


# *COMPARISON OF THE ACCURACY OF TWO HIGH RESOLUTION GLOBAL GEOPOTENTIAL MODELS: EGM08 AND EIGEN-6C4. CASE STUDY AT THE AREA OF POLAND*

**Marek Trojanowicz, Olgierd Jamroz, Edward Osada**

*Wrocław University of Environmental and Life Sciences, Institute of Geodesy and Geoinformatics*

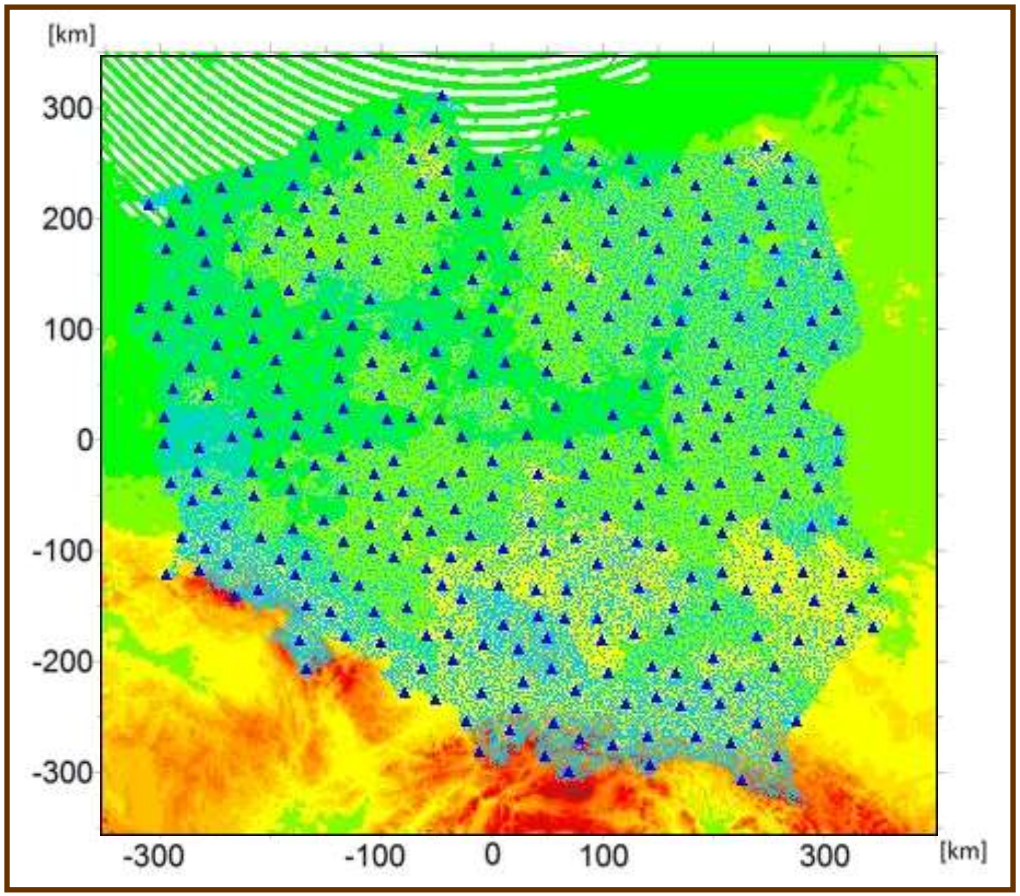
18. ročník semináře s mezinárodní účastí **DRUŽICOVÉ METODY V GEODÉZII A KATASTRU**,
Brno, Czech Republic, 5.02.2015

# THE ANALYSED GLOBAL GRAVITY MODELS

| Model name | Year of development | Degree Order | Semi-major axis $a$ GM | Used data |
|---|---|---|---|---|
| EGM2008 | 2008 | 2190<br>2159 | 6378137.00 m<br>$3.986004418 \times 10^{14} \frac{m^3}{s^2}$ | ITG-GRACE03S (180/180)<br>$5' \times 5'$ free-air gravity anomalies grid (global grid formed from terestrial, altimetry-derived and airbornr gravity data) |
| EIGEN-6C4 | 2014 | 2190<br>2190 | 6378136.46 m<br>$3.986004415 \times 10^{14} \frac{m^3}{s^2}$ | LAGEOS (30)<br>GRACE (130)<br>GOCE SGG Txx + Tyy + Tzz + Txz (235)<br>$2' \times 2'$ free-air gravity anomalies grid (altrimetry over the oceans and EGM2008 over continents) |

