The atmospheric corrections for absolute and relative gravity measurements in Józefosław, Poland

Marcin Rajner
Tomasz Olszak

Abstract

In this paper we discuss the importance of atmospheric gravity corrections in gravimetric works conducted in Józefosław, suburb area of Warsaw, Poland. We present here different methods which are usually used when influence of atmosphere on gravity measurements has to be mitigated. The first one is simple approach which use regression coefficient. This admittance factor were estimated using relative gravity measurements from spring gravimeter along with atmospheric pressure recordings. We also used the nominal factor, when the empirical one cannot be determined. The second one uses vertical profiles of meteorological data (hence called 3D method here).
These last two methods has the main advantage that they do not rely on any statistical assumption and reflects physics of the phenomena. This methods model both the attraction („newtonian") part and indirect deformation term. In this work we study how the different approach change the corrected gravity results and consequent inferences. For this purpose we used the gravity measurement from absolute (FG5 no. 230) and relative (LCR ET no. 26) gravimeters which are a part of gravimetric equipment in Józefosław. We give discussion when the complex atmospheric gravity correction are necessary and when the simple approach is sufficient enough. The differences between different methods are at the microgal level but this can be crucial in geophysical and geodynamics studies.

Physical mechanism

Figure: The initial state of atmosphere (left graph, orange vector depicts earth gravity) and the gravity changes due to atmospheric pressure increase – the "newtonian" effect (upward, green vector), the deformation term through mass reditribution and through gravimeter position change (pink and yellow repectively). The attraction term is dominant. The graph is not in scale.

Tidal analysis results

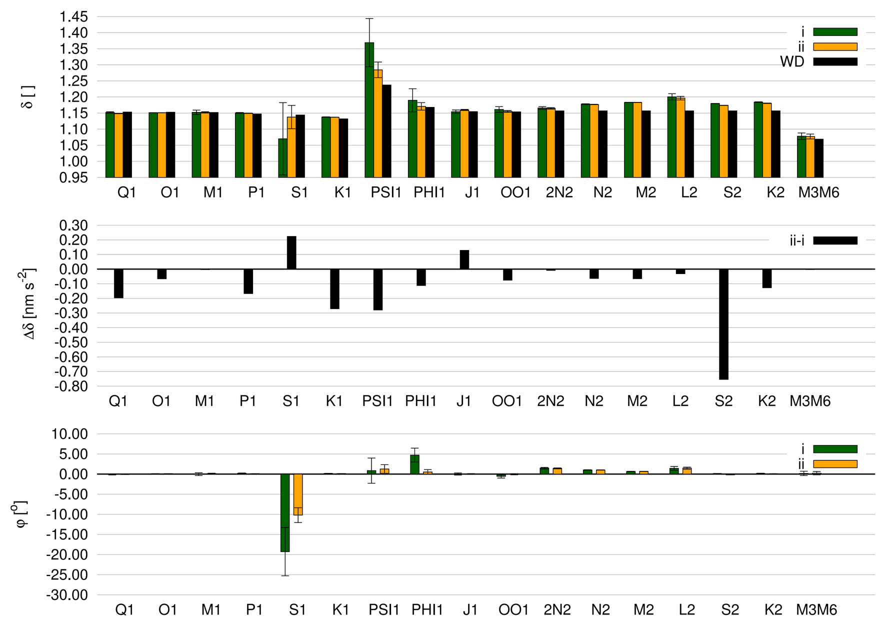

Figure: The estimated tidal gravimetric factors from gravity measurements once without (i) and with use of atmospheric pressure records with estimated atmospheric admittance factor (ii) compared to Wahr – Dehant tidal model (WD, upper graph). The difference in grvity unit (depending on tidal wave amplitude) middle graph and the phasese (bottom graph).

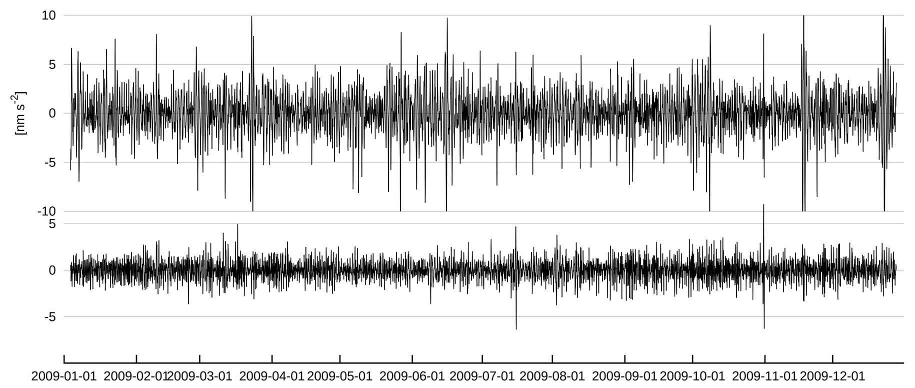

Figure: Gravity residuals – without pressure correction (upper graph) and with pressure correction (bottom graph)

