USE OF NUMERICAL WEATHER MODELS FOR ATMOSPHERIC GRAVITY CORRECTIONS IN TERRESTRIAL GRAVITY MEASUREMENTS

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INTRODUCTION

The atmosphere is the main source of noise in high precision terrestrial gravity measurements. Usually we can deal with this phenomena by means of local pressure recordings utilizing simple atmosphere models or standard or site dependent admittance factors. Despite of their great simplicity this method performs very well. As this methods do not reflect the physical phenomena of atmosphere impact on gravity they limit the accuracy of high precision superconducting and ballistic gravimetric measurements. This can be important obstacle in terms of interpretation of subtle geodynamic processes. We present here not yet very well known so-called 3D atmosphere modelling with minor improvements using recent numerical weather models. The calculation of gravity corrections using this advanced method is verified using large data set of superconducting gravimeter data. The improvement of atmospheric corrections is confirmed with reduced gravity residuals (in time and frequency domain), better agreement of tidal gravimetric factors (mainly for long-period awes) and polar motion gravimetric factor with values predicted with Earth models. Within this work the on-line service for computing 3D atmospheric gravity measurements is also presented.

IMPORTANCE

The atmosphere is one of most important source of disturbances in gravimetry. This effect can easily mask small geophysical and geodynamics signals.

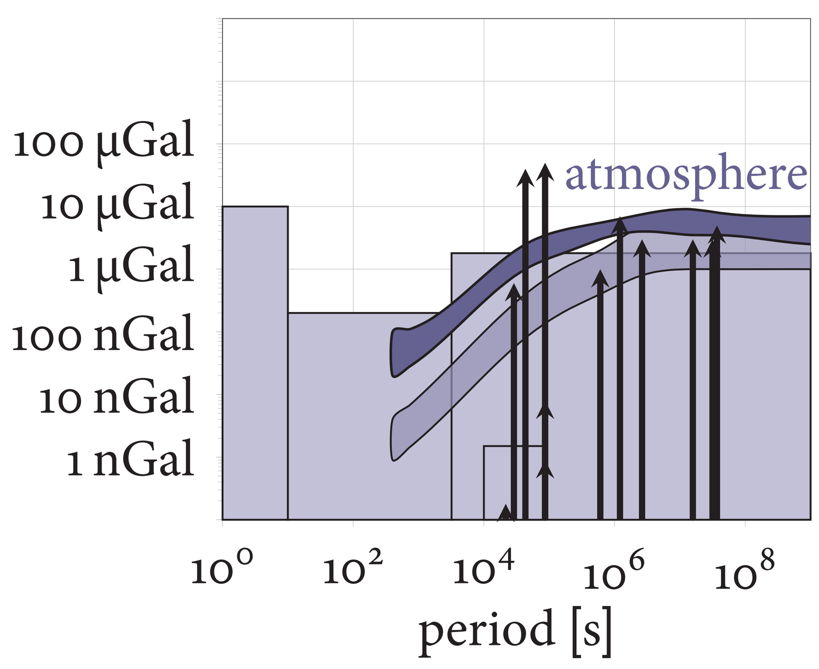

Figure: the solid blocks, arrows and filled area represent geophysical and geodynamical phenomena contained in gravity signal. This includes ocean noise, Earth free oscillations, core modes, slow earthquakes, secular deformations (rectangles), tides, tidal loading, pole tide (arrows) and hydrosphere (light irregular area). The atmosphere is shown as dark filled irregular area (values for Józefosław Observatory, idea after Hinderer, Crossley, and Jensen 1995)

WHAT'S WRONG WITH STANDARD METHOD

Usually the impact of atmosphere is reduced with single admittance factor. This method works great but when sub microgal precision is necessary this simple method could be not sufficient in precise gravity measurements

Figure: Changes of admittance factor for selected GGP sites for different years within 1996 – 2011 period

DATA USED IN THIS STUDY

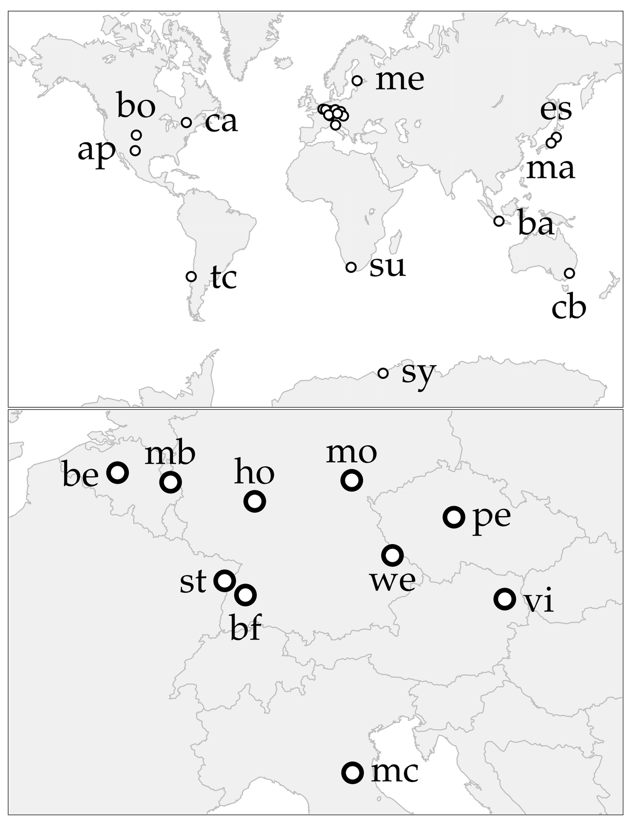

Figure: In this study we used the data from GGP superconducting gravimeters (obtained trough *Information Systems and Data Center*)