On the continents for wavelengths beyond spherical harmonics degree 235, EIGEN-6C4 is basically a reconstruction of EGM2008

# USED TEST DATA




**33330 Gravity points referred to the International Gravity Standardization Network 1971 (IGSN71)**

**HIGH ACCURACY GNSS/LEVELLING POINTS**
**(estimated error of height anomaly $\pm 1cm$)**

- **Selected points of networks EUREF-POL,POLREF, EUVN, ASG-EUPOS-EA - Adjustment 2011, (241 points provided by CODGiK)**
  **short name of the group: ASG 2011**

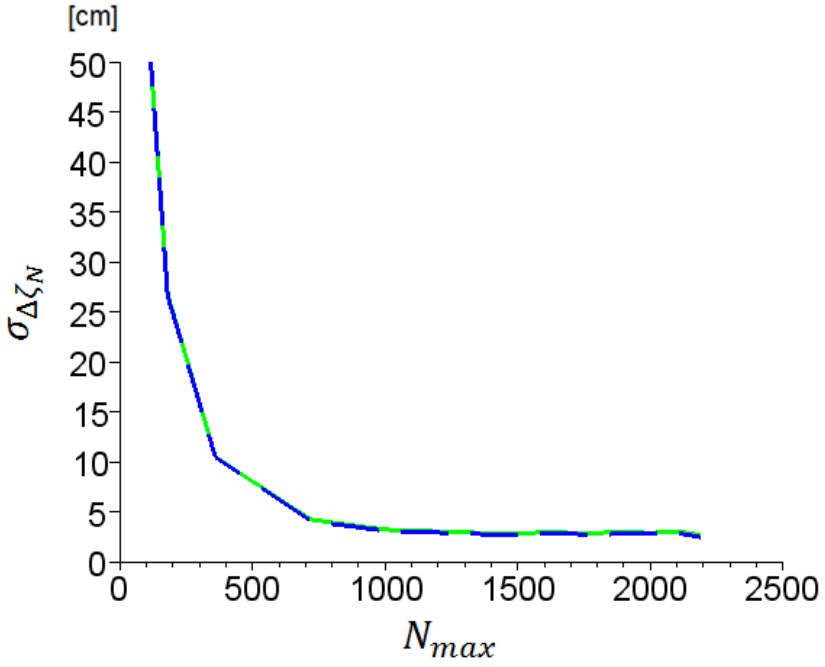
BASIC ACCURACY PARAMETERS OF THE ANALYSED MODELS

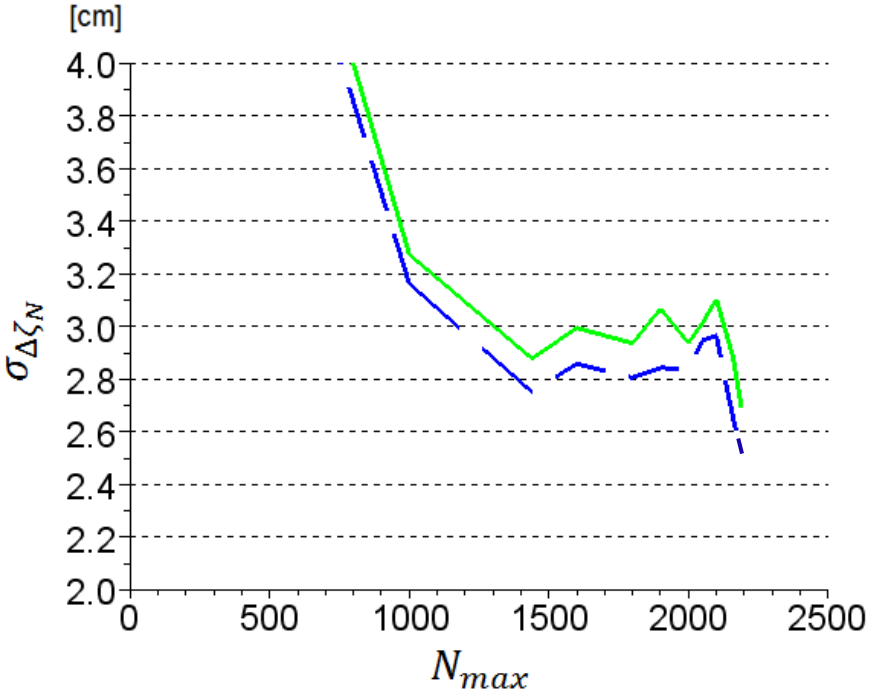
| | EGM2008 | EIGEN-6C4 |
|---|---|---|
| $\max(\Delta\zeta)$ [cm] | 9.8 | 4.1 |
| $\min(\Delta\zeta)$ [cm] | -17.4 | -17.8 |
| $\mathrm{mean}(\Delta\zeta)$ [cm] | -3.9 | -4.5 |
| $\sigma_{\Delta\zeta}$ [cm] | **2.7** | **2.5** |
| $\max(\Delta\delta g)$ [mGal] | 64.4 | 63.8 |
| $\min(\Delta\delta g)$ [mGal] | -20.4 | -20.8 |
| $\mathrm{mean}(\Delta\delta g)$ [mGal] | 13.4 | 13.1 |
| $\sigma_{\Delta\delta g}$ [mGal] | **3.7** | **3.7** |

