Investigation in Tidal Gravity Results in Józefosław Observatory

Marcin Rajner

mrajner@gik.pw.edu.pl

Department of Geodesy and Geodetic Astronomy
Warsaw University of Technology

Katedra Geodezji i Astronomii Geodezyjnej
Politechnika Warszawska

Abstract

In this paper we used 40 months (2007-2010) of continuous gravity measurements to study different tidal phenomena. The records are taken from Observatory in Jozefoslaw equipped with LaCoste&Romberg Earth Tide Gravimeter.

Tidal gravity parameters in diurnal and semi-diurnal bands are computed using international standard data processing techniques. Accuracy assessment, as well variation in time of those parameters are given. Long series of consistent data allows to investigate in small signals such as gravity changes due to ocean loading. Subtracting body tides from results yields a differences up to 1 μGal which are in good common with computed indirect effect of ocean using most recent models. It clearly explains main source of disagreement between results from measurements and tidal models, despite of long distance to nearest ocean. Paper deals also with barometric pressure influence on gravity measurements. Importance of reducing pressure variation in tidal analysis is discussed and admittance factor is computed.

Introduction

TIDAL laboratory in Józefosław is equipped with **LC&R ET-26** gravimeter with electrostatic feedback since 2001 (**?**). It is located on the pillar about 6 m under ground level in thermal stabilized chamber. After serious repair in summer 2006 gravimeter operates continuously. Since end of 2005 scale factor is controlled through periodically synchronous measurements with FG5 gravimeter (**?**)

Figure 1: Observatory in Józefosław

Observations

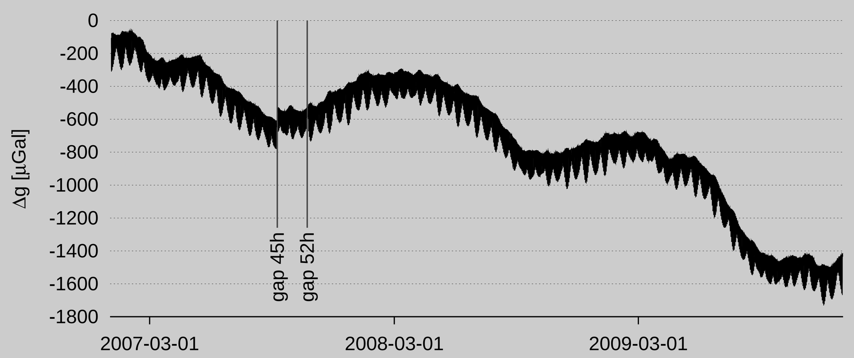

Figure 2: *Raw records of gravimeter.*

RAW measurements are shown in the fig. **??**. The average drift rate is 1.5 μGal per day, but one could see strong yearly variation of drift curve with amplitude of about 100 μGal. This behaviour is probably caused by humidity variation which is typical for LCR gravimeter and was noted before by some authors (**?**). This study will be expanded soon through installation additional humidity sensor and air-dryer in gravimeter chamber. The data discussed here were measured at 1 min samples. The main source of decreased quality of observations are strong earthquakes (fig **??**). This is clearly seen in daily RMS graph, which was plotted using series where tides and $9^{\mathbf{th}}$ degree polynomial were subtracted. Bad points were replaced by interpolation, the data was digitally filtered and decimated to hourly samples using `Tsoft` (**?**).

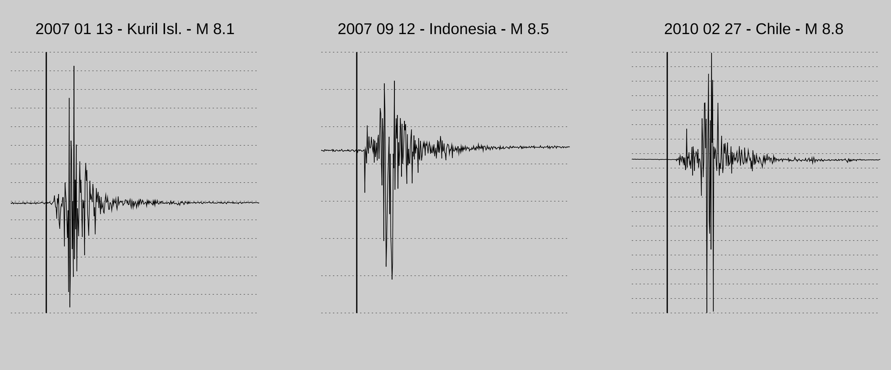

Figure 3: *Earthquakes in observations (every window is 7 h width, y grid is 1 Gal, vertical bar represents start of the earthquake).*

