Acta Geod. Geoph. Hung., Vol. 42(2), pp. 141–167 (2007)
DOI: 10.1556/AGeod.42.2007.2.2

HUNGARIAN NATIONAL REPORT ON IAG 2003–2006

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This report outlines Hungarian activities in geodesy for the period January 2003 to December 2006. It has been prepared for submission to the International Association of Geodesy (IAG) at its General Assembly in Perugia, Italy during the XXIVth General Assembly of the International Union of Geodesy and Geophysics (IUGG) on July 2–13, 2007. It is issued on behalf of the IAG Section of the Hungarian National Committee for IUGG.

Since the last XXIIIrd General Assembly in Sapporo, Japan, June 30–July 11, 2003 there have been some minor changes in the list of members of the IAG Section of the Hungarian National Committee for IUGG. Currently the National Correspondent to the IAG is also the Chairman of the IAG Section. The members of the IAG Section for the period of 2004–2007 are as follows: J Ádám (Chairman), L Bányai (Secretary), Á Barsi, P Bíró, T Borza, G Csapó, I Fejes, I Joó, A Kenyeres, Gy Mentes, G Papp, Sz Rózsa, Gy Tóth, P Varga, L Völgyesi and J Závoti.

The following useful and successful geodetic event sponsored by IAG took place in Hungary during the quadrennium to which this report refers:

International IAG School on "The Determination and Use of the Geoid", Budapest, Hungary, January 31–February 4, 2005.

Co-operating institutions in the field of IAG in Hungary are as follows: a) Department of Geodesy and Surveying, Budapest University of Technology and Economics, (http://www.geod.bme.hu); b) Satellite Geodetic Observatory of the Institute of Geodesy, Cartography and Remote Sensing, Budapest-Penc (http://www.sgo.fomi.hu); c) Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences, Sopron (http://www.ggki.hu);

d) College of Geoinformatics, University of West Hungary, Székesfehérvár (http://www.geo.info.hu); e) Eötvös Loránd Geophysical Institute of Hungary, Budapest (http://www.elgi.hu), and f) Mapping Service of the Hungarian Defence Forces, Budapest.

The national report has been divided into commissions corresponding to the new structure of IAG. The commission reports are compiled by the authors indicated in brackets, who are responsible for the content of their corresponding reports, namely I. Commission 1 "Reference Frames" (T Borza and A Kenyeres), II. Commission 2 "Gravity Field" (G Papp and L Völgyesi), III. Commission 3 "Earth Rotation and Geodynamics" (L Bányai, Gy Mentes and P Varga, and I Joó), IV. Commission 4 "Positioning and Applications" (Gy Mentes), V. Inter-Commission Committee "Theary" (J Závoti) and VI. Communication and Outreach Branch (J Ádám, Sz Rózsa and Gy Tóth). This report would not be possible without their efforts.

I. Commission 1 (Reference Frames)

(Tibor Borza and Ambrus Kenyeres, Satellite Geodetic Observatory)

1. Geodetic infrastructure

Since 2002 an essential development of the Hungarian Active GNSS Network has been carried out. In 2002 we operated only 3 reference stations, which number was expanded to 22 by the end of 2006. The initial 3 stations (PENC, OROS and NYIR) are contributing to the EUREF Permanent Network (EPN), submitting daily and hourly RINEX data to the EPN Data Centres at BKG and OLG. However, concerning the equipment types and quality, communication infrastructure and ownership the current network configuration is very inhomogeneous. Most of the stations are installed at Land Registry Offices, but private companies (e.g. GNSS receiver dealers) also contribute to the national network with setting up reference stations on their own premises. The obsolete GPS equipments, which degrade the quality of the services, will be replaced by state-of-the-art GNSS receivers in 2007. With the new GPS+GLONASS combined receivers the country will be covered with GLONASS corrections as well, helping GNSS surveyors to be more productive working on field. In order to cover the whole country an additional 15 receivers should be installed, this will be done by 2008. The expected average station separation distance will be 70 km.