$$\Delta\zeta = \zeta_{GNSS/lev} - \zeta_{GM}$$

$$\Delta\delta g = \delta g_{MEASURED} - \delta g_{GM}$$

# VALUES OF THE STANDARD DEVIATION ($\sigma_{\Delta\zeta_N}$) AS FUNCTION OF $N_{max}$ VALUES



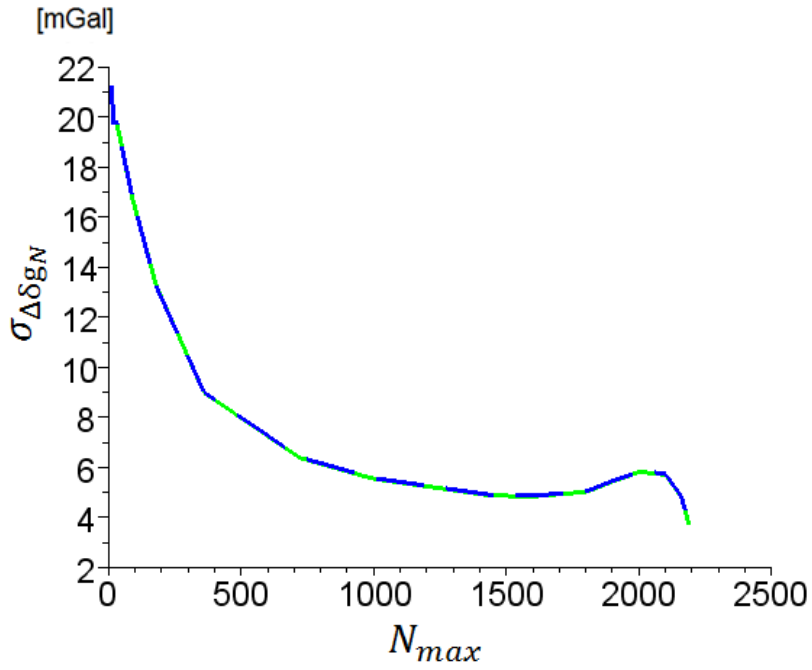



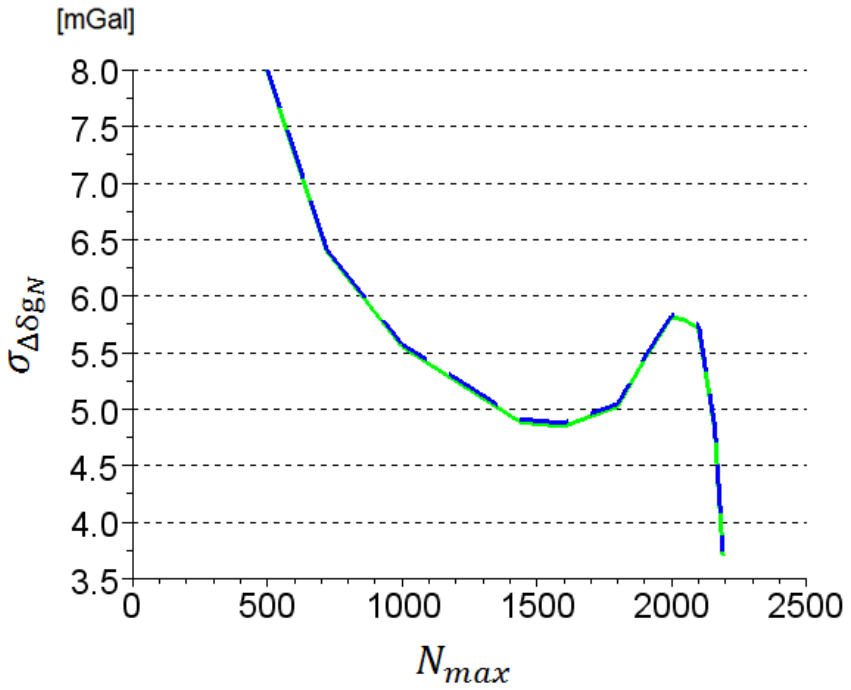

