MAIN GEODETIC ACTIVITIES IN LITHUANIA

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Introduction

Main Lithuanian geodetic activities were related to the development of the Lithuanian National Geodetic Vertical Network (NGVN) during the 2003. Also geomagnetic field investigations were performed. Tide gauge equipment at the Klaipeda port was upgraded and permanent GPS station was established.

1. National GPS Network

Four Zero Order stations of Lithuanian National GPS Network as well as EPN GPS station VGTU and permanent GPS station at Klaipeda port were occupied during the 7 days GPS observation campaign organized by Nordic Countries in autumn of 2003.

2. National Geodetic Vertical Network

Institute of Geodesy is involved in the establishment of National Geodetic Vertical Network since 1998. The main geodetic activities of Lithuania are supervised by the Department of Geodesy and Cartography of the National Land Service under Ministry of Agriculture. The NGVN is composed of two orders. First order of NGVN consists of 5 loops of precise levelling lines (Fig. 1). Second and fifth loops are already levelled. Closing errors of second and fifth loop are 12 and 14 mm. 231,34 km double levelling run was performed during 2003. Perimeter of the whole network (5 loops) is ca. 1900 km. Every ground benchmark of the levelled polygon of the National Geodetic Vertical Network was coordinated by the GPS. Gravity values were determined from the Bouguer anomaly maps. Digital levels Leica NA 3003 and bar coded staffs Wild GPCL-3 were used. Bar coded staffs were calibrated at the Finnish Geodetic Institute.

The procedure of data treatment and computation of corrections is provided bellow.

Data of everyday levelling was downloaded from digital levels *NA3003* memory blocks using module *WILD GIF10* and program *transint.exe* of software *TC600*, were copied to PC and safe copy to 3.5'' floppy disk. When campaign was completed the data was prepared for processing by text editor *NE* at the office in the following way: correction of point numbers (due to insufficient possibilities of observing queue by *NA3003*) selecting and deleting repeated observations based on field levelling book and entering the time of beginning and end of levelling, number of first levelling staff, lowest and highest temperature during observations, direction of levelling, temperature of air and staff invar strips.

Final height difference between neighbouring points of NGVN was computed using algorithm realised by *MATLAB* and *FORTRAN* language. Improved programs were used since 2003.

Tides are caused due to Moon and Sun tidal effect (Petroskevicius. P. 2001a). Due to this a periodical change of height difference between Earth surface points is going on. Height difference change due to Moon is possible from –0,18 mm to 0,18 mm and due to the Sun from –0,07 mm to 0,07 mm on the Lithuanian territory for the points separated by 2,5 km (Petroskevicius P. 2004). There are two maximums and minimums during the day time. The largest effect of both celestial bodies is during the full and young moon periods. Tidal corrections δ_{MS} for the height differences were computed using formulas:

$$\delta_{MS} = \delta_M + \delta_S , \tag{1}$$

where δ_M – correction due to the Moon

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$$\delta_M = \nu_M S \cos(A_M - A)\,, \tag{2}$$

δ_S – correction due to the Sun

$$\delta_S = \nu_S S \cos(A_S - A)\,, \tag{3}$$

S – line between points of vertical network in km, ν_M and ν_S – deflection of vertical due to Moon and Sun, A_M and A_S – azimuths of Moon and Sun, A – azimuth between the points.