In 2004 the operation of the GNSS Service Centre started at the FÖMI Satellite Geodetic Observatory. The Centre is responsible for the development and maintenance of the active network and for the provision of real-time GNSS correction services and RINEX data to the user community. In 2006 the GNSMART software package of the Geo++ company was purchased and installed. During the test phase, by mid-2007 the DGPS and networked RTK data streams are provided free of charge. The streams are available on the Internet, fully exploiting the NTRIP technology. The users can access the corrections through GPRS/HSDPA services of the Hungarian mobile telecommunication service providers. A dedicated website

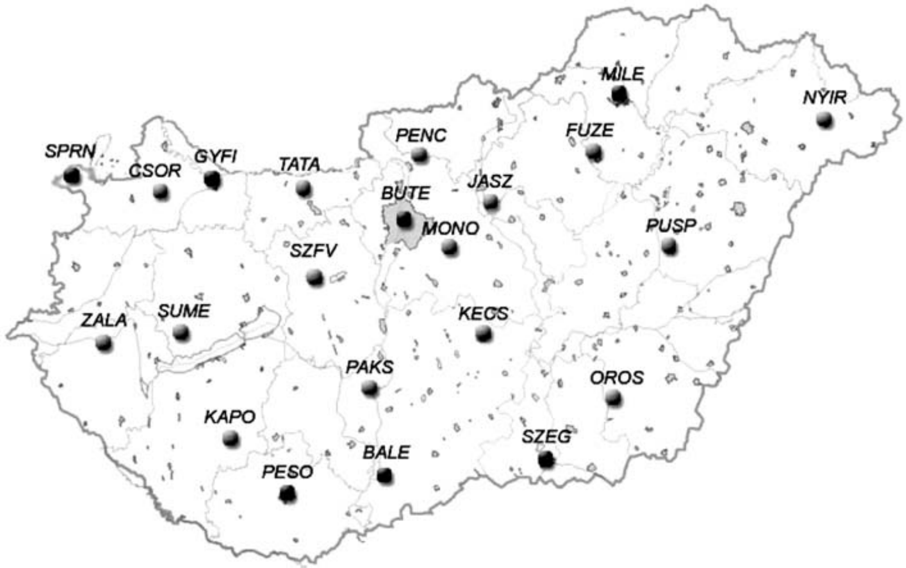

Fig. 1. Sites of Hungarian Active GPS Network

(www.gpsnet.hu) has been installed as information source and user interface. The users may get from there information on the status and quality of the GNSS network. The RINEX and virtual RINEX data service of the GNSMART software can also be accessed here.

The SGO GNSS Service Centre is also contributing to EUPOS. EUPOS is the co-ordination body of the GNSS real-time networks being installed in the Central and Eastern European countries. The intention is the harmonization of the GNSS services and promotion of cross-border co-operation both on the user and service provider levels.

The Service Centre also provides user support to access the national horizontal co-ordinate system (EOV) in post-processing and real-time positioning applications. Free transformation software (EHT^2) is available for post-processing applications. The real-time users are also supported with a cm-accurate transformation solution and database. The VITEL database is currently available for Leica and Sokkia rovers.

The accurate height transformation solution will be provided later.

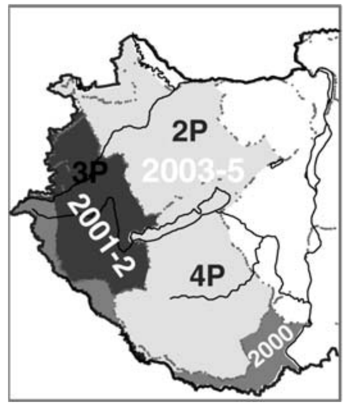

Fig. 2. The schedule of the EOMA densification

2. GPS heighting

Since 2000 the Hungarian Land Survey successfully applies the GPS-heighting technology (Kenyeres 1999), elaborated at the FÖMI Satellite Geodetic Observatory. The technology replaces the classical levelling at the IIIrd order densification of the Hungarian Levelling network (EOMA). The new GPS and geoid based network relies on the existing (or parallel determined) 1st and 2nd order levelling networks and covers those loops with evenly distributed benchmarks. Each settlement receives at least one levelling point, the average site distance is approximately 5 km.

The sea-level heights are derived from the GPS-determined ellipsoidal heights using the GPS-gravimetric geoid — the appropriately fitted gravimetric geoid solution. Compared to the traditional levelling this technology is much more cost effective as requires less benchmarks, quicker measurement and processing cycle. The densification work has been completed in 2005. About 900 levelling benchmarks have been determined with the GPS/geoid technology. Based on the positive experiences the work will be extended to the whole country in order to set up and integrated GPS-leveling network for the future GNSS heighting applications.

