

**Regional quasigeoid determination
in the area of Poland**

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Outline

- Introduction
- Gravimetric quasigeoid
- Astro-geodetic geoid
- GPS/levelling quasigeoid
- Combine geoid
- Comparison of quasigeoid models
- Summary and conclusions

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Introduction

- **1949** - first gravimetric geoid model for the region of Central Europe, including Poland,
- **1962** - first astro-geodetic geoid for Poland,
- **1993** - first gravimetric quasigeoid, using the least squares collocation combined with the integral method,
- **2002-2005** - research on precise geoid (quasigeoid) model in Poland supported by the Polish Committee for Scientific Research

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Gravimetric quasigeoid (1)

- Computational method

$$N = N_{GM} + N_{\Delta g} + N_H$$

$$\Delta g = \Delta g_{FA} - \Delta g_{GM} - \Delta g_H$$
- where:
 - N_{GM} reflects the contribution of the GM coefficients
 - $N_{\Delta g}$ represents the contribution of the residual mean free-air gravity anomalies after removing the effects of the GM, i.e. Δg_{GM}
 - N_H corresponds to the indirect effect of the terrain reduction on N ,
 - Δg_{FA} free-air gravity anomalies
- The computed geoid undulation N was converted to the quasigeoid height ζ using the relation

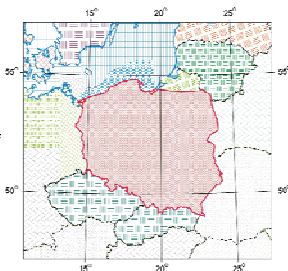
$$\zeta = N - \frac{\Delta g_H}{\gamma} H$$

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Gravimetric quasigeoid (2)

- Gravity data
 - Gravity data is not uniform both in terms of quality and coverage,
 - Terrestrial gravity data consists of point and mean free-air gravity anomalies of different spatial resolution,
 - Marine gravity data



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Gravimetric quasigeoid (3)

- Geopotential models used in the study
 - EGM96
 - GGM02S,
 - GGM02C
 - GGM02S/EGM96

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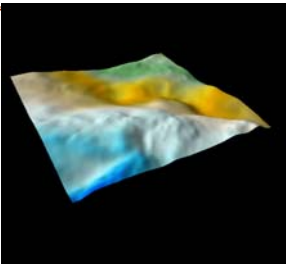
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Gravimetric quasigeoid (4)

- Practical computations
 - In the frame of the project on a cm geoid in Poland a few new gravimetric quasigeoid models were developed:
 - quasi04a** - based on the initial set of gravity anomalies, correcting for geodetic datum and gravimetric system, and EGM96 geopotential model,
 - quasi04b**, **quasi04c**, and **quasi04d**, based on the same set of gravity anomalies, but different geopotential models, GGM02S, GGM02S/EGM96, and GGM02C,
 - quasi05a** - new set of gravity anomalies corrected for geodetic datum and gravimetric system at the level of point data was created at the beginning of 2005, and EGM96 model
 - quasi05b** - new set of gravity data plus some data from eastern region, and EGM96
 - quasi05c** - gravity data same as in quasi05b but with GGM02S/EGM96 model

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Gravimetric quasigeoid (5)

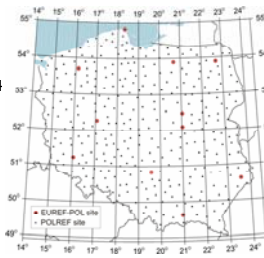


- The final model is given in a digital form on a regular grid 1.5' x 3.0' and is presented in a form of contour map

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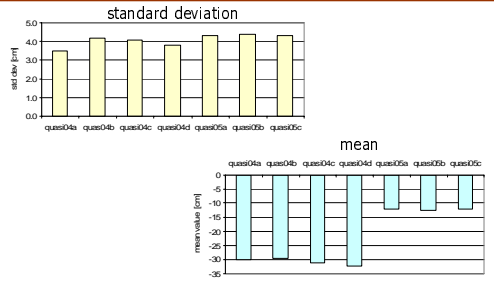
Gravimetric quasigeoid (6)

- Accuracy estimation using GPS/levelling
 - POLREF network (densification of EUREF-POL network) consists of **360** sites surveyed from July 1994 to May 1995
 - Stations of POLREF network were linked to the national vertical control by spirit levelling, with σ of normal height 1.0-1.5 cm
 - σ of ellipsoidal height 1.0-1.5 cm, and σ of height anomaly 2 cm (optimistic estimate)



