THE SITUATION IN EASTERN EUROPE ABOUT GEOID / QUASIGEOID MODELS DETERMINATION

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***Abstract**: In the last years, the evolution of the GNSS surveying techniques had an exponential increasing and therefore, until 2007, every European Union's member developed its own local precise geoid or quasigeoid model.*

Also, most of Eastern European countries developed or are being to develop their own precise geoid or quasigeoid model, for satisfying the last requirements of the branch.

In the next pages will be presented some examples of geoid or quasigeoid modeling in a few Eastern European countries, the main purpose being a better understanding of the problem and finally for developing an own precise quasigeoid for Romania.

***Keywords:** geoid / quasigeoid, GNSS, leveling, gravimetry.*

1. Introduction

The main goal of a local precise geoid / quasigeoid model is to provide direct, accurate and fast heights value with physical significance, for the surveyors which use GNSS receivers. Practically, the aim is to replace the geometric levelling with GNSS levelling, which is faster and more efficient.

In this context, most of European Union's member countries developed their own precise geoid or quasigeoid model, satisfying different tasks, precision requirements and so on.

In the next pages will be presented some examples of geoid or quasigeoid modeling in a few Eastern European countries such as: Latvia, Poland, Slovakia, Hungary and Republic of Moldova. After that, will follow a short report about the status and the last years progresses in Romania about modeling an own national precise quasigeoid.

The main purpose of this material is, based on real situations, a better understanding of the problem, and finally, to ensure a theoretical support sustained by examples from similar countries (in terms of social and economical situation).

2. Geoid model for Latvia

In Latvia there are more geoid models available, but, for recalculation of heights of points from ellipsoidal heights to orthometric heights, since 1998 the geoid model LV'98 is officially used.

Also, for the evaluation of the reference equipotential surfaces for orthometric height calculation and for the evaluation of conformity is used, as a reference surface, the global geopotential model EGM08 which includes the results of recent satellite mission data over the Baltic area (Janis KAMINSKIS, 2010).

The modeling area, shown in the next figure, was chosen for all Baltic countries by NKG (Nordic Geodetic Commission):