3. EUREF Analysis Centre

Since December 2001 the FÖMI Satellite Geodetic Observatory (SGO) is running a EUREF Local Analysis Centre (LAC). The SGO LAC is routinely processing 25 EPN (EUREF Permanent Network) and 22 Hungarian sites. The processed subnetwork concentrates to the Central and Eastern European region. The number of analyzed sites is continuously grow, when new stations are installed. The weekly subnetwork solutions are submitted to the EPN Combination Centre acting at the BKG Frankfurt, Germany.

FÖMI SGO is also contributing to EUREF with the analysis of the EPN coordinate time series. We compute and eliminate the offsets, outliers present in the time series in order to improve the kinematic quality (site velocities) of the permanent network. The offset and outlier database have been provided to the IGS supporting the realization of the new ITRF2005 reference frame.

Noise and harmonic analysis of the EPN time series is also routinely performed. All results are displayed on the EPNCB website (www.epncb.oma.be).

Since 2000 Ambrus Kenyeres is a member of the EUREF Technical Working Group.

4. Accredited calibration laboratory

The K-GEO Accredited Calibration Laboratory (acting at the FÖMI SGO) has been established in 2000, when the Hungarian Accreditation Board entitled the Laboratory to perform calibration of geodetic EDM (Electrooptical Distance Measurement) equipments. The main 'tool' of the calibration laboratory is the Gödöllő Standard Baseline. It has been measured in 1987 and 1999 with the Väisälä-interferometer by the Finnish Geodetic Institute. The differences between the two measurements at the underground and user markers are in the range of 0.01 mm and 0.1 mm, respectively. Following its excellent performance the Hungarian Office of Measures declared the Gödöllő Standard Baseline to National Geodetic Etalon of Length, which means that the calibration of all EDMs must be traced back to this baseline.

In 2004 the Hungarian Accreditation Board has been re-entitled the K-GEO Calibration Laboratory to perform calibration of geodetic EDM (Electrooptical Distance Measurement) equipments and geodetic GPS equipments. The calibration of EDM is being done on the Gödöllő Standard Baseline. The GPS calibrations are performed in a micro calibration network, installed on the roof of the Observatory's main building.

References

Ádám J, Bányai L, Borza T, Busics Gy, Kenyeres A, Krauter A, Takács B eds 2004: Satellite positioning (in Hungarian). Műegyetemi Kiadó, Budapest

Baker T, Bruyninx C, Francis O, Hinderer J, Ihde J, Kenyeres A, Makinen J, Rohde H, Simek J, Wilmes H 2003: Development of an European Combined Geodetic Network (ECGN). IUGG Abstract, Volume G05, 2003, Sapporo, Japan

Borza T, Kenyeres A, Frey S 2004: GNSS Activities at the Satellite Geodetic Observatory, with Emphasis on the Hungarian GBAS development. Second Galileo Conference for an Enlarged Europe, Budapest, Hungary

Fejes I 2003: The concept of the National EUPOS Service Centres. Presentation at the 2nd EUPOS Steering Committee Meeting, Riga, Latvia

Fejes I, Milev G, Rosenthal G, Vassileva K 2004: EUPOS – planning a regional ground based GNSS infrastructure in Central Europe. Paper presented at the Second Galileo Conference for an enlarged Europe, Budapest, Hungary

Grenerczy Gy 2004: The motion of Adria and its effect on the Pannonian basin. *Reports on Geodesy*, 2(69), 73–80.

Grenerczy Gy, Kenyeres A 2003: Velocity fields from EPN improved time series analysis and CEGRN campaigns: comparison, combination, interpretation, IUGG Abstract Volume G05, Sapporo, Japan

Grenerczy Gy, Kenyeres A 2006: Crustal deformation between Adria and the European Platform from space geodesy. In: The Adria Microplate: GPS Geodesy, Tectonics, and Hazards, N Pinter, G Grenerczy, J Weber, S Stein, D Medak eds, Springer, Dordrecht, 321–334.

Grenerczy Gy, Sella G, Stein S, Kenyeres A 2005: Tectonic Implications of the GPS Velocity Field in the Northern Adriatic Region. *Geophys. Res. Lett.*, 32, L16311.