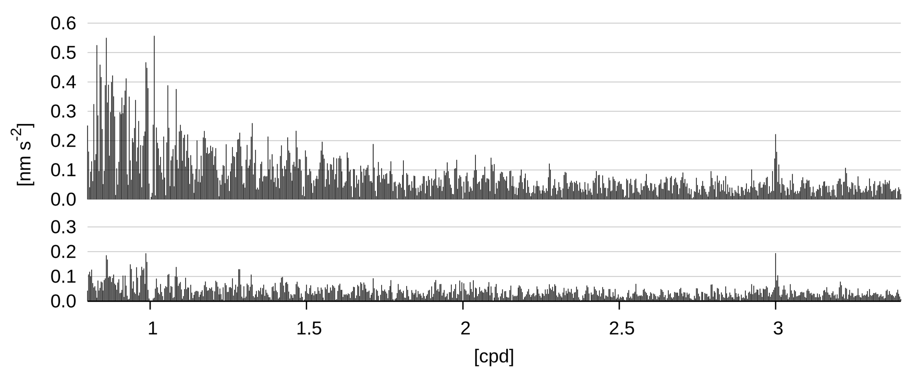

Figure: Residual amplitude spectra – without pressure correction (upper graph) and with pressure correction (bottom graph)

Gravity variations

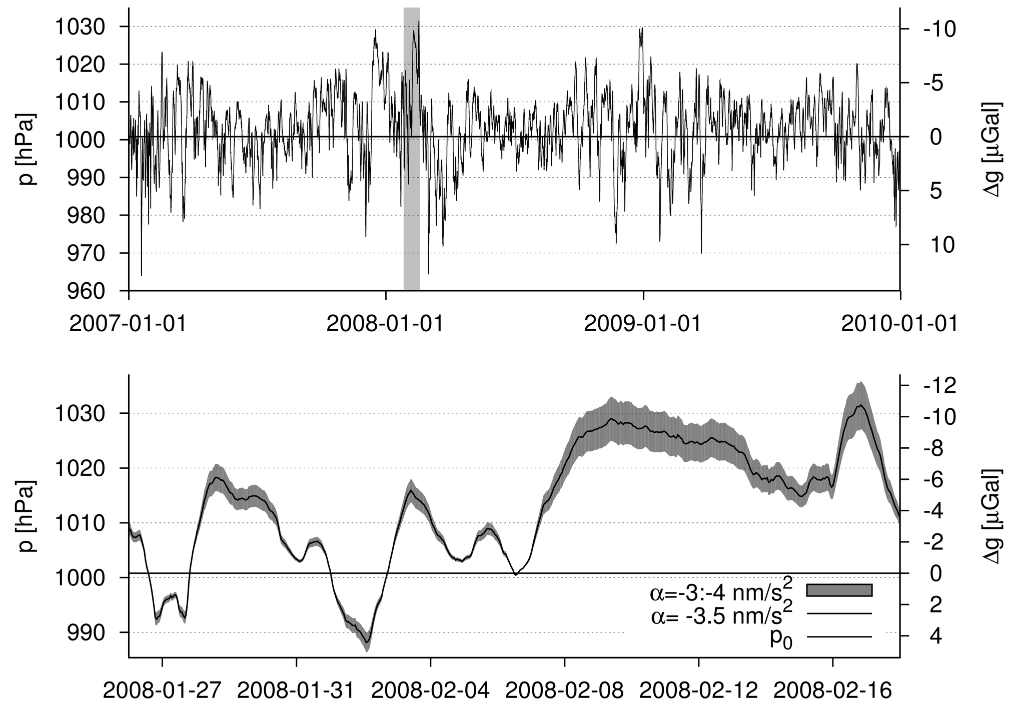

Figure: Pressure changes in Józefosław and the range of gravity changes due to this phenomena