EGM2008

EIGEN-6C4

$$\Delta\zeta_N = \zeta_{GNSS/lev} - \zeta_{Nmax}$$

# VALUES OF THE STANDARD DEVIATION ($\sigma_{\Delta\delta g_N}$) AS FUNCTION OF $N_{max}$ VALUES



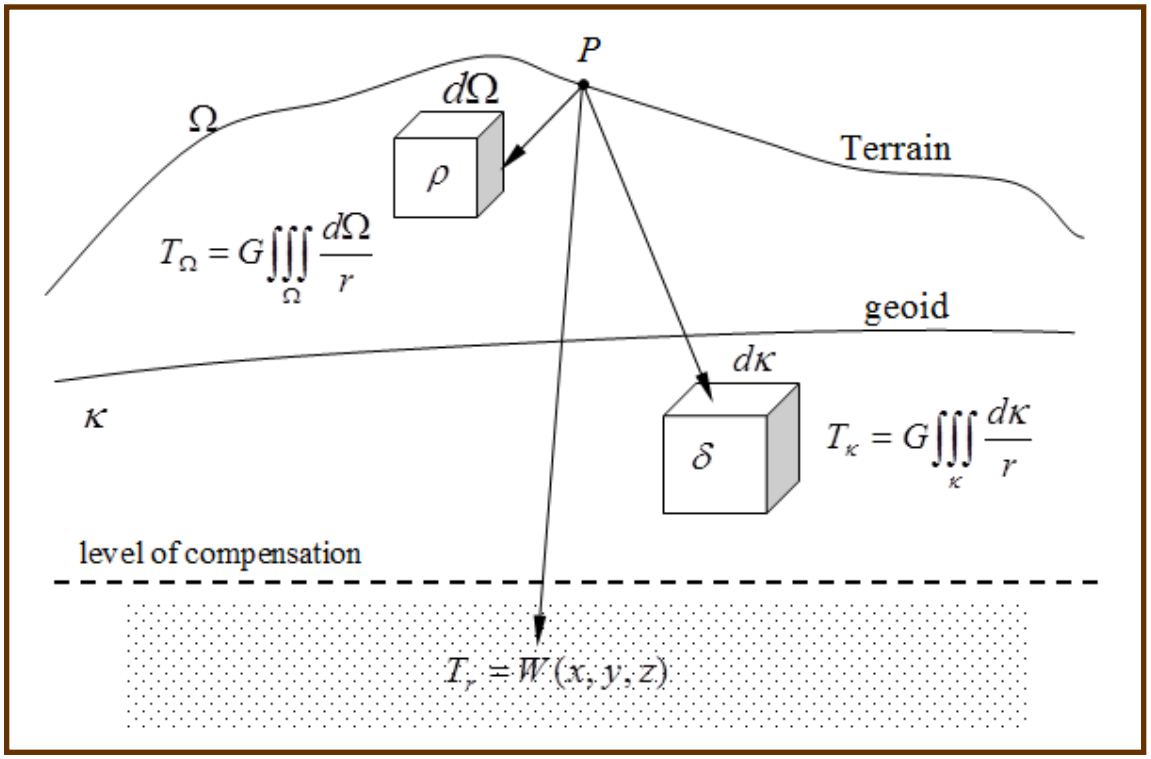




EGM2008

EIGEN-6C4