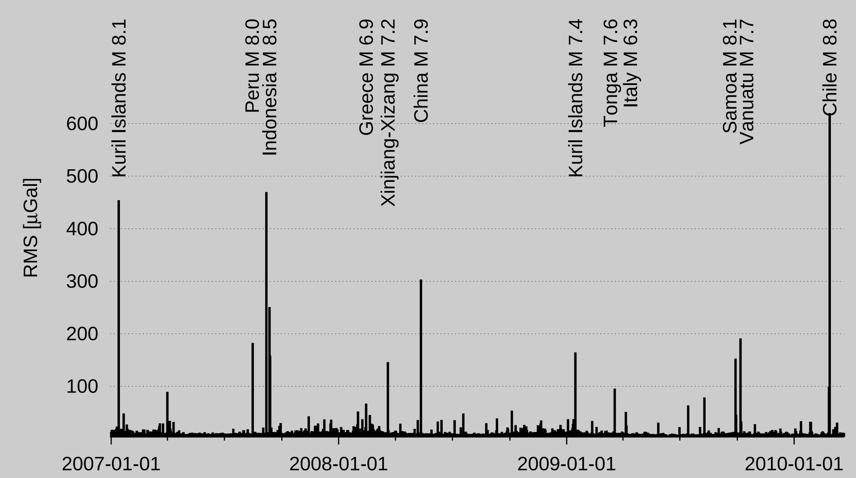

Figure 4: *Daily RMS.*

Analysis

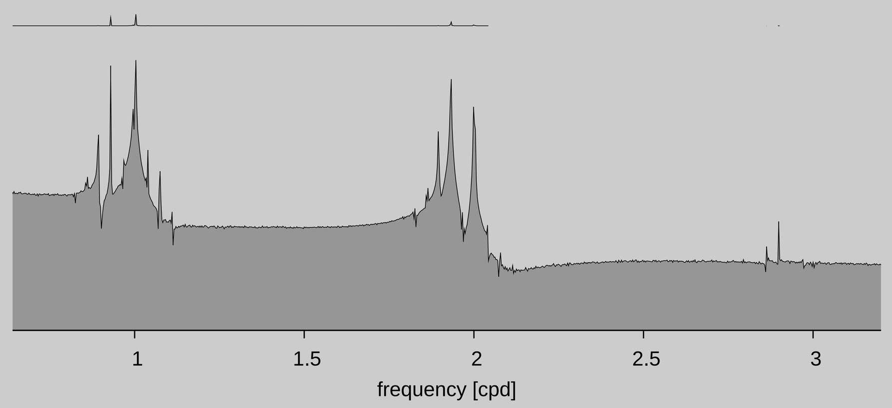

Figure 5: *Power Spectrum Density. Upper graph linear and bottom graph logarithmic scale.*

TIDAL parameters were computed using `eterna` (**?**) twice: without ($\sigma = 2.21\,nm/s^2$) and with barometric pressure as auxiliary series ($\sigma = 0.98\,nm/s^2$) for investigation in atmosphere importance.