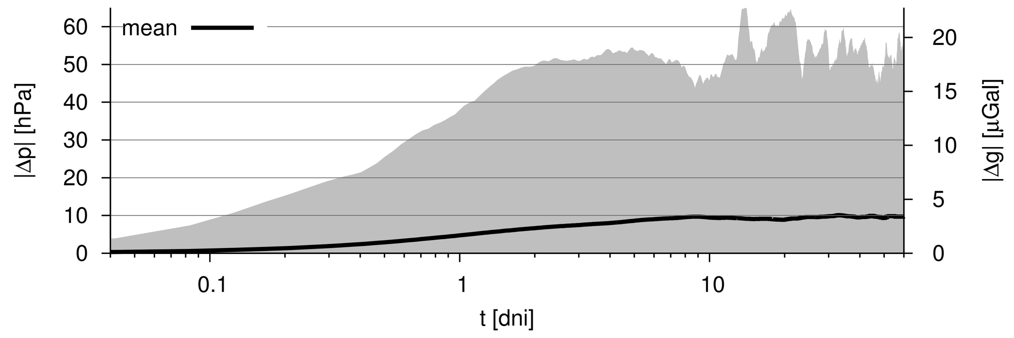

Figure: The reange of pressure and gravity changes depending on time span

Admittance factor

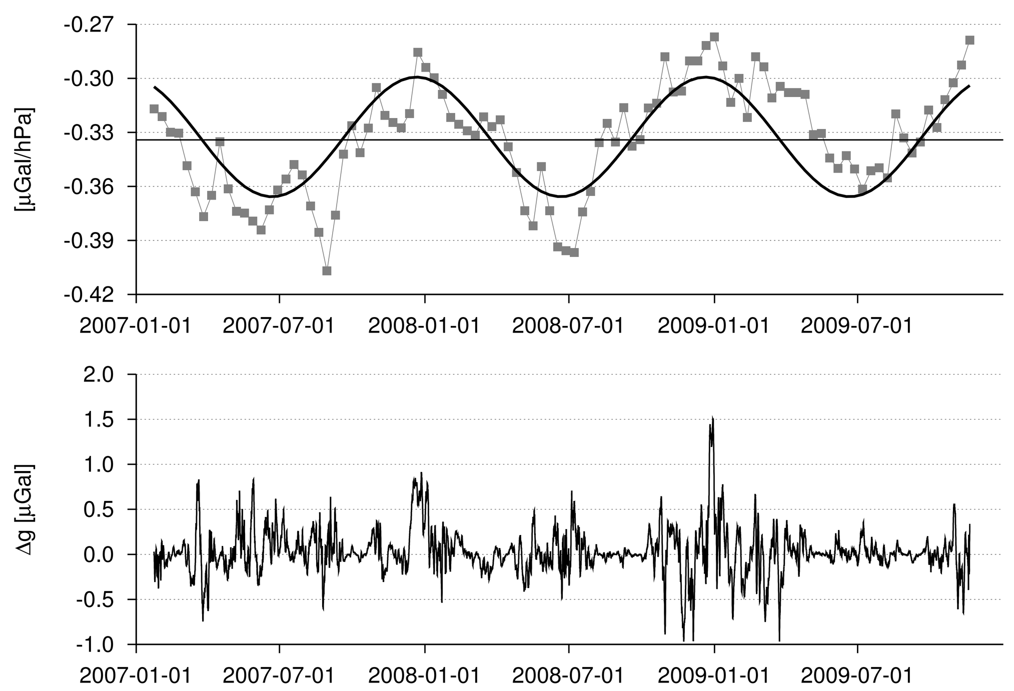

Figure: Seasonal variation of admittance factor (upper graph) and the difference in term of gravity correction when compared to single constant value

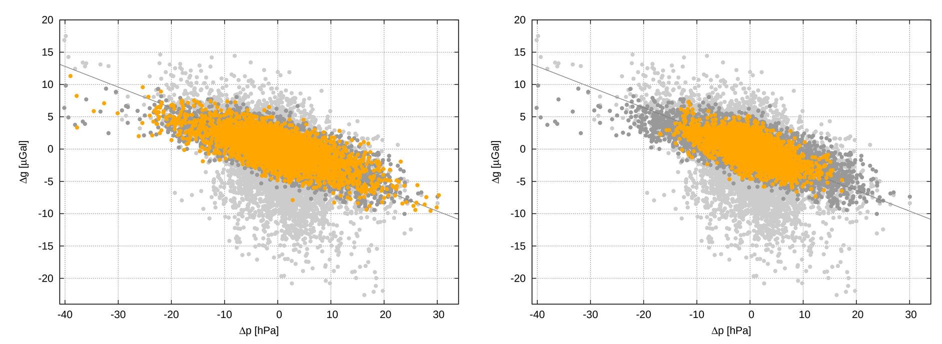

Figure: Correlation of gravity residuals with atmospheric pressure variation from multiyear measurements for winter (left graph) and summer season (right graph).