Horváth T 2006a: EUREF Permanent Network Resources for Real-Time GNSS Activities. Presentation at the "Streaming GNSS data via Internet" Ntrip Symposium and Workshop, Frankfurt am Main, Germany

Horváth T 2006b: ITS and Ground Based GNSS Augmentation Systems. Poster presented at "On Safe Roads in the XXI. Century, 4th Conference" 2006, Budapest, Hungary

Horváth T 2006c: Routine network operation and quality/integrity indicators. Presentation at the 2nd Meeting of the EUPOS WG on System Quality, Integrity and interference Monitoring (SQII), Budapest, Hungary

Ihde J, Baker T, Bruyninx C, Francis O, Amalvict M, Kenyeres A, Makinen J, Shipman S, Simek J, Wilmes H 2005: Development of a European Combined Geodetic Network (ECGN). *J. Geodyn.*, 40, 450–460, doi:10.1016/j.jog.2005.06.008

Kenyeres A 1999: Technology Development for GPS-heighting in Hungary. In: Proceedings of the 5th International Seminar on GPS in Central Europe, Penc, Hungary. *Reports on Geodesy*, No. 5(46), 89–96.

Kenyeres A, Bruyninx C 2004: EPN coordinate Time Series Monitoring for Improved Reference Frame Maintenance. *GPS Solutions*, Vol. 8, No. 4, 200–209.

Kenyeres A, Bruyninx C 2006: Noise and Periodic Terms in the EPN Time Series. Paper presented at the GRF2006 Symposium, Munich (paper submitted to the proceedings)

Kenyeres A, Borza T, Virág G 2002: The HUNREF2002 Campaign: Re-establishment of the EUREF Network in Hungary. Paper presented at the EUREF Annual Symposium, Toledo, Spain

Kenyeres A, Bruyninx C, Carpentier G 2003: Consistency Analysis of the EPN Time Series for Improved Velocity Estimation. IUGG Abstract Volume G05, Sapporo, Japan

Pesec P, Fejes I 2004: CERGOP-2/Environment, summary of the first year. Solicited paper, presented at the EGU 1st General Assembly G11. Nice, France. *Reports on Geodesy*, 2(69), 105–115.

Rosenthal G, Fejes I 2006: EUPOS – Developing a Full Scale Accuracy Ground Based Regional GNSS Infrastructure. Presentation at the UN/Zambia/ESA Regional Workshop on the Application of Global Navigation Satellite System Technologies for Sub-Saharan Africa, Lusaka, Zambia

Szentpéteri L, Borza T, Fejes I, Frey S 2003: GNSS infrastructure in Hungary – a status report. Galileo for an Enlarged Europe. 1st Conference for EU Candidate Countries, Warsaw, Poland

II. Commission 2 (Gravity Field) Gravimetry, gravity field modelling and geoid determination

(Gábor Papp, Geodetic and Geophysical Research Institute and Lajos Völgyesi, Budapest University of Technology and Economics)

A new method and software has been made and tested in the Hungarian part of the UEGN-2002 network. Making a suitable base gravity network and providing proper data for UEGN-2002 has required some experimental measurements and many important investigations. In case of precise gravity measurements the determination of the vertical gradients real value is necessary. Using the real or normal value of vertical gradients may give 6–10 μGal differences of height reductions depending on the reference height of the instruments. Taking into account the periodical errors of LCR gravimeters reading device is very important; neglecting the periodical errors may give 25–30 μGal errors of Δg between measured points depending on the instrument (in case of instruments LCR 963 and 1919 it was found to be below 2 μGal). The accuracy of the parameter estimation increases with fewer periods estimated. Using always a full parameter set for the estimation of the periodical correction is suggested. Based on the investigations the reliability of the MGH-2000's adjusted data is significantly better, than the reliability of the European network's one (probably because of the different reliabilities of the different European countries' gravity data) (Völgyesi et al. 2007). According to our plans, after the final adjustment of UEGN-2002 we are going to readjust the Hungarian MGH-2000 taking into account the adjusted g values of UEGN-2002.

In the framework of EU5 EVG1-2001-00061 OASYS project a local gravimetric network was established on a hazardous landslide area of Hungary, near the Danube (Papp et al. 2004). Based on the gravimetric data measured here an effort was made to indicate the geological connection between the steep loess wall and the underlying sedimentary structures. For the correct interpretation an accurate computation method of the so called complete Bouguer gravity anomalies was implemented. It involves the joint least-squares estimation of the density of topographical masses and the terrain correction. The results were validated by lab determination of the surface density from rock samples (Papp 2006).