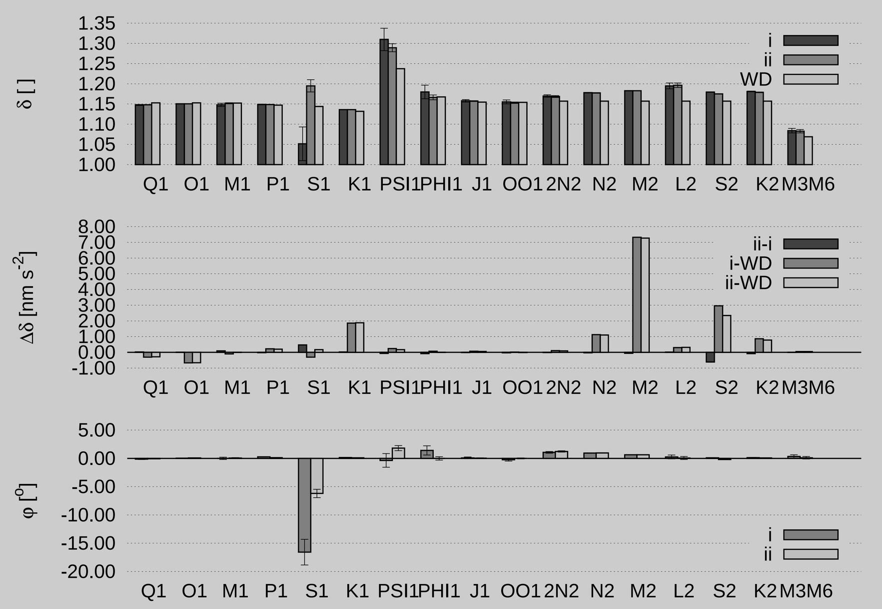

Figure 6: *Amplitude factor, difference in amplitude factor and phases for main tidal constituent estimated without (i) and with pressure correction (ii), compared to Wahr-Dehant model.*