Frequency dependence

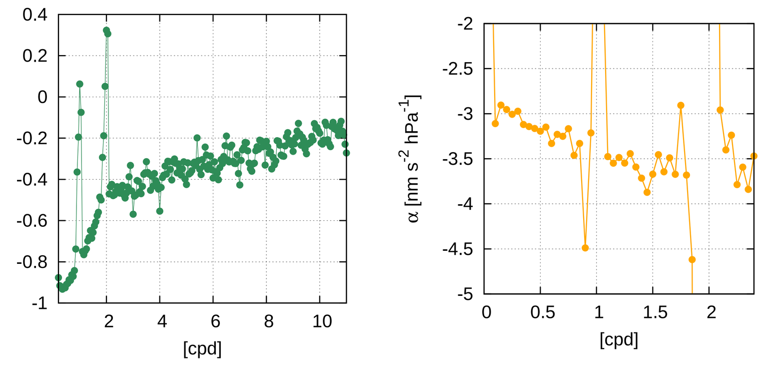

Figure: Correlation coefficient (left graph) and admitance factor (right graph) from frequency dependent analysis

Absolute gravity

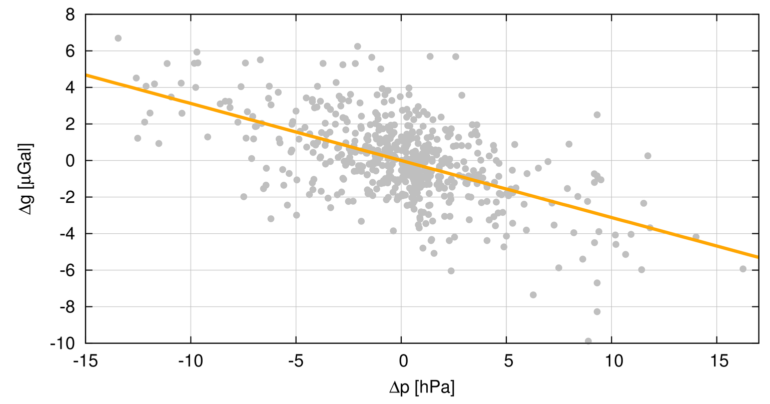

Figure: Admittance factor from absolute gravity measurements using value for each session within more than 30 measurements

Reference pressure problem

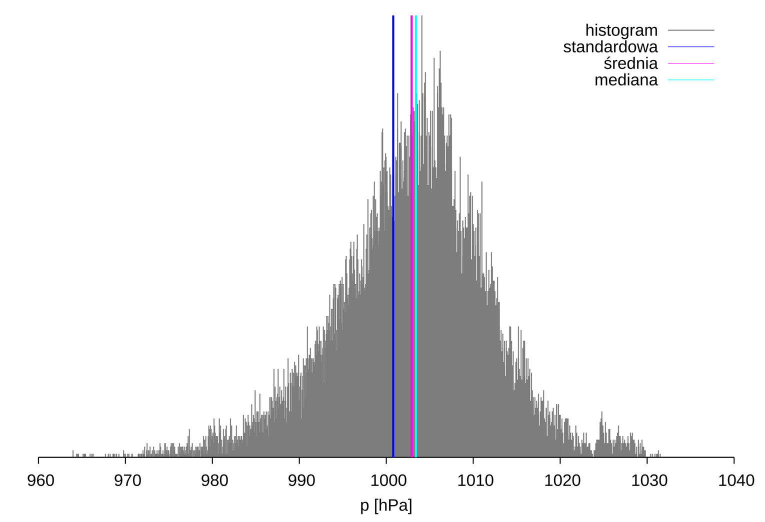

Figure: Multiyer pressure records in Józefosław

3D correction

We used the `http://atmacs.bkg.bund.de` service in order to compute 3-dimensional gravity correction. This model use numerical weather model in order to compute gravtional and deformational part of gravity variation due to pressure changes. This procedure can lead to discrepancies of a few μGal when compared to standard procedures. The efforts of established our own computation scheme which will utilie huge data set of meteorological parameters are alredy undertaken at our Department.

Acknowledgements
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