COMPUTATION SCHEME

With physical method we use different approach for gravity and elastic term. The gravity component is computed directly from atmospheric mass distribution while the deformation component is determined using Greens functions formalism.

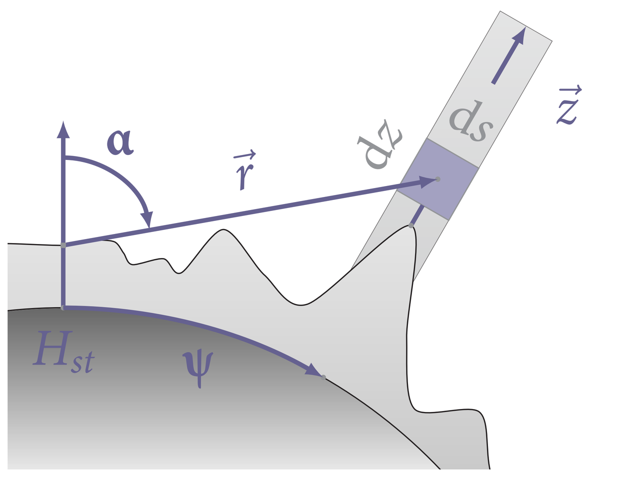

Figure: Geometrical dependencies for computing gravity component

COMPARISON OF DIFFERENT APPROACH

Here we compare results of three different method for computing atmospheric corrections – namely local admittance factor along with local atmospheric pressure (1D), using surface pressure distribution along with atmospheric Greens functions (2D), and finally taking into account full vertical atmospheric mass distribution from recent numerical weather models (3D, here ERA-INTERIM is shown, but similar test were taken using also different models)

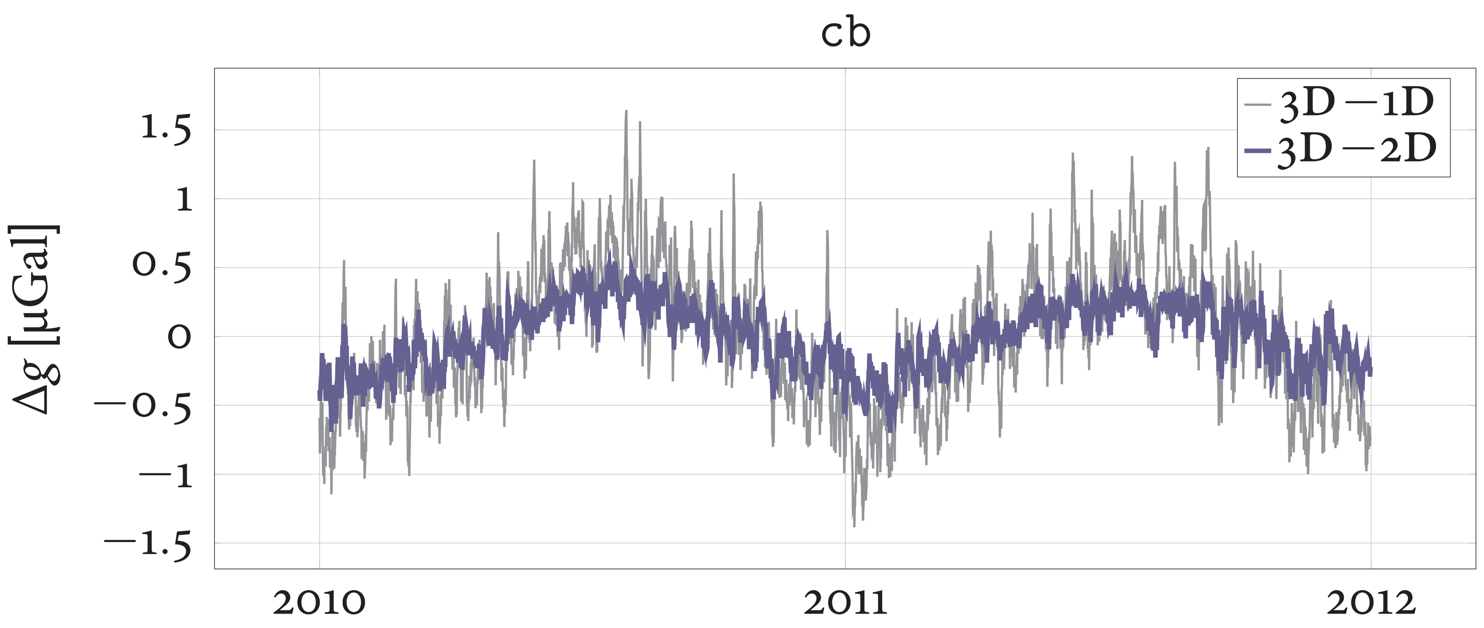

Figure: Atmospheric gravity corrections differences for Canberra GGP site

RESULTS

Below are presented advantages of physical methods by means of gravity residuals RMS. We also observe imorovement of tidal factors for long period tidal waves and pole tide.