$$\Delta\delta g_N = \delta g_{IGSN71} - \delta g_{Nmax}$$

# THE GGI METHOD OF LOCAL QUASIGEOID MODELLING



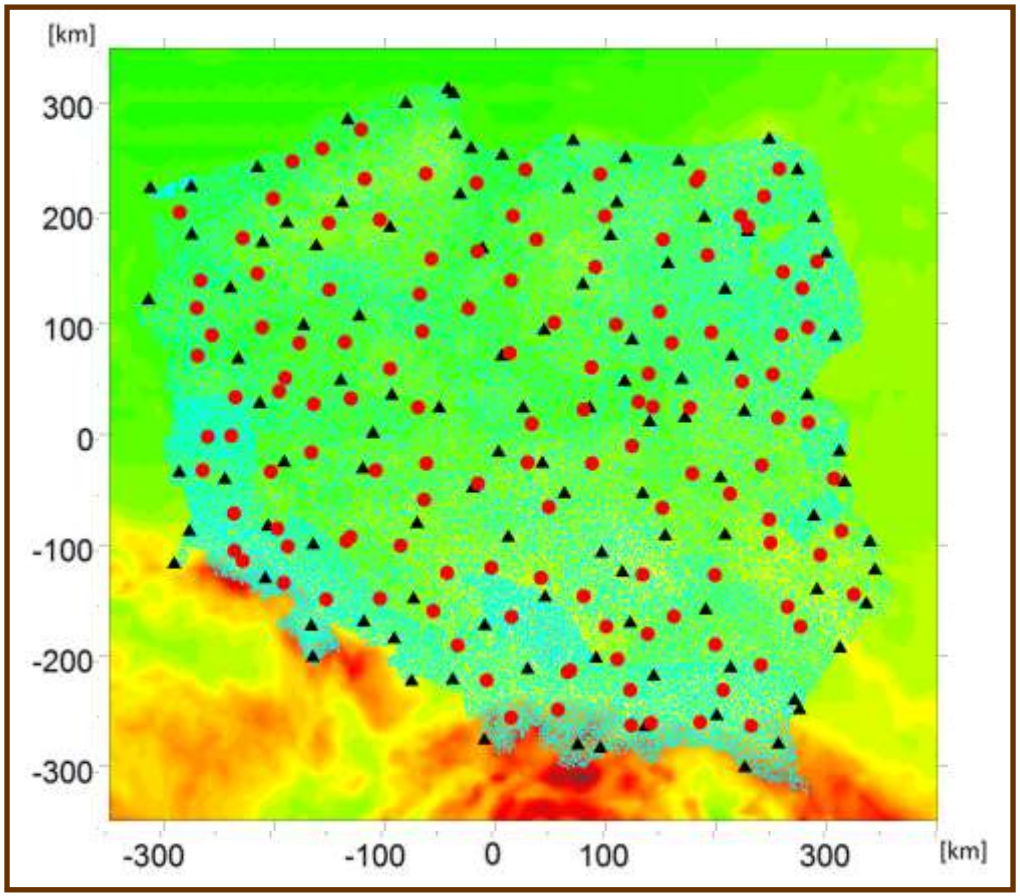

$$T_P = T_r + T_\Omega + T_\kappa$$

GGI method - local quasigeoid modelling method which uses Geophysical Gravity data Inversion technique