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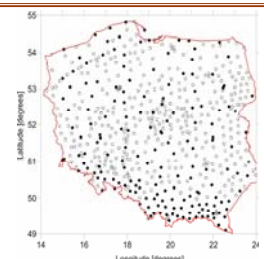
Gravimetric quasigeoid models



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Astro-geodetic geoid (1)

- Deflections of the vertical data
 - 171 astro-geodetic,
 - 370 astro-gravimetric, determined before 2001,
 - new astronomical observations at 29 points performed with circumzenithal from May 2003 until July 2004




Distribution of astro-geodetic (•) and astro-gravimetric points (◦) in Poland determined before 2001

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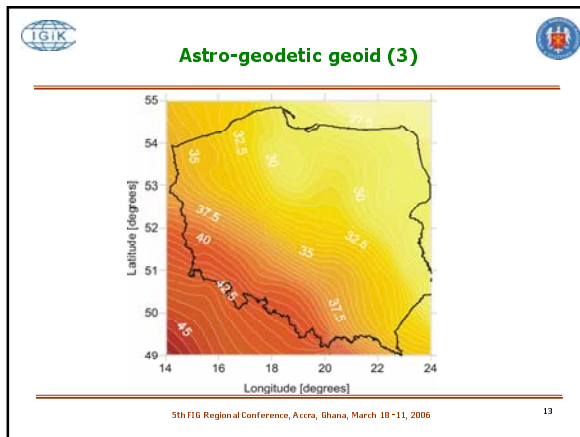
Astro-geodetic geoid (2)

- Practical computations
 - The network formed of 561 points,
 - Astronomical levelling was performed using the formula

$$\Delta N_{i,z} = -\int_1^2 (\xi \cos \alpha + \eta \sin \alpha + \delta \epsilon)$$
 - The network of geoid height differences ΔN has been adjusted with a parametric method,
 - Astro-geodetic geoid model developed was compared with gravimetric quasigeoid models ($\sigma = \pm 10$ cm).

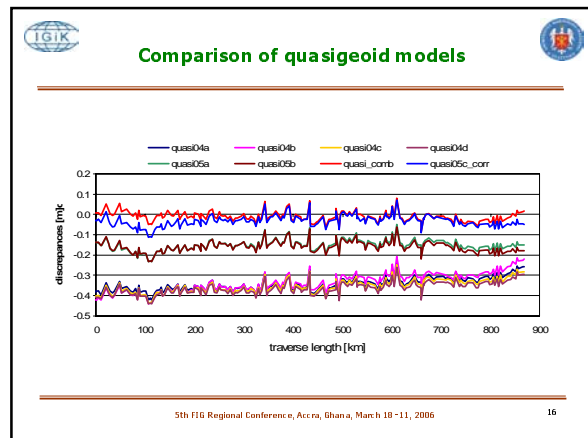


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- GPS/Levelling quasigeoid**
- Pure numerical GPS/levelling quasigeoid models
 - Two quasigeoid GPS/levelling models were developed:
 - first applies the "kriging" model that is based on LS collocation with 4-order polynomial trend and signal,
 - second involves the "minimum curvature" model with parameters determined using spline functions
 - Numerical GPS/levelling quasigeoid model with support of gravity data
 - The "kriging" GPS/levelling quasigeoid model based on quasigeoid heights at the POLREF sites supported with mean $1' \times 1'$ gravity anomalies Δg was further developed,
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- Combined quasigeoid**
- Combined GPS/levelling/gravity quasigeoid model was developed,
 - It uses LS collocation for fitting the quasigeoid model to height anomalies obtained at GPS/levelling sites with simultaneous determination of model parameters,
- $$\zeta = \zeta_{GM} + \zeta_{\delta g} + \zeta_{G_1} + t + s$$
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- Summary and conclusions**
- All available data has been gathered and extensively qualitatively and quantitatively analyzed,
 - The data was archived and appropriate databases were developed,
 - New gravimetric quasigeoid models based on gravity data transformed to a new gravity system and to ETRF89 reference frame with EGM96, GGM02S, GGM02S/EGM96, and GGM02C geopotential models were computed,
 - Finally gravimetric quasigeoid model was computed from the revised point gravity data corrected for the effect of topography computed from high resolution DTM,
 - new astro-geodetic geoid model based on deflections of the vertical surveyed in the second half of last century and on some new astronomical observations was computed,
 - the combined quasigeoid model based on gravity, GPS/levelling and topographic data was developed,
 - developed methods and computing strategies as well as experience gained reflect high potentiality for further research on developing precise quasigeoid models in Poland
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