The gravity field of the Earth is a resultant of three different fields, the gravitational, the centrifugal and the tidal one. Time variation of each component causes the time variation of gravity. At present the measurements by gravimeters reach so high accuracy that non tidal variations of gravity need to be taking into consideration. The nGal sensitivity of the most modern superconducting gravimeters may require taking into consideration of some special new gravity effects. Two peculiar effects were discussed (Völgyesi 2005, 2006). The supposed time variation of gravitational constant (suggested by the Nobel prise winner physicist Dirac in 1937) may cause the decreasing of gravity by the value of 0.1 μGal/year. The other effect is the supposed expanding Earth (suggested by the Hungarian geophysicist Egyed in 1970) which may cause the decreasing of gravity by the value of 0.2 μGal/year.

The application of polyhedron volume elements (PVEs) can provide a more realistic geometrical description of the topographic surface than the description made by rectangular parallelepiped (prism) models. The use of density models based on PVEs provides smoother and more realistic field structure for the second derivatives of the disturbing potential than the ones provided by prism model. An effort (Benedek 2004) was made to compute synthetic vertical gravity gradients from a polyhedron model of the topography the resolution of which was 10 m $\times$ 10 m near to the computation points. The results were compared to the data obtained from the prism model of the topography and the in situ VG measurements. Apart from a shift the field structure generated by the polyhedrons fit to the VG measurements sufficiently. If the calculation level is close to the surface of topography, then the accuracy of gravity related quantities (e.g. gravity anomaly, gravity disturbance) can be improved significantly by a detailed description (e.g. by polyhedrons) of this surface in the vicinity of the calculation point. The improvement is in the range of a few cm in terms of geoid undulation and it shows a clear correlation with the height.

On a local area in Canada the convergence between the geoid solutions obtained from astronomical deflections and gravimetric deflections were investigated (Papp et al. 2004). The gravimetric deflections were determined by the Vening-Meinesz (VM) integral solved by spectral convolution technique using different grids of interpolated gravity anomalies. Because of the adaptive grid making procedure the gravimetric deflections could be computed at those locations where the astronomical deflections were known. This way the same network geometry for the solution of astronomical levelling was provided. From both type of deflection data geoid undulations were computed by least-squares adjustment. The geoid undulations, however, were not compared but rather the *a posteriori* standard deviations of the unit weight observable were analysed. The correlations between the corrections of the observables and 1. vertex lengths of the network and 2. the so called variability parameter of the gravity field were also determined. The results show that the spectral solution of the VM integral provides a $\pm$(2–3) cm loss of information/accuracy related to what can be obtained from the astronomical deflections even if the point density of the gravity data is about 2 km^2/point.

In the framework of IAG SG2.2 a probabilistic inversion method was developed and tested in a mining area of Western Australia (Strykowski et al. 2005). It is based on the iterative statistical analysis of the misfit between the observed gravity field and the superimposed response of a number of elementary prismatic sources (rectangular parallelepipeds). The *a priori* model should rely on some *a priori* geological information giving the approximate 3D extension of the source. The method is applicable if the gravitational effect of the source body to be determined can be isolated from the regional gravity signal and from the signal of other local sources. For this purpose a so called multi-scale edge technique is used.

Looking forward to accessing the on board gradiometer data of GOCE the possibility of their geophysical inversion was investigated in the Alps-Pannonian-Carpathians region (Benedek and Papp 2006). Here a detailed 3D model of the lithosphere is available and its improvement is desired. The spectral and space domain investigations show that it will be possible to give a reliable estimation for the density contrast on the Moho discontinuity. For this purpose the gravitational effect (the second derivatives of the disturbing potential T) of both the topographic masses and the well explored Neogene-Quaternary sediments have to be removed from the satellite observations. The amplitude of the gravitational signal generated by the Moho and the surface topography may reach 1 Eötvös unit at satellite altitude. The effect of the sedimentary complex is less by about one order of magnitude. The forward computations, however, have to be performed in a global co-ordinate system, because the planar approximation may introduce about 10% systematic distortion of the simulated gravitational gradients.