## THE INPUT DATA

- Digital Terrain Model
- The Moho depth model
- Gravity data
- GNSS/levelling data

# DATA USED FOR QUASIGEOID MODELLING BY GGI METHOD




**Gravity points**

▲ GNSS/Levelling data points

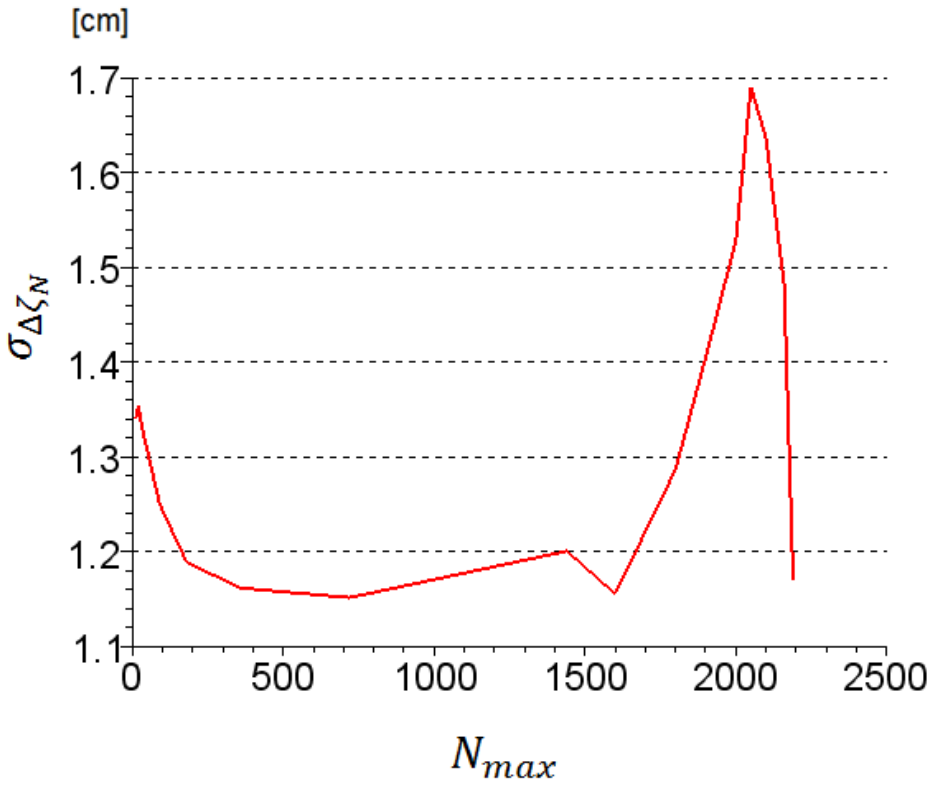
● GNSS/Levelling test points

BASIC ACCURACY PARAMETERS OF QUASIGEOID MODELS CALCULATED BY GGI METHOD WITH THE USE EGM2008 AND EIGEN-6C4 GLOBAL MODELS

| | EGM2008 | EIGEN-6C4 |
|---|---|---|
| Max($\Delta\zeta$) [cm] | 3.9 | 3.9 |
| Min($\Delta\zeta$) [cm] | -3.0 | -2.9 |
| stdev($\Delta\zeta$) [cm] | 1.17 | 1.17 |

$$\Delta\zeta = \zeta_{GNSS/lev} - \zeta_{GGI}$$

VALUES OF THE STANDARD DEVIATION OF DIFFERATIONS $\Delta\zeta = \zeta_{GNSS/lev} - \zeta_{GGI}$
THE $\zeta_{GGI}$ VELUES CALCULATED WITH THE USE OF TRUNCATED EGM2008