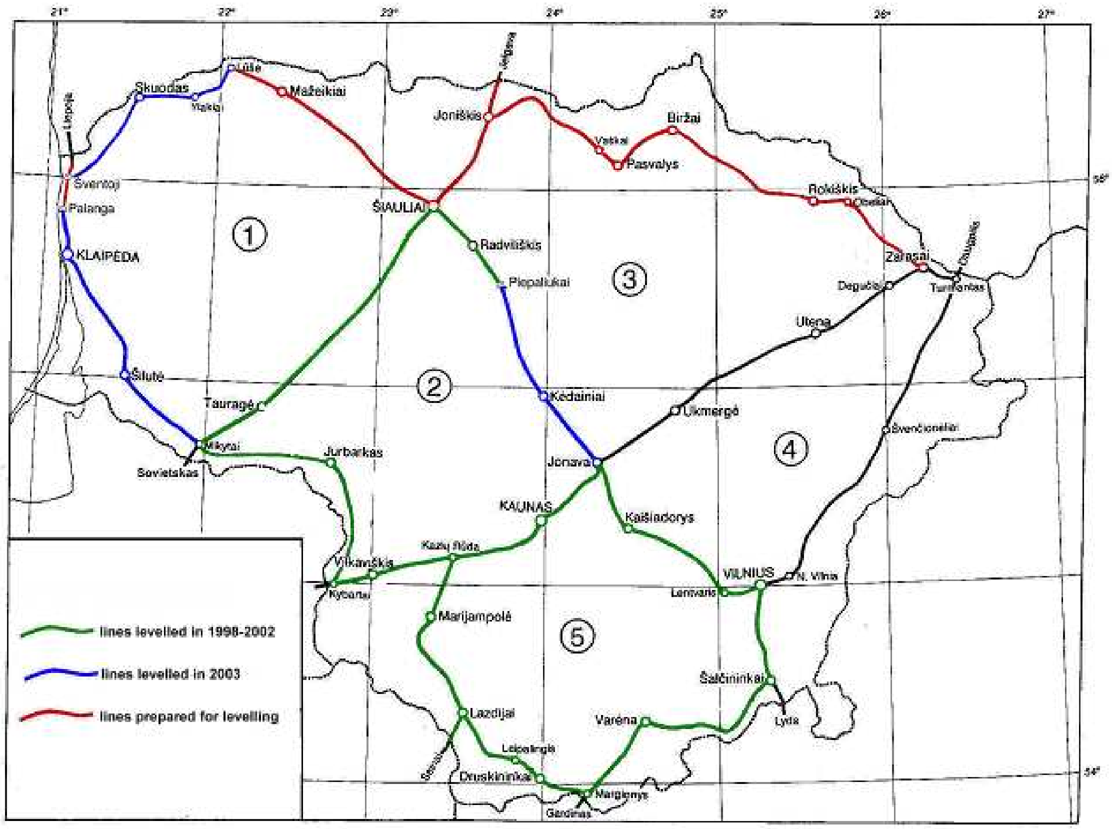

Fig. 1. First order lines of the NGVN

Codes were written and computations were performed using *MATLAB*.

Staff readings were reduced to the staff calibration temperature +20°C. Temperature correction is computed from formula

$$\delta_t = a_m \times \alpha\,/2{,}93, \tag{4}$$

where a_m – staff reading, α – equation of temperature dependency of staff invar strip of 2,93 m, which common expression is

$$\alpha = k_1\,(t_m - 20°) + k_2\,, \tag{5}$$

where k_1 and k_2 – are coefficients of equation of staff length termal dependency, determined at Finnish Geodetic Institute, t_m – temperature of invar strip during the levelling.

Staff readings corrected by staff calibration corrections

$$\delta_k = k_3 + k_4\,a_m + k_5\,a_m^{\,2} + \ldots + k_N\,a_m^{N-3}\,, \tag{6}$$

Height difference at the station

$$h'_s = (a_m + \delta_t^a + \delta_k^a) - (p_m + \delta_t^p + \delta_k^p), \tag{7}$$

where a_m and p_m –backsight and foresight staffs readings, δ_t^a and δ_t^p – temperature corrections for backsight and foresight readings, δ_k^a and δ_k^p – calibration corrections for backsight and foresight readings.
Height differences were corrected for refraction

$$\delta_r = A\,\Delta t\, S^2\, h'_s, \tag{8}$$

where A – coefficient, Δt – temperature difference between heights Z_2 and Z_1 above earth, S – length of collimation line, h'_s – height difference at the station.
Coefficient A computed:

$$A = \frac{4{,}76 \cdot 10^{-4}}{Z_2^c - Z_1^c}\left\{\frac{p^{c+1} - a^{c+1}}{c+1} - Z_0^c(p-a)\right\} \tag{9}$$

where c – coefficients, Z_0 – levelling instrument height. Values used Z_0 = 1,5 m, Z_1 = 1,0 m, Z_2 = 2,0 m.
Coefficient c was taken from (Jordan B. 1963). Intermediate values derived from second order conformal transformation.
For determination of point’s normal heights differences it is needed to evaluate normal field equipotential surfaces non-paralellity, real and normal field non-coincidence. For this purpose normal corrections for height differences determined by levelling in real gravity field are computed (Petroskevicius P. 2004).
Gravity value g_{71r} of European system at the marks height of first order network points computed from Bouguer anomalies $(g_p - \gamma_H)_{2,3}$, taken from gravity map, scale 1:200 000. Gravity value g_{71z} at the surface derived from the formula :