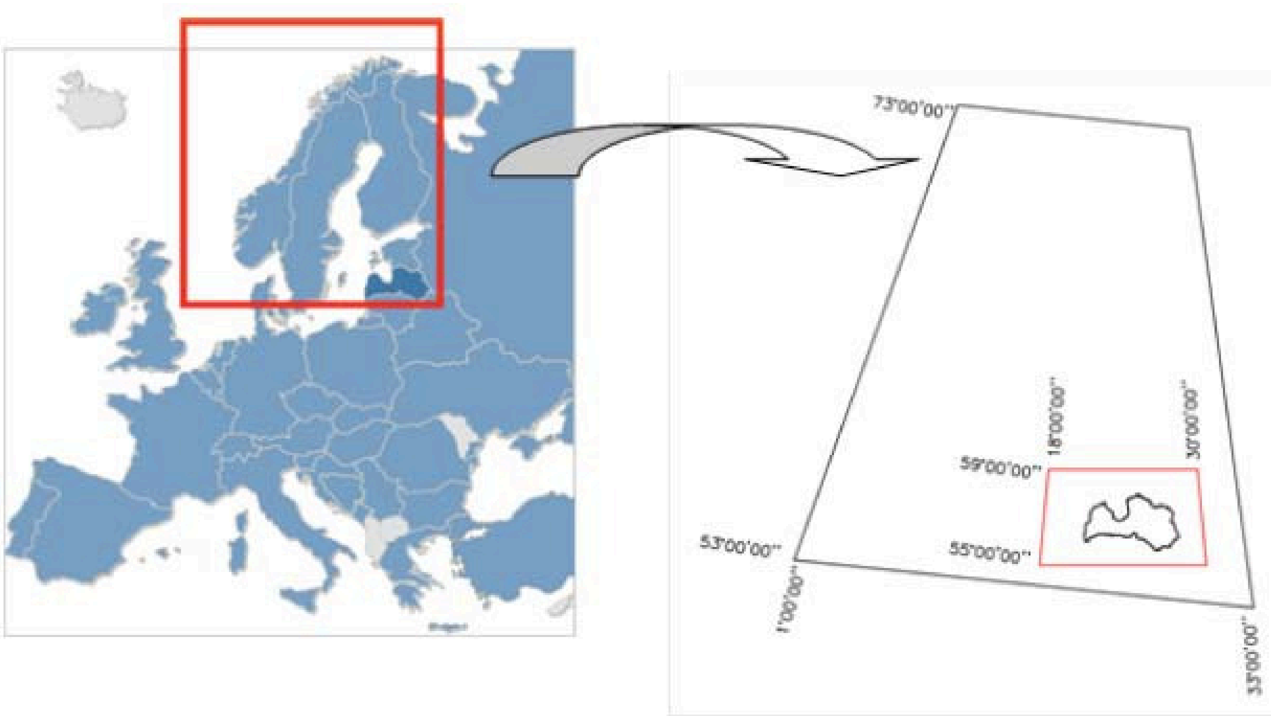

Fig. 1 Modeling area for the Baltic countries geoid

The surface for the Latvian geoid is about 270000 km^2, between 55° and 59° of Northern latitude and 20° and 30° of Eastern longitude with 32361 calculation points and root mean square of anomaly 16,44 mGal.

The accuracy of the actual geoid model was improved over time, from 1993, when was computed the first digital geoid model for Latvia (in Helsinky) until nowadays. The heights of LV’98 geoid are computed in 1998, above the GRS80 ellipsoid:

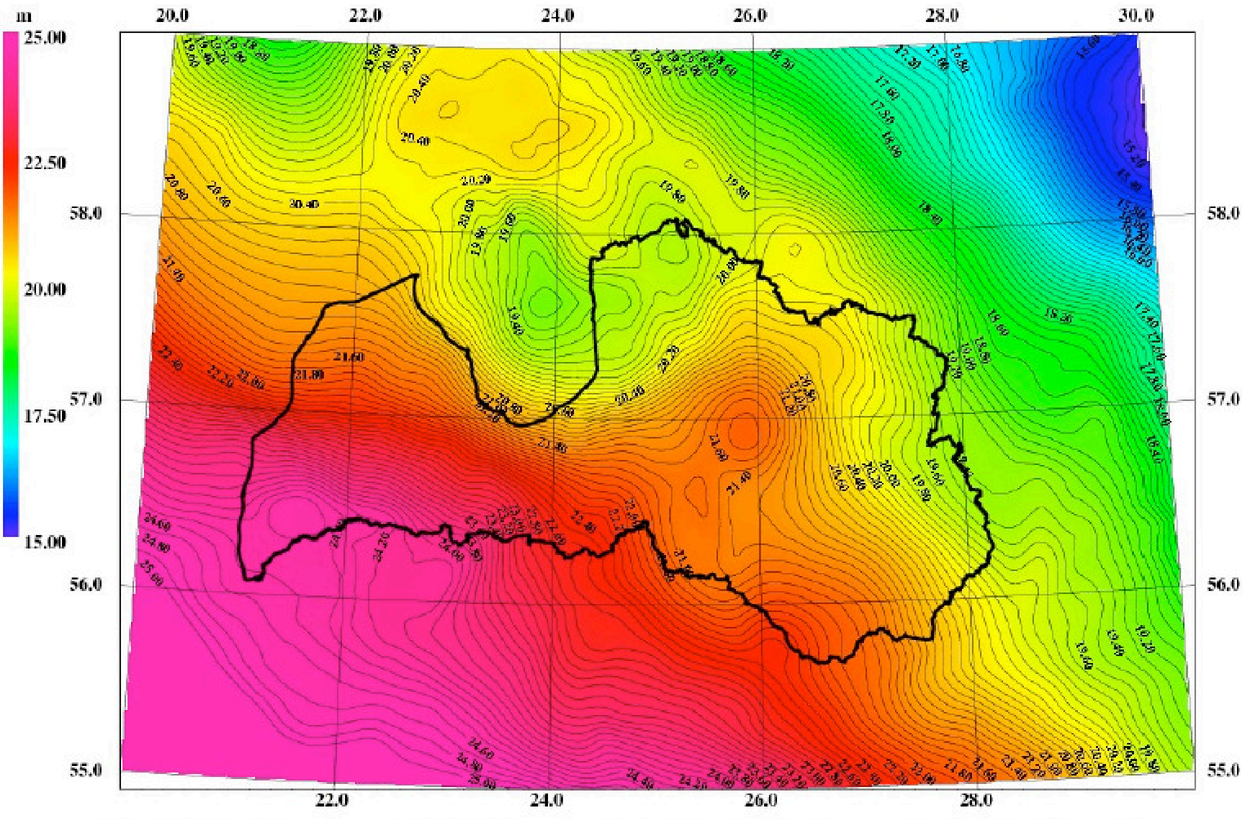

Fig. 2 Latvian LV'98 geoid (heights above GRS80 ellispoid)

The variation of the geoid heights over the entire Latvian territory is from 24.5m (in Liepaja district near the Baltic Sea) and 19.3m (in Balvi district, near the russin border). The root mean square of this geoid model is ±6 cm anywhere in the Latvian area (Janis KAMINSKIS, 2010).