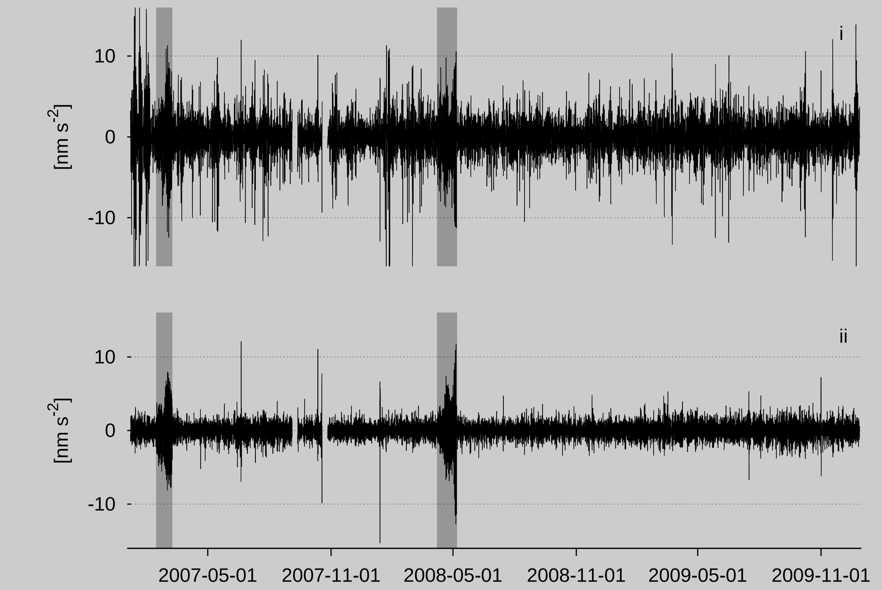

Figure 7: *Gravity residuals without (i) and with pressure correction (ii).*

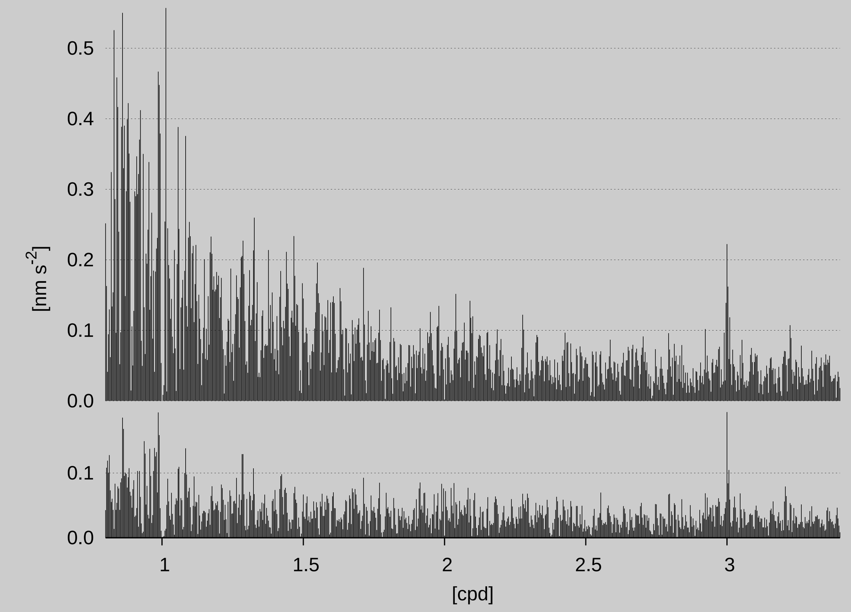

Figure 8: *Fourier's spectrum of residuals. Upper graph without and lower graph with pressure correction.*

Tidal parameters variation

WE performed tidal analysis using `baytap08` (**?**) with moving window 40 days span and 10 days shift. In the fig. **??** we see that amplitude for M_2 is stable within $1\ \frac{nm}{s^2}$ range. The change in phase is significant only during registration problem confirming its origin.

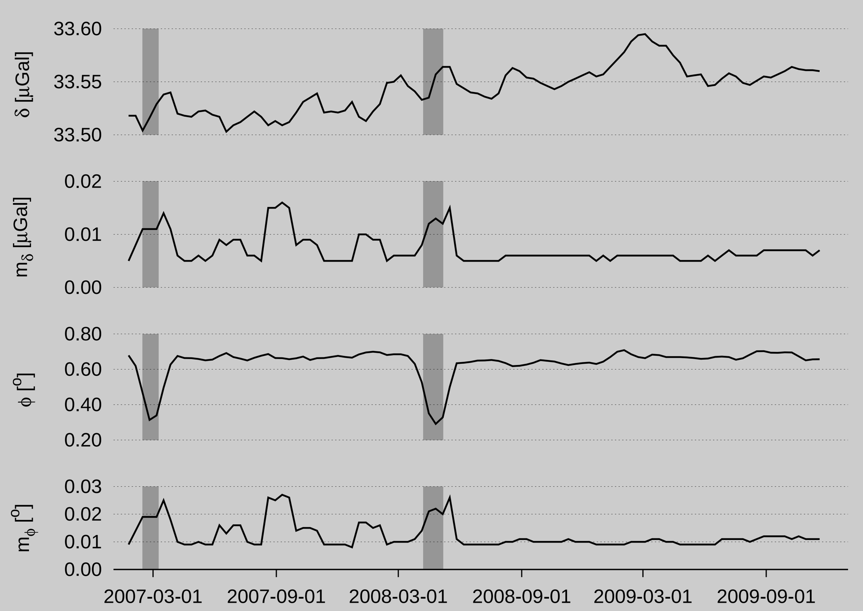

Figure 9: *Tidal parameters for M2 constituent.*

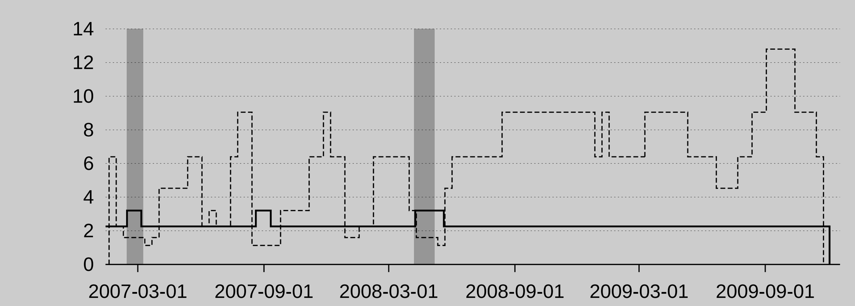

Figure 10: *D-hyperparameter variation using moving window (intermittent line, span - 40 days, shift - 10 days, higher value means better fit to model) and ,,excluding data" window (solid line, span - 20 days, shift - 20 days).*

It was found that factor determining ,,goodness" of fitting model using Bayesian approach clearly indicates periods with instrumental problems or environmental influences especially when using ,,excluding data" moving window.
Using this manner we examined seasonal behaviour of pressure admittance factor which is presented in the fig. **??**.