The investigation of phenomena, influencing the short time variation of gravity, has gained importance with the increasing accuracy of gravimeters. Vertical surface movements, attributable to two effects: compaction of sediments, on the one hand, and structural movements, on the other in the young sedimentary Pannonian Basin were studied. In most of the deep sedimentary regions positive correlation can be found between sediment thickness and subsidence. As a consequence of subsidence, observation points on the surface get into a different equipotential level of the Earth's gravity field. Calculating the effects of the vertical surface movements, determined by repeat levelling, for a 10-year time span, the variation of gravity in general should be about 3 μGal, but at special places it may reach as much as $10 - 20$ μGal (Völgyesi et al. 2004a, 2005b).

Two case studies were considered where gravity field changes were detected resulting from water mass variations. The first case is an urban water reservoir where the maximum daily change of water is 40000 m^3. The 3D model of the water mass allowed us to build an accurate polyhedral model of the variation of mass changes of the water. This mass density variation model made it possible to compute and compare variations of various gravitational field functionals. Gravity and full gravity gradient tensor changes were computed on a regular grid for the model area. Gravity changes were also compared with actual gravity field measurements made with two LaCoste & Romberg (LCR) gravimeters. The measured gravity change was nearly 30 mGal relative to 5000 m^3 water mass. A good agreement was found between the computed and measured changes. The second case is the water level fluctuations of the Danube River in Budapest. In this case also modelling and measurements were compared. We found the gravitational change to be very sensitive to the actual distance of the point from the river bank (Völgyesi and Tóth 2004, Tóth et al. 2004).

Measured vertical gravity gradients usually quite differ from the normal value of 0.3086 mGal/m. Generally the changing of vertical gradient is rather big, up to a few 10 cm height above the ground and can be taken into consideration as a second order function. The vertical gradients can be used for the conversion of measured gravity from the reference height of an instrument to a bench mark. So the vertical gradients should be determined as high accuracy as it possible and using the normal value of vertical gradient is not sufficient for this purpose (Csapó and Völgyesi 2004a, 2004b).

The efficiency of the application of soft computing methods like Artificial Neural Networks (ANN) or Support Vector Machines (SVM) depends considerably on the representativeness of the learning sample set employed for training the model. In this study a simple method based on the Coefficient of Representativity (CR) is proposed for extracting representative learning set from measured geospatial data. The method eliminating successively the sample points having low CR value from the dataset is implemented in Mathematica and its application is illlustrated by the data preparation for the correction model of the Hungarian gravimetrical geoid based on current GPS measurements (Paláncz et al. 2006).

A method was developed, based on integration of horizontal gradients of gravity W_{zx} and W_{zy} to predict gravity and gravity anomalies at all points of a torsion balance network. Test computations were performed in a typically flat area where both torsion balance and gravimetric measurements are available. There were 248 torsion balance stations and 1197 gravity measurements on this area. 18 points from these 248 torsion balance stations were chosen as fixed points where gravity are known from measurements and the unknown gravity values were interpolated on the remaining 230 points (Völgyesi et al. 2004b, 2005a, 2007a). Comparison of the measured and the interpolated gravity values indicates that horizontal gradients of gravity give a possibility to determine gravity values from torsion balance measurements by mGal accuracy on flat areas. A correlation can be found comparing the surface map of differences between the measured and the interpolated gravity values by the topography of the test area. The biggest errors can be found at the test area, where the biggest height differences are. In case of a hilly area accuracy of interpolation would probably be increased by taking into consideration the real vertical gradient values instead of the normal one.

In the 20th century more than 60000 torsion balance measurements were made in Hungary. At present efforts are made to rescue the historical torsion balance data; today approximately 30000 torsion balance measurements are available for further processing in computer database. Previously only the horizontal gradients of gravity were used by geophysicists, but there is a good possibility in geodesy to interpolate deflections of the vertical, and to compute geoid heights from curvature gradients of gravity. A new practical computation of astronomical levelling is suggested, and test computations were performed. The standard deviations of geoid height and deflection of the vertical differences at checkpoints were about $\pm 1-3$ cm, and $\pm 0.6''$ respectively; which confirm that torsion balance measurements give good possibility to compute very precise deflections of the vertical and local geoid heights at least for flat areas (Völgyesi 2005).