$$g_{71z} = (g_p - \gamma_H)_\delta + \gamma_H^0 - 0{,}3086 H_z + 0{,}0419\delta H_z - 14, \tag{10}$$

where g_P – free fall acceleration in Potsdam system; γ_H – Helmerts field normal gravity value at the teluroid; H_z – approximate earth surface normal height, $\delta = 2{,}3$ g/cm^3 – density of Earth crust, γ_H^0 – normal gravity value at the ellipsoid surface, from Helmerts formula :

$$\gamma_H^0 = 978030(1 + 0{,}005302\sin^2 B_{42} - 0{,}000007\sin^2 2B_{42})$$

where B_{42} – latitude in 1942 system.
Gravity value g_{71r} at the mark height H computed from:

$$g_{71r} = g_{71z} + dg\,. \tag{11}$$

If $H_z > H$, then

$$dg = 0{,}3086 dh - 2 \cdot 0{,}0419\delta dh, \tag{12}$$

where $dh = H_z - H$.
If $H_z < H$, then

$$dg = -0{,}3086 dh, \tag{13}$$

where $dh = H - H_z$.

Normal height difference in LKS 94 (Lithuanian Coordinate System) is determined in GRS 80 normal field, applying new European gravity system and evaluating GRS 80 normal field equipotential surfaces non-linearity (Moritz H. 1984).
Normal correction computed from formula:

$$f_{ik}^{80} = \frac{1}{\gamma_{80v}}(g_{71} - \gamma_{80})_v h_{ik} - \frac{1}{\gamma_{80v}}(\gamma_{80k}^0 - \gamma_{80i}^0) H_v, \tag{14}$$

where g_{71} – gravity value in European system; γ_{80} – GRS 80 field gravity value on teluroid surface; h_{ik} - measured height difference; GRS 80 normal field gravity value γ_{80}^0 computed from :

