 2003) he used for this purpose instead of radiosonde data the data of the weather model LM of the German Weather Service (DWD), Offenbach. The modelling has been done for a longer time interval, covering one year (2003) now.

A first comparison of both types of the $g_c(t)$ curves was made in 2006, February. We found smaller double amplitudes of KLUEGEL's $g_c(t)$ variations all the three stations. The empirically determined air pressure coefficients for the modelling of the $A_p(t)$ -component were smaller, too: $0.35 \mu\text{Gal/hPa}$ instead of $0.40 \mu\text{Gal/hPa}$. The discrepancy between the corresponding $g_c(t)$ variations practically disappeared after a multiplication of KLUEGEL's $g_c(t)$ model curves by a factor of 2.2.

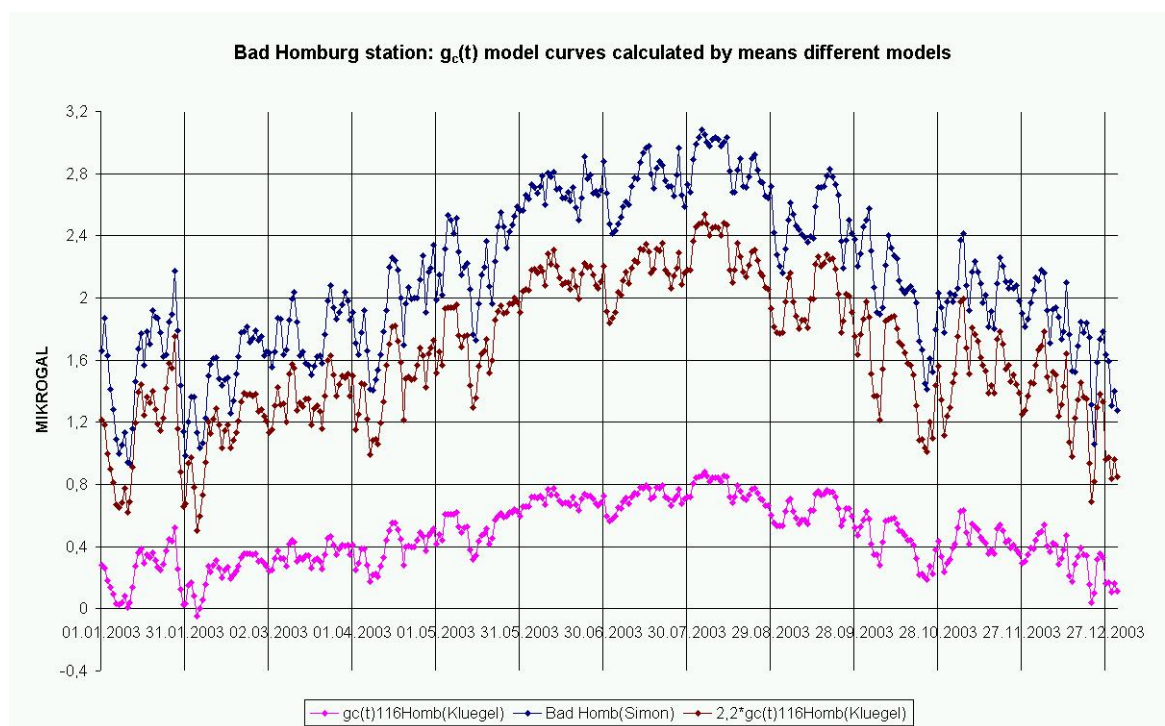


Fig.7: Gravimetric effects of vertical air mass shifts calculated either by means of radiosonde data and by weather model data (LM data) using different models.

The $g_c(t)$ -curves of the Bad Homburg station for 2003 calculated by different models and data are compared in Fig.7. The upper curve was calculated by means of the model by SIMON (2003) and is based on radiosonde data. The middle $g_c(t)$ -model curve is equal to the lowest one multiplied by the factor 2.2. The lowest curve was calculated by means of the model by KLUEGEL (2003) and is based on data of the local weather model data LM.

The reasons of the discrepancy between the $g_c(t)$ -model curves are not completely known until now. The first results of a comparison of the calculations carried out in the last month for this purpose are shown in the paper of SIMON et al. (2006).

3. Conclusions

The figures of the $g_c(t)$ -variations at the six European gravimeter stations in Fig.1–6 show that the amplitudes of the seasonal waves are relatively constant. Differences are mainly induced by variations of the regional climate from one year to the next one. Other effects such as e.g. the so-called “Sudden warming” or “Berlin phenomenon” (SCHERHAG, 1952) cause only short-time deviations from this normal behaviour.

Furthermore the regional variability of the $g_c(t)$ -component is low (SIMON, 2003): The seasonal warming / cooling of the atmospheric air masses which produces the effect has practically the same qualities. As a consequence it seems to make sense to calculate this simple constructed $g_c(t)$ component separately and to subtract it from the total effect of air mass shift. The residuum thus obtained is not anymore a mixture of two effects with different origins. After the $g_c(t)$ elimination it is easier to find out the qualities of the remaining component which is primarily induced by horizontal air mass shifts.

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