Development of such a good geoid model was possible by combining gravimetric data, which was improved with GNSS and leveling data.

3. Regional quasi-geoid in the area of Poland

In Poland, between 2003 and 2005 were computed some quasigeoidal models, using for this purpose different methods, such as:

1. **Gravimetric method**. In this case, the geoid undulation is composed of combination of three effects: global, regional and local and was calculated using Stokes' integral in spherical approximation (Jan Krynsky and Adam Lyszkowicz, 2006). The aspect of the gravimetric geoid for Poland is shown in the bellows figure:

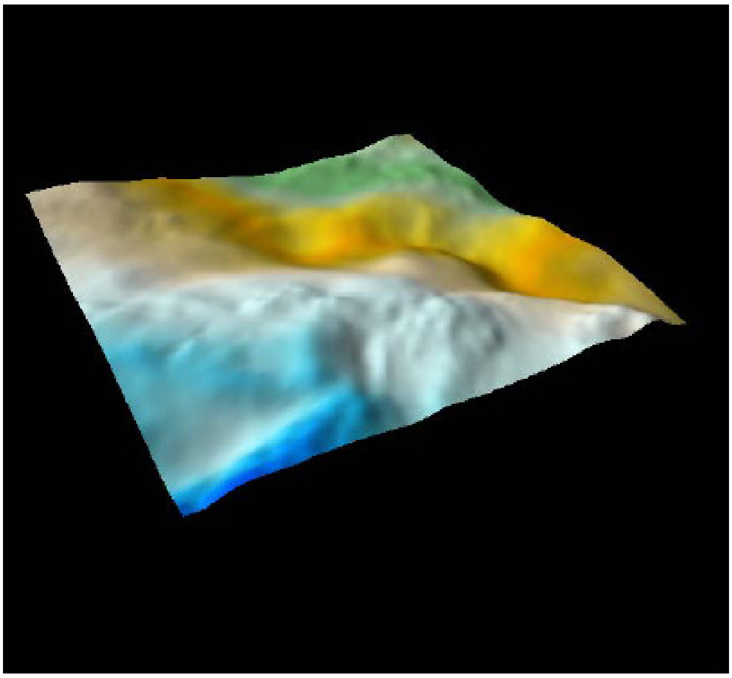

Fig. 3 Gravimetric quasigeoid model for Poland

2. **astro-geodetic method.** For the area of Poland exists a quasigeoid which is computed based on 171 astro-geodetic points and 370 astro-gravimetric points with astro-gravimetric deflections determined before 2001. Distribution of these points are shown below (Jan Krynsky and Adam Lyszkowicz, 2006):

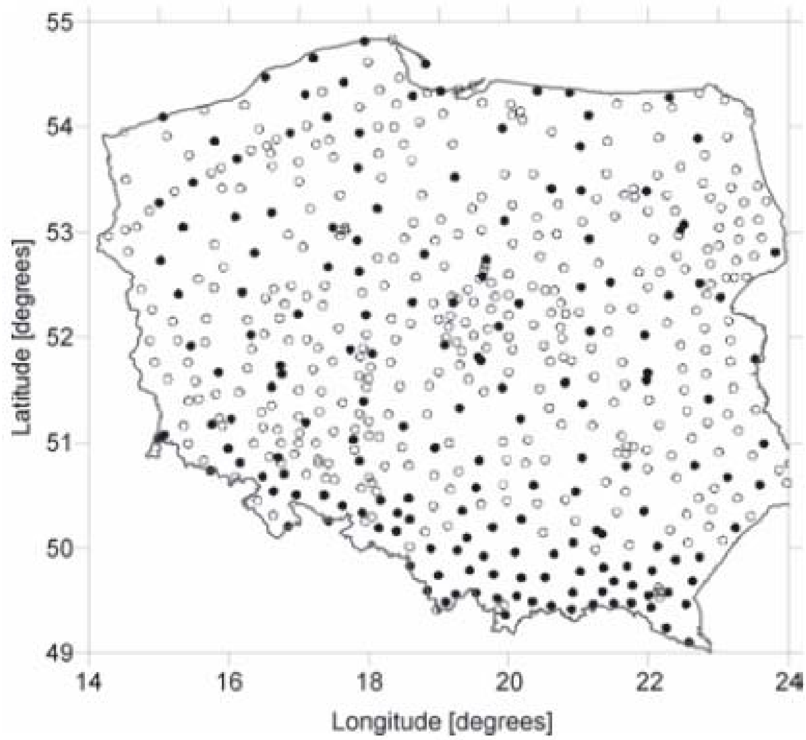

Fig. 3 The astro-geodetic (full colour) and astro-gravimetric (empty colour) points determined before 2001 in Poland