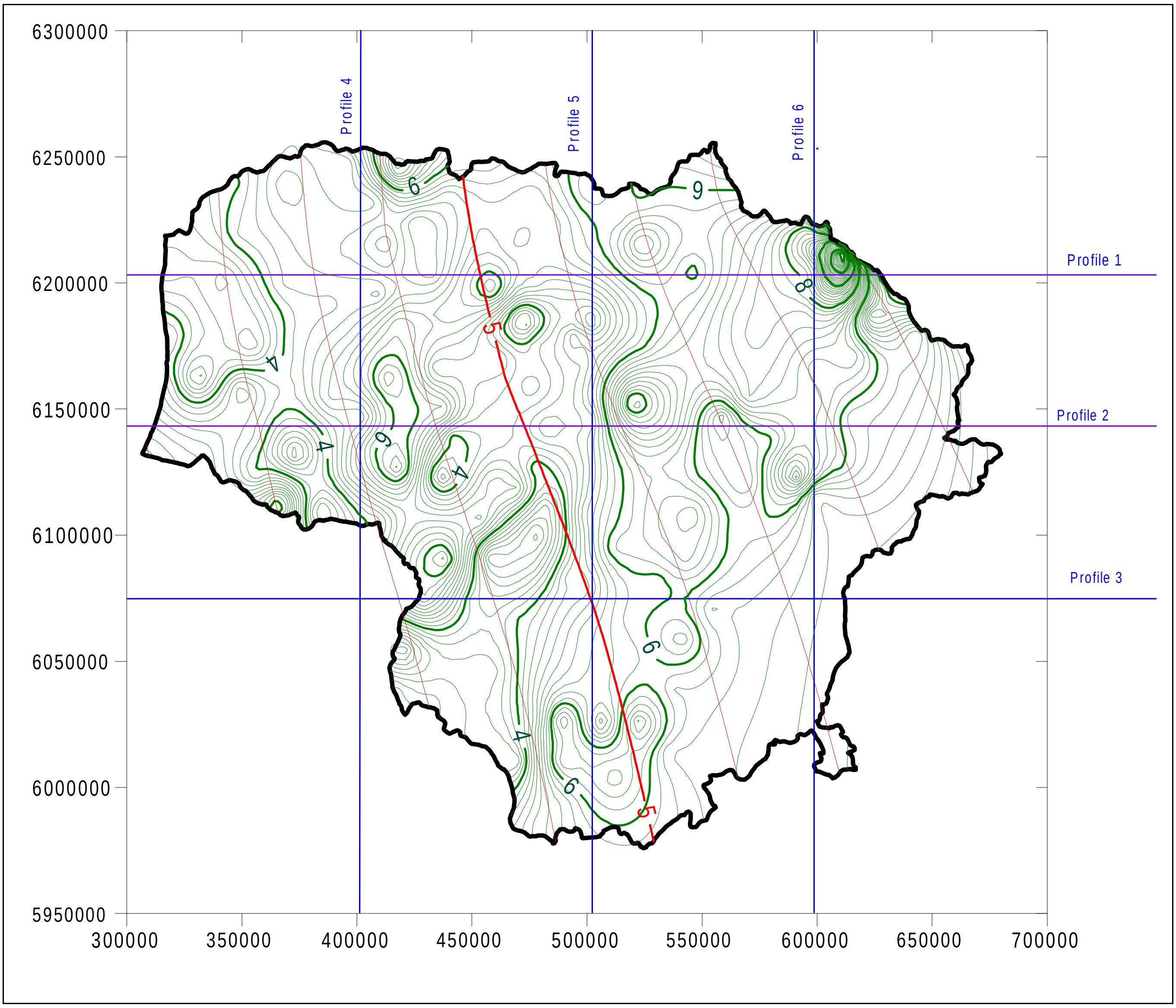

Fig. 2. Comparison of updated Lithuanian geomagnetic map and World Magnetic Model

$$\gamma_{80}^{0} = \gamma_{80e}^{0} \frac{1 + k_{80} \sin^{2} B_{94}}{\sqrt{1 - e_{80}^{2} \sin^{2} B_{94}}} \,, \tag{15}$$

where B_{94} – geodetic latitude in LKS 94 system; normal gravity value at equator on equipotential ellipsoid surface γ_{80e}^{0} = 978032,67715 mGal; e_{80} – first eccentricity of ellipsoid; e_{80}^{2} = 0,00669438002290; coeficient k_{80} = 0,001931851353.

Mean normal gravity value between ellipsoid and teluroid for Lithuanian territory γ_{80v} = 981 500 mGal.
Free air gravity anomaly of vertical network points:

$$(g_{71} - \gamma_{80}) = g_{71} + \delta g_{a} - \gamma_{80}^{0} - \Delta\gamma_{80} \,, \tag{16}$$

here atmospheric gravity correction (Wenzel H.G. 1985)

$$\delta g_{a} = 0{,}874 - 0{,}99 \cdot 10^{-4} H + 0{,}356 \cdot 10^{-8} H^{2} \,, \tag{17}$$

height correction (H in metres) (Torge W. 1989):

$$\Delta\gamma_{80} = -0{,}30877(1 - 0{,}00142 \sin^2 B_{94})H + 0{,}75 \cdot 10^{-7} H^2 . \qquad (18)$$

Observed height differences were corrected by temperature, calibration, refraction and tidal corrections, so the corrected height differences for forward and backward levelling were computed. Mean height difference values were computed and corrected by normal correction f_{ik}^{80} and final height differences were computed.

3. Geomagnetic field investigation

Geomagnetic field research in Lithuania is performed in close cooperation with Warsaw Institute of Geodesy and Cartography. Six points of secular magnetic variation in Lithuania were observed in 1999 and 2001. Geomagnetic map of Lithuania was updated (isogons shown in green, Fig. 2), and compared using 6 profiles (in blue, Fig. 2) with magnetic declination values derived from World Magnetic Model (in red, Fig. 2.). The comparison cleared out the difference of magnetic declination up to 3 degrees for the territory of Lithuania.

4. Tide gauge and CGPS in Klaipeda

Studies of climate changes and also climate warming problems are related to the analysis of the geophysical processes including changes in regime of some hydrological elements. One of the indicators of the changing climate is the water level, i.e. the long-term changes of waters level. The Centre of Marine Research, Ministry of Environmental analyse the time series of water level long-term changes in South-Eastern Baltic Sea and in the Curonian Lagoon.

The tide gauge Klaipeda was upgraded to digital one by the Institute of Geodesy, Vilnius Gediminas Technical University in the frame of the ESEAS-RI project. The Hydrocom tidal monitoring system was purchased, which includes SUTRON Shaft encoder model 56-0540 , SUTRON Xpert datalogger, UPS unit, 12V power supply unit, XConnect and XTerm software. The tidal monitoring system was installed on October 3, 2003. Also the levelling benchmarks were set up, forming the levelling network for tide gauge vertical movements monitoring. The levelling was performed in May-June and October of 2003.