A new method was worked out for the inversion reconstruction of gravity potential. This method gives a possibility to determine the potential function and all of its important derivatives using the common inversion of gravity gradients and the first derivatives of potential. Gravity gradients can be originated from Torsion balance measurements, while the first derivatives of potential can be derived from the deflections of the vertical data. Different fields having great importance can be originated from this reconstructed potential function at any points of the investigated area. Advantage of this method is that the solution can be performed by a significantly overdetermined inverse problem. Test computations were performed for the inversion reconstruction of gravity potential. There were 248 torsion balance measurements and 13 points where the deflections of the vertical are known in the test area. This inversion algorithm is rather stable. Gravity potential, the first and the second derivatives of the potential were determined for the test area by this suggested method. This method gives a good possibility for a useful geodetic application; deflections of the vertical based on torsion balance measurements can be determined for the whole area for each torsion balance stations (Dobróka and Völgyesi 2005a, 2005b).

Almost 100,000 surface gravity gradient measurements are existing in Hungary over an area of about 45000 km^2. These measurements are a very useful source to study the short wavelength features of the local gravity field, especially below 30 km wavelength. The aim was to use these existing gravity gradient data in gravity field modeling together with gravity anomalies. Therefore the gravity anomalies from horizontal gravity gradients using the method of least-squares collocation were predicted. The cross-covariance function of gravity gradients and gravity anomalies was estimated over the area and a suitable covariance model was estimated for the prediction. The full covariance matrix would require about 15 GB storage, however, the storage requirement can be reduced to about 300 MB by inspecting the structure of the cross-covariance function. Using sparse linear solvers the computation proved to be manageable, and the prediction of gravity anomalies for the whole area was performed. The results were evaluated at those sites where Δg values were known from measurements in the computational area (Tóth and Völgyesi 2007).

Torsion balance measurements in Hungary were checked by least-squares collocation. The methodology was the so-called "leave-one-out" prediction of horizontal gravity gradients. The gradient vectors determined by prediction have been compared to original ones and the differences were tested against 3-sigma confidence ellipses. The method was successfully tested on a selected subset of torsion balance measurements and only few possible outliers have been detected. These computations were started with the purpose of utilizing a very large number of torsion balance measurements in view of a new Hungarian geoid solution (Tóth and Völgyesi 2005).

The forthcoming GOCE mission will produce gravity gradient data at satellite altitude and consequently contribute to the more accurate determination of the gravity field. There are different data processing strategies in order to obtain updated gravity field information from these measurements, but most of them are based on the spherical harmonic expansion of the gravity field. An alternative approach would be the direct use of the GOCE data in the space domain. In this case we need formulas for transferring gravity gradients and other gravity field information in spherical approximation between different height levels. The well known upward/downward continuation problem of second vertical gravity gradients has been already solved. Formulas for the other gravity gradients are discussed. The proposed approach was to use these gravity gradients in two combinations with special kernel functions. These kernel functions are infinite sums of Legendre functions of orders 0, 1 and 2. As a continuation of our previous study, several practical aspects of the proposed approach are addressed. First, the practical use of formulas in gravity field determination makes it necessary to evaluate these kernel functions in a band-limited setup. Second, the integration radius of gravity gradient data depends on the particular data combination, bandpass filter and altitude. Third, the upward/downward continuation problem can be extended to other gravity field functionals with appropriate kernel functions. These issues are investigated in the present paper in the context of GOCE (Tóth et al. 2006a, 2006b).

CHAMP and GRACE global geopotential models EIGEN-3p, EIGEN-GRACE01S, GGM01S and GGM01C are compared with terrestrial gravity field data in Hungary. The methods used for comparison were direct comparison with gravity anomalies and the reference geoid solution method. Free-air gravity anomalies were interpolated on a 1×1.5 grid covering Hungary. In the second method these geopotential models were used to compute gravimetric geoid solutions and the results were compared with GPS/leveling data from EUVN campaign and the Hungarian GPS network (Tóth and Rózsa 2005, 2006).

References

Benedek J 2004: The application of polyhedron volume element in the calculation of gravity related quantities. In: Proceedings of the 1st Workshop on International Gravity Field Research, B Meurers ed., Graz 2003, *Öster. Beitr. Meteorologie und Geophys.*, 31, 99–106.

Benedek J, Papp G 2006: Geophysical Inversion of On Board Satellite Gradiometer Data: A Feasibility Study in the ALPACA Region, Central Europe (accepted for publication in IAG Symp. Series, IGFS2006, Istanbul)

Csapó G, Völgyesi L 2004a: New measurements for the determination of local vertical gradients. *Reports on Geodesy*, 69, No.2, 303–308.