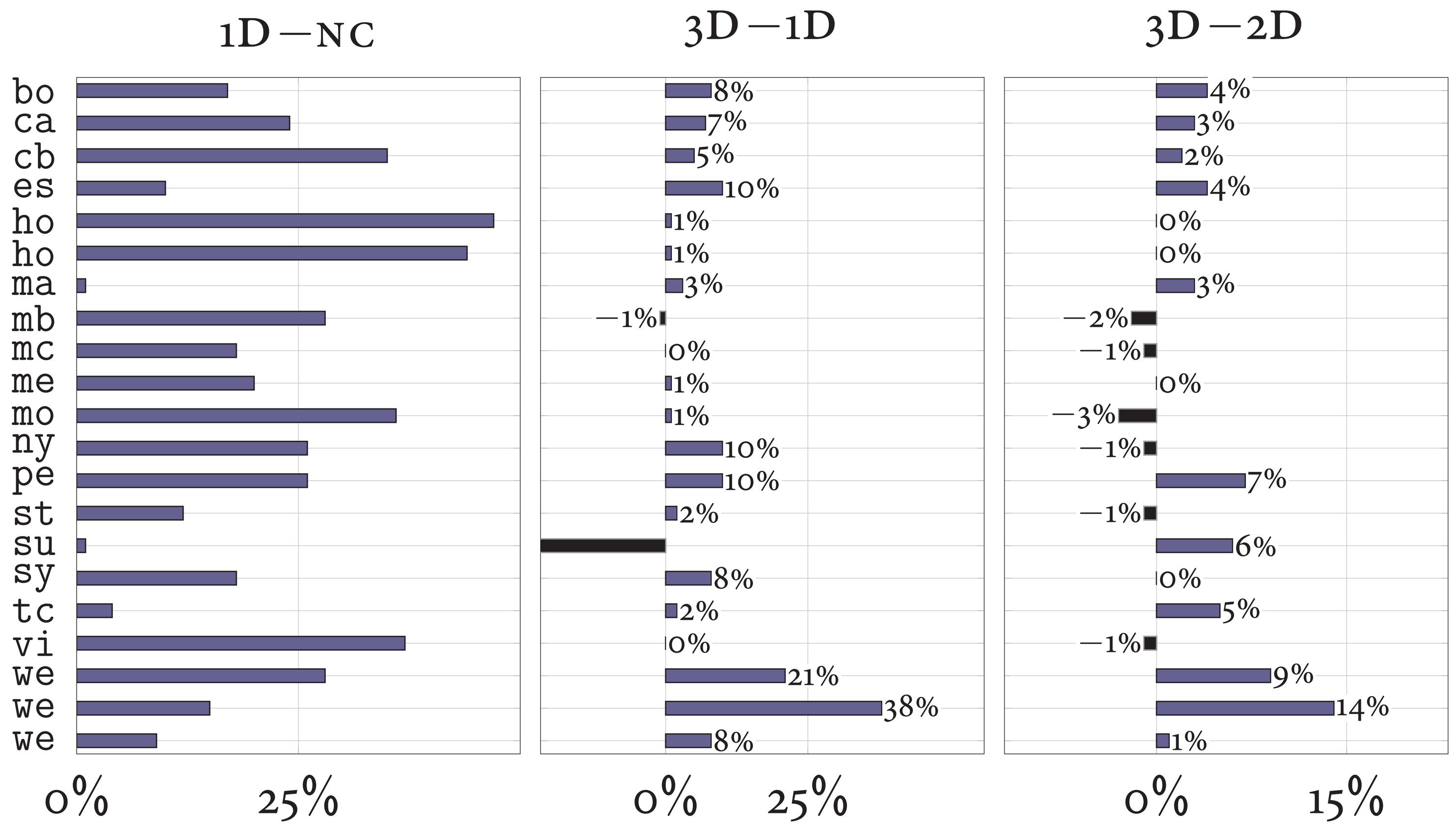

Figure: Comparison of different type of gravity corrections for reduction of residuals RMS; NC means no atmospheric correction; note different scale on *x*-axis

CONCLUSIONS AND REFERENCES

The more advanced methods are crucial for detecting and interpreting subtle geodynamic signals.

please see references in

Marcin Rajner. "Determining of atmospheric gravity corrections using numerical weather models". In Polish. PhD thesis. Warsaw University of Technology, Faculty of Geodesy and Cartography, 2014, p. 117. URL: http://www.grat.gik.pw.edu.pl/dr

for source code of computer program

grat. 2013–. URL: https://code.google.com/p/grat