The astro-geodetic geoidal heights are shown in the next figure:

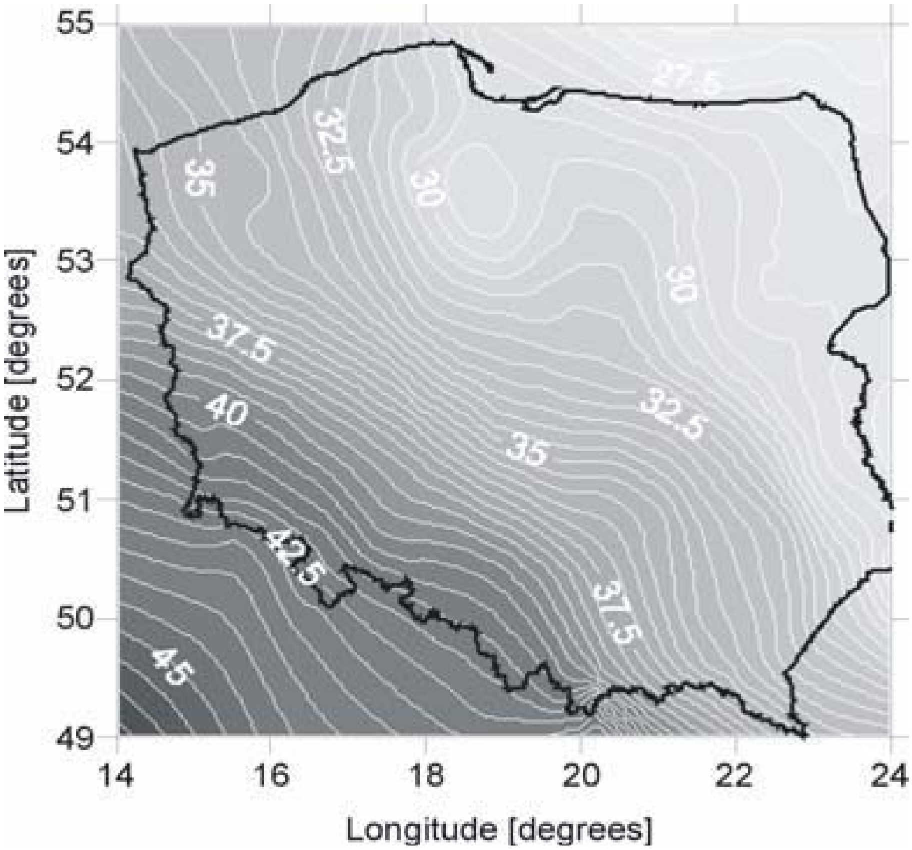

Fig. 4 Astro-geodetic geoid heights

3. In Poland, between 2003 and 2005, were also computed two **GPS/leveling quasigeoid models:** one model was pure numerical and another one was computed with support of gravity data. The statistics of the obtained differences between these models are given in the Table 1:

Table no. 1. The statistics of the obtained differences between the two GPS/leveling quasigeoid models

Model	Mean	Std. dev	Min.	Max.
Pure numerical	-0.034	0.048	-0.213	0.103
With gravity data	-0.031	0.029	-0.124	0.021

4. Quasigeoid in Hungary

Based on gravimetric and astro-geodetic data and, on the other hand GPS/leveling data, in Hungary in 2007 was computed a new precise quasigeoid model: HGTUB2007. This quasigeoid model is shown in the next figure:

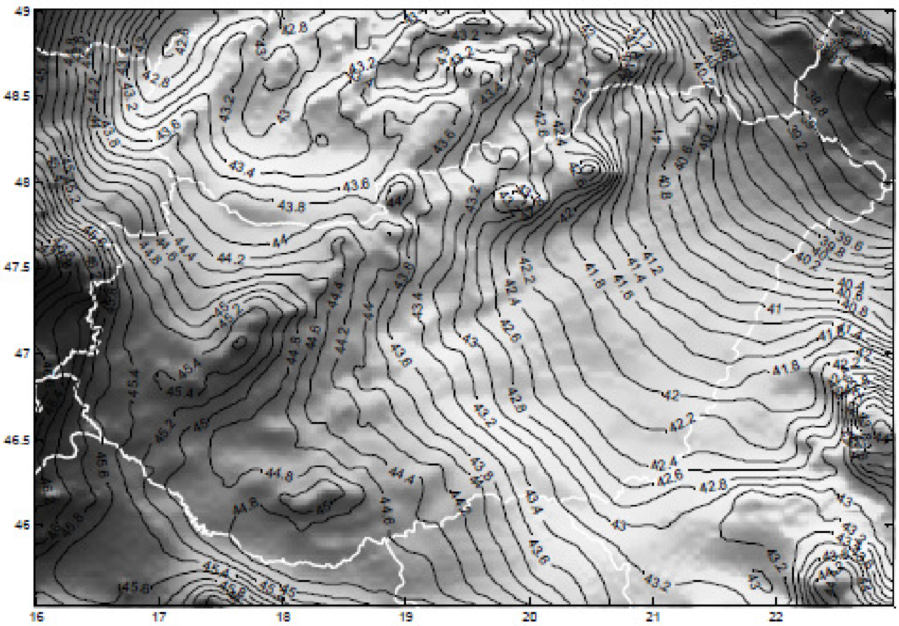

Fig. 5 Hungarian quasigeoid model HGTUB2007

Is noted that for this precise quasigeoid the GPS data were collected by rapid-static method and were processed with a commercial software, not with a scientific one (Gy. Toth).

5. Gravimetric quasigeoid for Slovakia

In terms of level differences, the situation from Slovakia is very similar with Romania. More exactly, in Slovakia altitudes varies from 100 m to 2660 m. Also, the gravity anomalies values are between -25 mGal and 130 mGal.

The gravimetric quasigeoid model for Slovakia was determined using the finite element method with a standard deviation of ± 0.202 m:

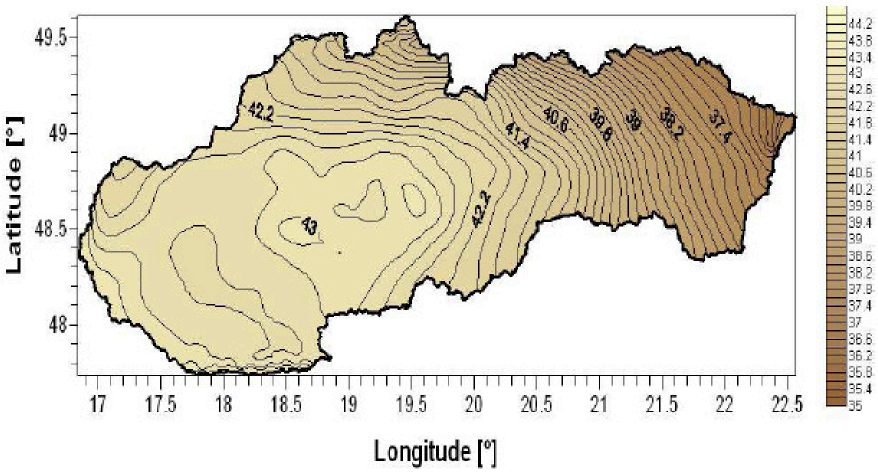

Fig. 6 Slovakian quasigeoid model, computed using the finite element method

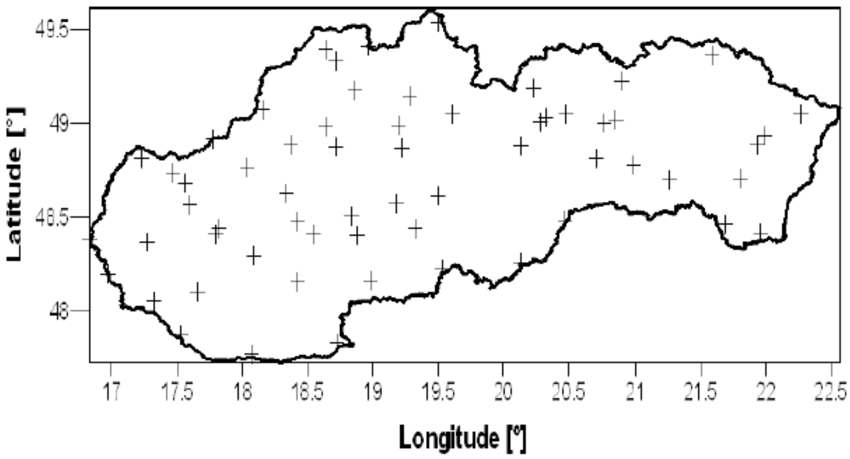

Fig. 6 Distribution of used points for the Slovakian quasigeoid computation

6. Quasigeoid model for Republic of Moldova

In one of the most recent studies in Moldova, finalized in January 2006, was determined a local geometric quasigeoid model, based on GPS/leveling data. For this purpose, were used 971 GPS points (having orders between 0 and 3), which had heights determined in Baltic Sea 1977 system:

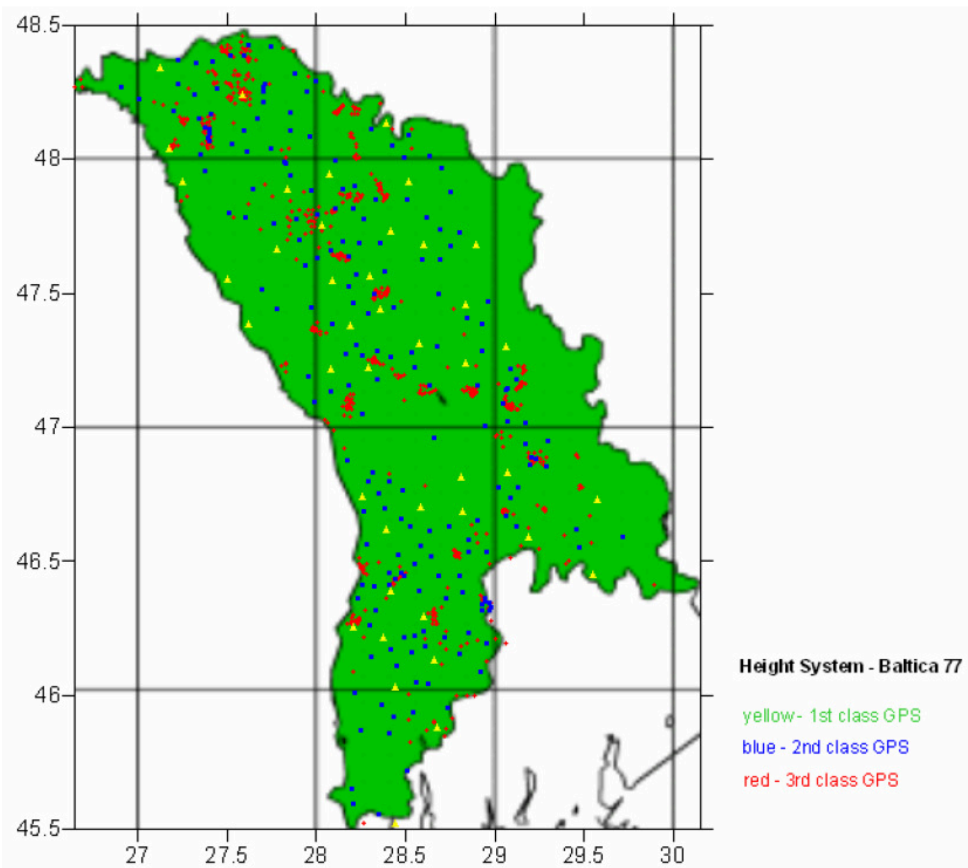

Fig. 7 GPS network for Republic of Moldova

Based on this network, was calculated the next quasigeoid model:

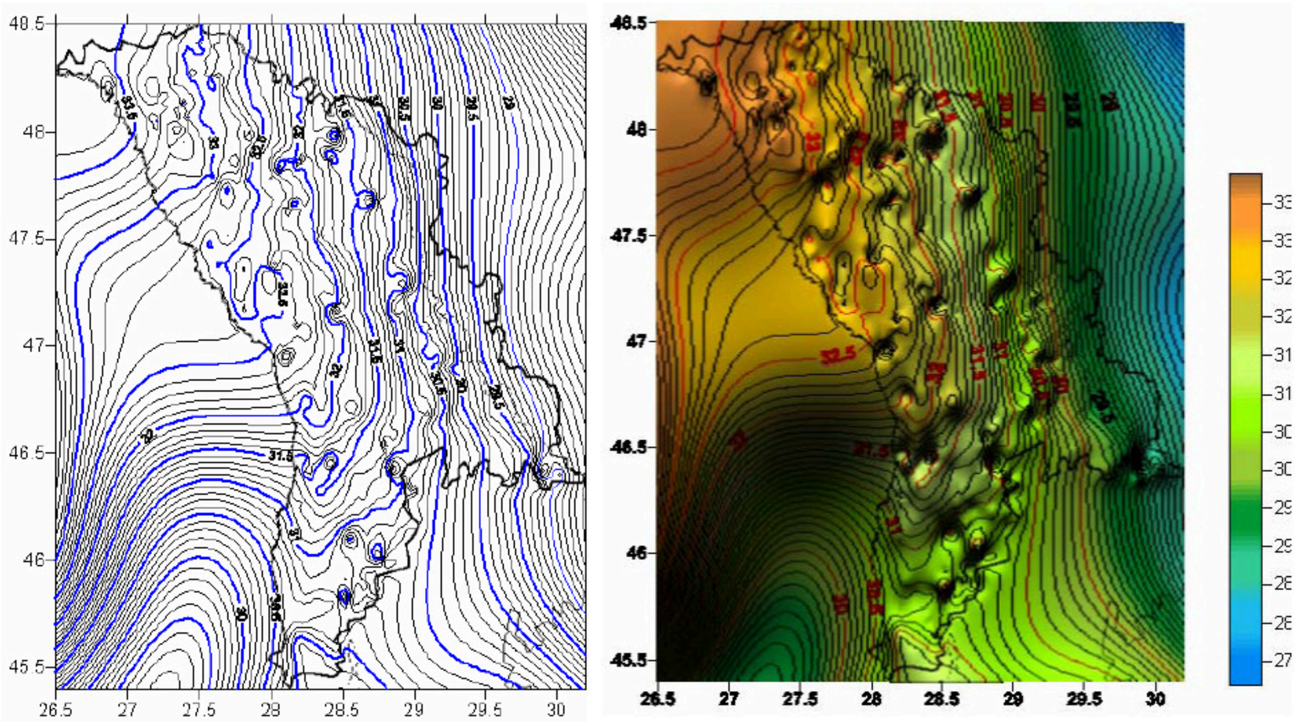

Fig. 8 Moldavian quasigeoid model based on GPS/leveling determinations in 971 points (height system is Baltica 1977)

7. Status and progresses in Romania about modeling an own national precise quasigeoid

In the last two years, in Romania was registered major progresses about developing an own precise quasigeoid model. Thereby, on march 2011, was presented the last and most accurate (± 15 cm for geoid undulation values) national quasigeoid model which is based on EGG97 regional geoid, improved by GNSS/leveling determinations.

This model is shown below (Dumitru P.D., 2011):

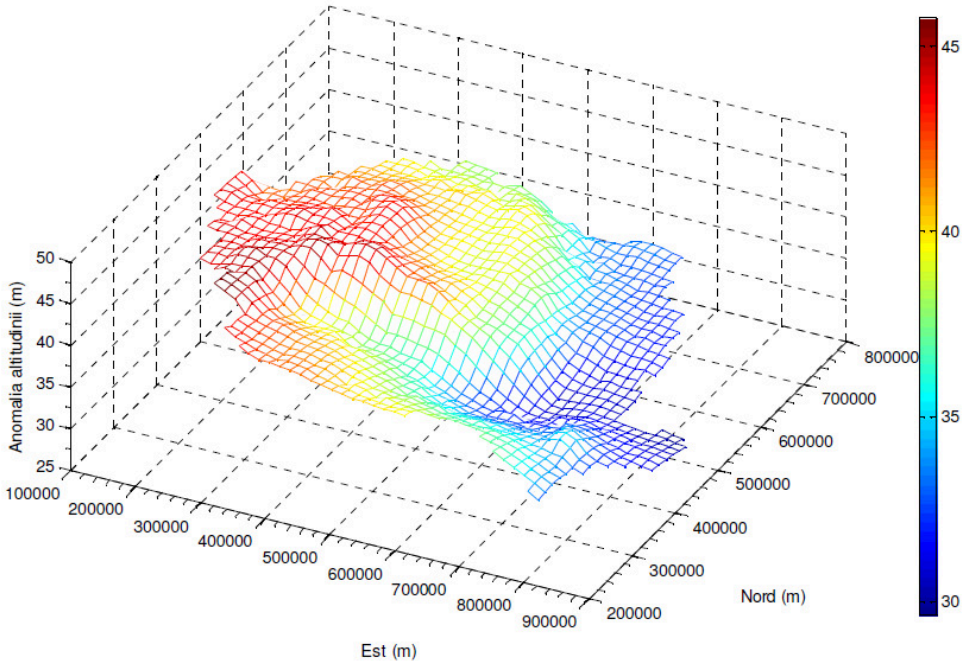

Fig. 8 Romanian quasigeoid model, based on EGG97 and GNSS/leveling determinations. The grid spacing is 16000 m

Also, in may 2011, on GeoPreVi Symposium, organized by Faculty of Geodesy from Technical University of Civil engineering Bucharest, under the Intenational Federation of geodesy – FIG, was presented a national quasigeoid, based on GNSS/leveling determinations in points of National Spatial Geodetic Network:

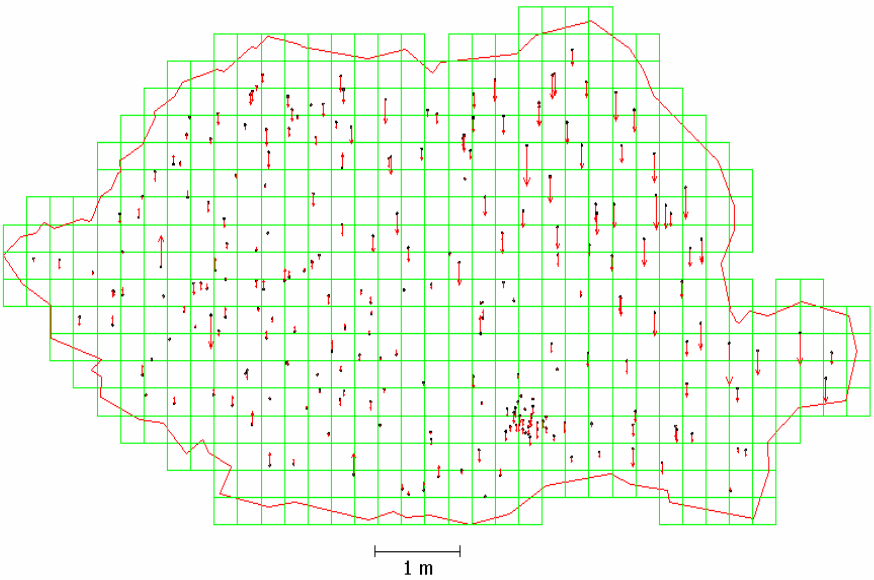

Fig.8 Point distribution of the National Spatial Geodetic Network, with heights in Black Sea 1975 system

Finally, the model looks like in the below figure (Dragomir P., Avramiuc N., Sorta V., 2011):

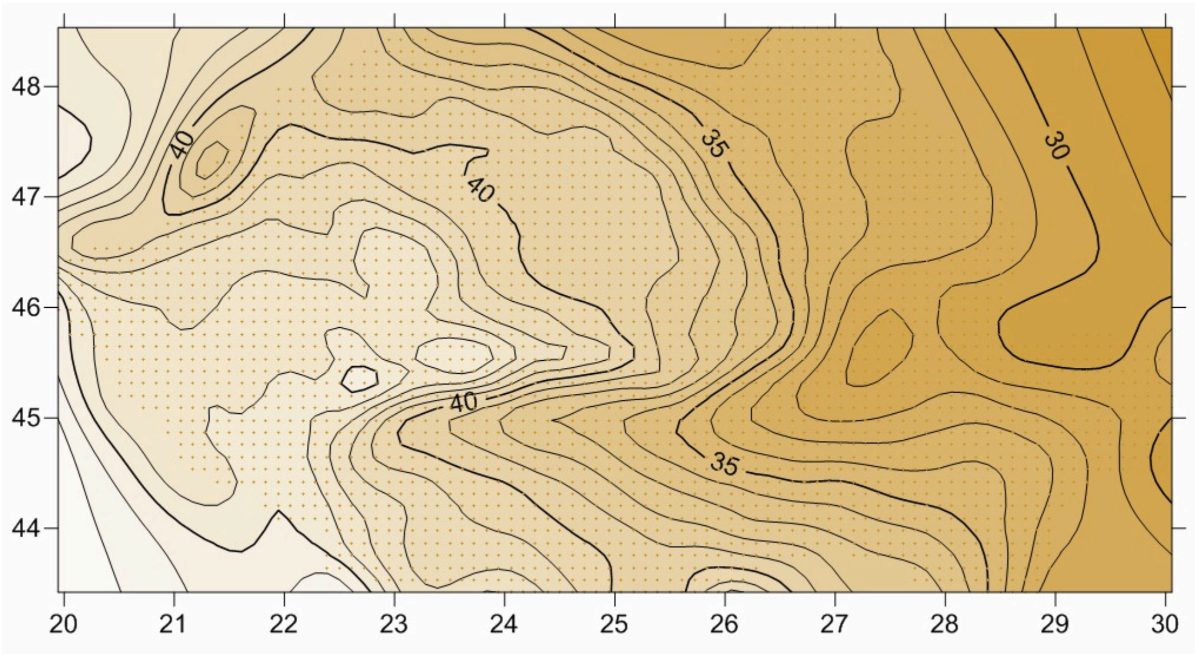

Fig.8 Quasigeoid model for Romania, obtained by correcting the regional EGG97 model with GNSS/leveling determinations

8. Conclusions

Excepting the Western European countries, from the presented material we can observe that in the Eastern Europe also, the progresses related to modeling a local quasigeoid model are significant. Every country, with GNSS technology exponential development, aspires to realize an own precise geoid or quasigeoid model.

In this context, also in Romania in the last years, the progresses are significant with a very good perspective to realize an own reliable and precise local quasigeoid model. The article presented some practical examples on this direction in order to support the Romanian research for finalize as short as possible a new qusigeoid model, based on combined gravimetric and GNSS/leveling data.

9. References

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