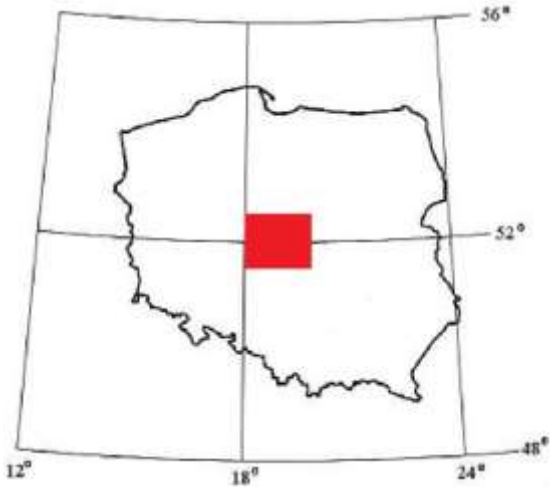



$$\Delta\zeta = \zeta_{GNSS/lev} - \zeta_{GGI}$$

# DETAILED COURSE OF THE ANALYSED GLOBAL MODELS

For a small part of the central Poland ($51.5^o \leq \varphi \leq 52.5^o, 18^o \leq \lambda \leq 20^o$), dense grid ($\Delta\varphi = 0.01^o, \Delta\lambda = 0.02^o$) of the values $\zeta_{N_{max}}$ and $\delta g_{N_{max}}$ were determined. Because the changes in height anomalies ( $\zeta_{N_{max}}$) were very small in relation to their values, a linear trend: $t_{N_{max}}(\varphi, \lambda) = a_0 + a_1\varphi + a_2\lambda$ for each set of $\zeta_{N_{max}}$ were estimated by least square method.

Subsequently residual height anomalies $\delta\zeta_{N_{max}} = \zeta_{N_{max}} - t_{N_{max}}$ were determined.




Dense grid of values $\zeta_{N_{max}}$, $\delta g_{N_{max}}$

Range of the grid: $51.5^o \leq \varphi \leq 52.5^o, 18^o \leq \lambda \leq 20^o$

Grid resolution: $\Delta\varphi = 0.01^o, \Delta\lambda = 0.02^o$

Truncation: $N_{max} \in \{1000, 1600, 2000, 2100, 2190\}$

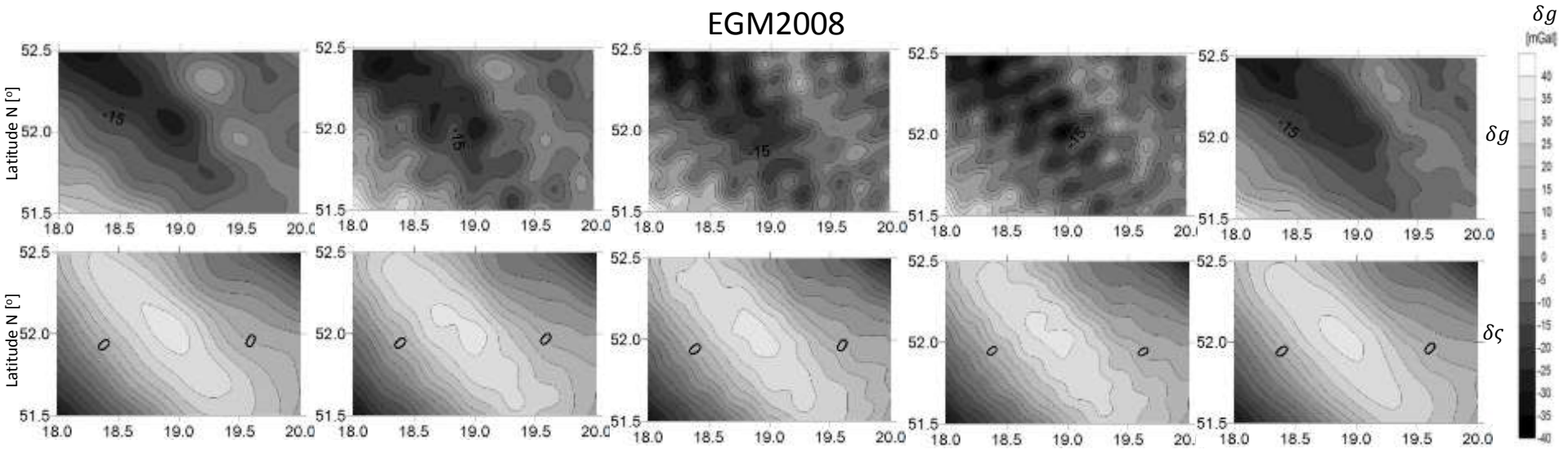
Linear tred remooved: $\delta\zeta_{N_{max}} = \zeta_{N_{max}} - t_{N_{max}}$