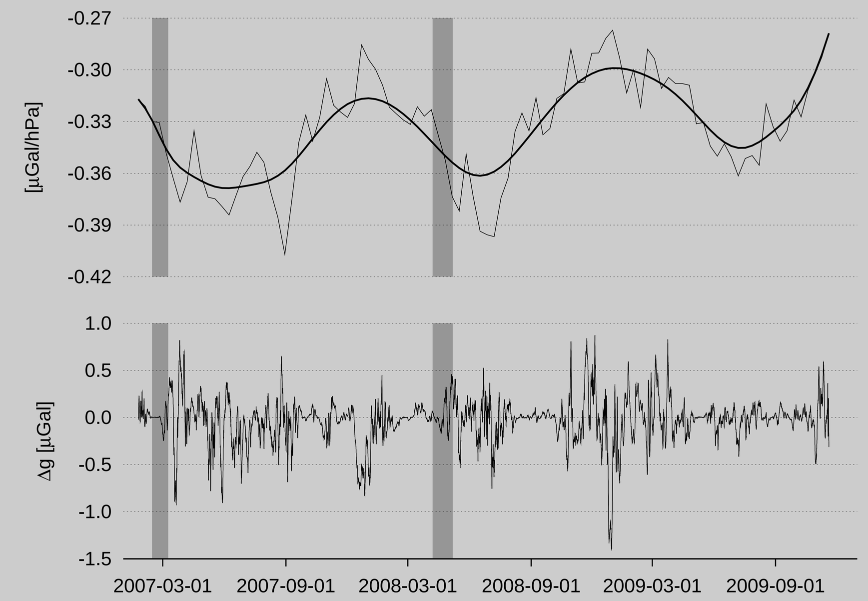

Figure 11: *Seasonal variation of atmospheric pressure admittance factor and differences between using mean and time-dependent values for gravity correction.*

Ocean indirect effect

JÓZEFOSŁAW is far from nearest ocean and the nearest sea (Bałtyk) is almost tideless. However we can see that residual for M_2 constituent are greatly reduced using ocean loading correction.

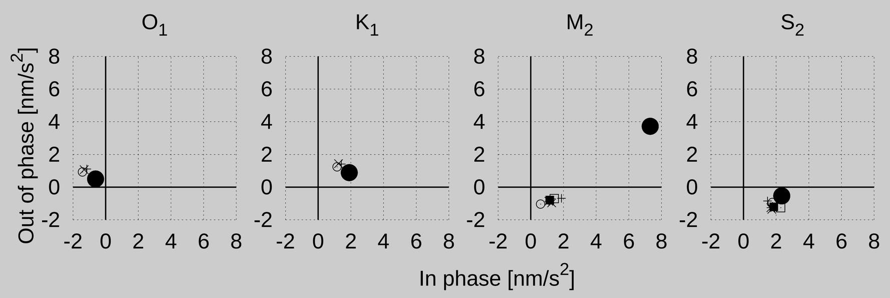

Figure 12: *Phasor plots for residual values (subtracted body tides, filled circle) and residua corrected for ocean loading using most recent models (other marks).*

Acknowledgments

This work has been supported by the European Union in the framework of European Social Fund through the Warsaw University of Technology Development Programme.
J. Bogusz is acknowledged for carrying observation during 2007 and 2008.

References

Bogusz, Janusz, 2002. New tidal gravimetric laboratory in Jozefoslaw, *Reports on Geodesy*, **61**(1).

Pálinkáš, V., 2006. Precise tidal measurements by spring gravitmeters at the station Pecný, *Journal of Geodynamics*, **41**.

Rajner, M. and T. Olszak, 2010. Calibration of spring gravimeter using absolute gravity measurements. Results of parallel observations using LCR-ET and FG5 gravimeters during 2007-2010 in Józefoslaw Observatory, *Poster EGU, Vienna, 2-7 May 2010*.

Tamura, Y. and D. C. Agnew, 2008. Baytap08 User's Manual.

Van Camp, Michel and Paul Vauterin, 2005. TSoft: graphical and interactive software for the analysis of time series and Earth tides, *Computers and Geosciences*, **31**(5).

Wenzel, Hans-Georg, 1996. The nanogal software: Earth Tide Data processing package ETERNA 3.30, *Bulletin d'Informations Marees Terrestres*, **124**.

European Geoscience Union, Vienna, 2-7 May 2010