Tide gauges measure sea level relative to land. For most applications, tide gauges need to be monitored for vertical motion, relative to the adjacent land, as such vertical motion introduces a bias in any derived relative sea level trends. The permanent GPS station Klaipeda was established, equipped by the Ashtech Z-12 GPS receiver with Dorne Margolin chock ring antenna. The CGPS Klaipeda (KLPD) was installed on September 24, 2003. It was included into two episodic GPS campaigns (GPS weeks 40 and 42 of 2003) in order to connect the tide gauge and CGPS station to a global reference frame.

The great concern should cause the increase in water level observed in the 20th century, which could be directly related to the problems of the coast erosion, land overflow, the distortion of the ecological equilibrium. Investigations of water level change based on the observation of the period from 1898 till 2002 show, that water level near the coastline of Lithuania rise about 13.5 cm (Fig. 3). The speed of water level rise is about 3.0 mm per year from the 1960.

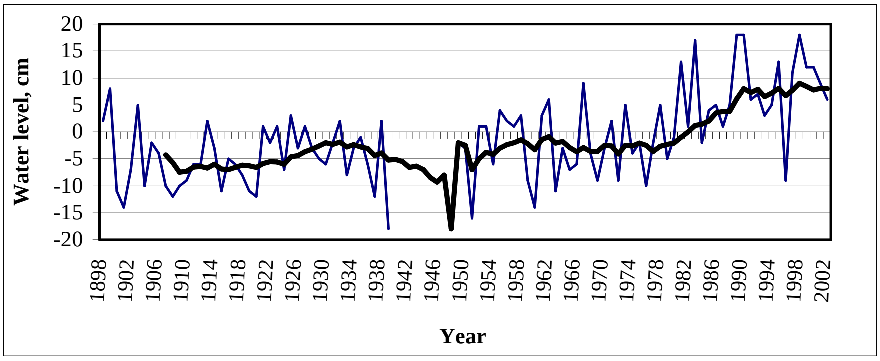

Fig. 3. Change of water level at Klaipeda strait and curve of moving decades, 1898–2002

Conclusions

The development of the Lithuanian National Geodetic Reference is going on as well as investigations of geomagnetic field. First order of Lithuanian National Geodetic Vertical Network should be completed in 2-3 years and the country will be ready for the introduction of the new height system. The network of permanent GPS stations in Lithuania is expanding.