$$t_{N_{max}}(\varphi, \lambda) = a_0 + a_1\varphi + a_2\lambda$$

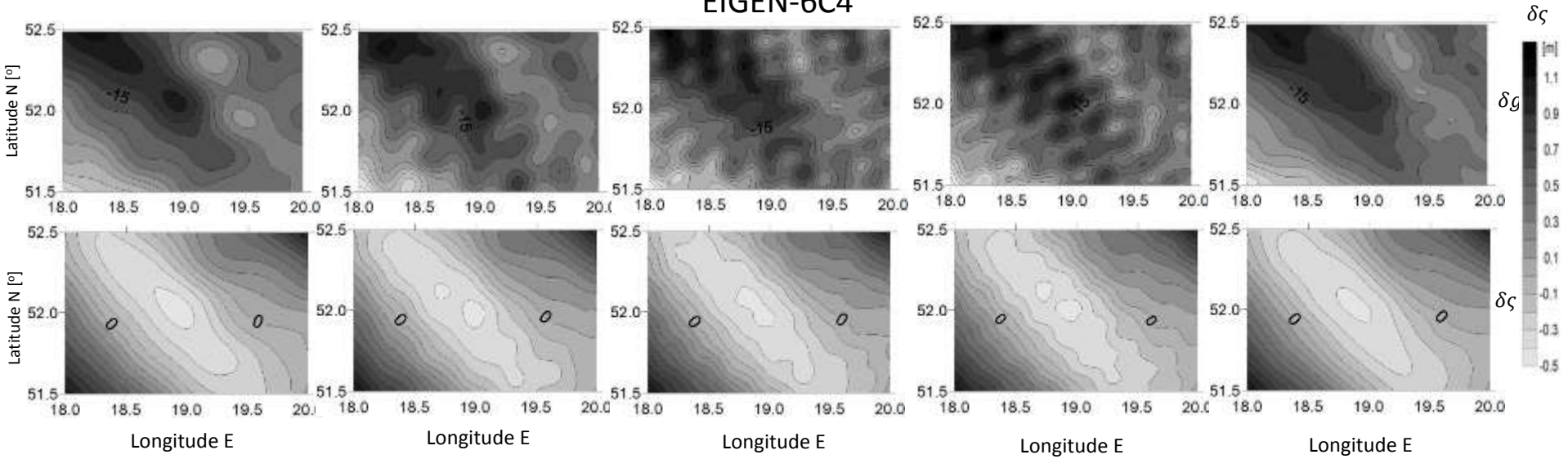
Contour maps of gravity disturbances $\delta g_{N_{max}}$ and residuals height anomalies $\delta \zeta_{N_{max}}$ determined for different $N_{max}$ values from EGM08 (top) and EIGEN-6C4 (bottom) for the central part of Poland

$N_{max} = 1000$ $N_{max} = 1600$ $N_{max} = 2000$ $N_{max} = 2100$ $N_{max} = 2190$

EGM2008




EIGEN-6C4



# CONCLUSIONS

- Both tested models are very similar.
- The basic accuracy parameters of gravity disturbances are the same for both models ($\sigma_{\Delta\delta g} = \pm 3.7$ mGal).
- The basic accuracy parameters of height anomalies ($\sigma_{\Delta\zeta}$) are respectively:

  $\pm 2.7$ cm for EGM2008

  $\pm 2.5$ cm for EIGEN-6C4.

  EIGEN-6C4 model if slightly more accurate (at the level of $8\%$)
- It was also noted an „unexpected behaviour” of both models when truncated models was studied. As a result of this, one can see a significant decrease in the accuracy of gravity disturbances and height anomalies of both models in the range of $N_{max}$ about 2000-2100.

  This indicates the need of using in geoid or quasigeoid modelling all coefficients of both models.

# Thank you for your attention