References

1. Borre K., Petroskevicius P. (1995): Fundamental GPS network in Lithuania, Geodetic Theory Today. Third Hotine . Marussi Symposium on Mathematical Geodesy. L.Aquila, Italy, May 30.June 3, 1994. Springer, 1995, pp. 27-31.
2. Buga A., Petroskevicius P. (2000): National Report of Lithuania, Veroffentlichungen der Bayerischen Kommission fur die internationale Erdmessung der Bayerischen Akademie der Wissenschaften. ISSN 0340-7691. Munchen, 2000. Heft Nr. 61, pp. 274-275.
3. Buga A., Sleiteris E. (2001): Lithuanian GPS network status and its development, Proceedings from Seminar of the Danish & Baltic Sector Programme held in Riga March 2 and 3, 1999, Copenhagen, 2001, pp 48-53.
4. Bukantis, A., et al. (2001): Climate changes influence to the physical geographical processes in Lithuania (Klimato svyravimų poveikis fiziniams geografiniams procesams Lietuvoje). Institute of Geography of Vilnius University, 2001. 280 p. (in Lithuanian).
5. Dailidiene I., Stankevicius A., Tilickis B. (2004): Peculiarities of the long-term water level fluctuations in the southeastern part of the Baltic sea and the Curonian lagoon. Geodezija ir kartografija (Geodesy and Cartography), Vilnius: Technika, 2004, Vol XXX, No 2, pp. 58–64.
6. Dubra, J. (1978): Peculiarities of the sea level changes (Vandens lygio svyravimu ypatybes). Kursiu marios. 1978, p. 7–16 (in Lithuanian).
7. Jordan V., Eggert O., Kneissel M. (1963): Manual of Geodesy (Rukovodstvo po vysshey geodezii), Part II, Moscow, Nedra, 1963, p. 264 (in Russian).
8. Juceviciute V., Kumetaitis Z., Sleiteris E., Buga A., Parseliunas E., Petroskevicius P. (2002): Trends of Development of the Lithuanian National Geodetic Control, EUREF publication No. 12, Verlag des Bundesamtes fur Kartographie und Geodasie. ISSN 1436-3445. Report on the Symposium of the IAG Subcommission for Europe (EUREF) held in Ponta Delgada, pp. 273-281.
9. Kazakevicius S., Petroskevicius P., Zakarevicius A. (1999) On the principles of Lithuanian geodetic vertical network Establishment, Geodesy and Cartography (Geodezija ir kartografija), XXV t., Nr. 2. ISSN 1392-1541. V.: Technika, 1999, pp. 47-59. (in Lithuanian).
10. Moritz, H. Geodetic Reference System 1980. Bull. Geod. 58 (3), 1984, p. 388-398.
11. Mroczek S.; Sas A.; Sas-Uhrynowski Petroskevicius, P. Obuchovski R., Rimkus R. (2002) Establishment of Lithuanian Gravimetric First Order Network, Geodesy and Cartography (Geodezija ir kartografija), Vol XXVII, No 3. ISSN 1392–1541. Vilnius: Technika, 2002, pp. 75–82.
12. Parseliunas E., Petroskevicius P., Sleiteris E. (1999): National Report of Lithuania, Mitteilungen des Bundesamtes fur Kartographie und Geodasie. ISSN 1436-3445. Frankfurt am Main , 1999. Band 6, pp. 187-189.
13. Petroskevicius P., Parseliunas E. (1997): GPS Method in Lithuania, Civil GPS Service Interface Committee, International Information Subcommittee Meeting, 6th European Meeting. Warsaw, 1997. pp. 210-214.
14. Petroskevicius P.; Parseliunas E. (1999): Investigation and improvement of the Lithuanian gravity control. (Lietuvos gravimetrinio pagrindo tyrimas ir tobulinimas) Geodesy and Cartography (Geodezija ir kartografija), Vol XXV, No 2. ISSN 1392–1541. Vilnius: Technika, 1999, p. 73–82 (in Lithuanian).
15. Petroskevičius P. (2000): Reduction of gravity anomalies and free fall acceleration (Sunkio anomaliju ir pagreicio redukavimas) Geodesy and Cartography (Geodezija ir kartografija), Vol XXVI, No 4. ISSN 1392–1541. Vilnius: Technika, 2000, p. 167-170 (in Lithuanian).
16. Petroškevičius P. (2001a): Evaluation of celestial bodies effect on the Vertical (Dangaus kūnų poveikio vertikalei įvertinimas) Geodesy and Cartography (Geodezija ir kartografija), Vol XXVII, No 2. ISSN 1392–1541. Vilnius: Technika, 2001a, p. 49–54 (in Lithuanian).
17. Petroskevicius P. (2001b): Vertical deflection and changes of Earth surface height differences due to tides (Su potvyniais susijes vertikales krypties ir zemes pavirsiaus tasku auksciu skirtumo kitimas) Geodesy and Cartography (Geodezija ir kartografija), Vol XXVII, No 3. ISSN 1392–1541. Vilnius: Technika, 2001b, p. 93–100 (in Lithuanian).
18. Petroskevicius P. (2004): Gravitation field effect on geodetic observations (Gravitacijos lauko poveikis geodeziniams matavimams), Monography, Vilnius: Technika, 2004, p. 292 (in Lithuanian).

19. Tilickis B., Stankevicius, A. (1999): Hydrological regime at Baltic seashore (Hidrologinis rezimas Baltijos pajuryje). Sea and environment (Jūra ir aplinka), No 2. Klaipėda University, 1999, p. 27–36 (in Lithuanian).
20. Torge, W. (1989): Gravimetry. Berlin; New york: de Gruyter, 1989, 465 p.
21. Wenzel H.G. (1985): Hochauflosende Kugelfunktionsmodelle fur das Gravitationspotential der Erde. Wiss. Arb. Univ. Hannover Nr.137, 1985, pp. 5-13.
22. Yakovlev B. (1989): Geodesy (Vysshaya geodeziya), Moscow, Nedra, 1989, p. 445.
23. Zalnierukas A., Petroskevicius P. (1998) Neue Geodasie in Litauen in der Zeit der letzten Umwandlungen, Schriftenreihe des DVW. Wiesbaden: Wittwer, 1998. Band 33, pp. 71-81.
24. Zaromskis, R. (1996): Oceans, seas, estuaries (Okeanai, juros, estuarijos). Vilnius, 1996. 211 p. (in Lithuanian).