Csapó G, Völgyesi L 2004b: New measurements for the determination of local vertical gradients (in Hungarian). *Magyar Geofizika*, 45, No.2, 64–69.

Dobróka M, Völgyesi L 2005a: Inversion reconstruction of gravity potential based on torsion balance measurements (in Hungarian). *Geomatikai Közlemények*, 8, 223–230.

Dobróka M, Völgyesi L 2005b: Inversion reconstruction of gravity potential based on gravity gradients. A joint meeting of the IAG, IAPSO and IABO; Dynamic Planet 2005, Cairns, Australia

Paláncz B, Völgyesi L, Zaletnyik P, Kovács L 2006: Extraction of representative learning set from measured geospatial data. In: Proceedings of the 7th International Symposium of Hungarian Researchers, Budapest, 295–305. ISBN 963715454X

Papp G 2006: Simultaneous Determination of Terrain Correction and Local Average Topographic Density (accepted for publication in IAG Symp. Series, IGFS2006, Istanbul)

Papp G, Benedek J, Nagy D 2004a: On the information equivalence of gravity field related parameters – A comparison of gravity anomalies and deflection of vertical data. In: Proceedings of the 1st Workshop on International Gravity Field Research, Graz 2003, B Meurers ed. *Öster. Beitr. Meteorologie und Geophys.*, 31, 71–78.

Papp G, Benedek J, Kalmár J 2004b: Gravity investigations on Dunaföldvár test area. In: Landslide monitoring of loess structures in Dunaföldvár. Gy Mentes, I Eperné P eds, Hungary, Sopron, 37–46.

Rózsa Sz, Tóth Gy 2005: The determination of the effect of topographic masses on the second derivatives of gravity potential using various methods. IAG Symposia Vol 130, Dynamic Planet, P Tregoning, C Rizos eds, Springer, 2007, 391–396.

Strykowski G, Boschetti F, Papp G 2005: Estimation of the mass density contrasts and the 3D geometrical shape of the source bodies in the Yilgarn area, Eastern Goldfields, Western Australia. *J. Geodyn.*, 39, 444–460.

Tóth Gy 2005: The gradiometric-geodynamic boundary value problem. IAG Symposia Vol. 129, Gravity, Geoid and Space Missions, C Jekeli, L Bastos, J Fernandes eds, Springer, 352–357.

Tóth Gy, Földváry L 2005: Effect of geopotential model errors on the projection of GOCE gradiometer observables. IAG Symposia Vol. 129, Gravity, Geoid and Space Missions, C Jekeli, L Bastos, J Fernandes eds, Springer, 72–76.

Tóth Gy, Merényi L 2005: Torsion balance measurement data for gravity map improvement (in Hungarian). *Geomatikai Közlemények*, 8, 209–215.

Tóth Gy, Rózsa Sz 2006: Comparison of CHAMP and GRACE geopotential models with terrestrial gravity field data in Hungary. *Acta Geod. Geoph. Hung.*, 41, 171–180.

Tóth Gy, Völgyesi L 2005: Investigation of Hungarian torsion balance measurements by prediction. *Reports on Geodesy, Warsaw University of Technology*, 73(2), 277–284.

Tóth Gy, Völgyesi L 2007: Local gravity field modeling using surface gravity gradient measurements. Dynamic Planet 2005, Cairns, Australia, P Tregoning, C Rizos eds, Springer-Verlag Berlin Heidelberg; Series: IAG Symposia, Vol. 130, 424–429.

Tóth Gy, Völgyesi L, Cerovsky I 2004: Modelling time variation of gravity gradients due to water level fluctuations. *Reports on Geodesy, Warsaw University of Technology*, 69(2), 309–314.

Tóth Gy, Földváry L, Tziavos I N, Ádám J 2006a: Upward/downward continuation of gravity gradients for precise geoid determination. *Acta Geod. Geoph. Hung.*, 41, 21–30.

Tóth Gy, Földváry L, Tziavos I N 2006b: Practical Aspects of Upward/Downward Continuation of Gravity Gradients. In: Proceedings of the 3rd GOCE User Workshop, ESA SP-627

Völgyesi L 2005a: Deflections of the vertical and geoid heights from gravity gradients. *Acta Geod. Geoph. Hung.*, 40, 147–159.

Völgyesi L 2005b: Some possible physical reason of time variation of Earths gravity field (a possible proof of time change of gravitational constant). A joint meeting of the IAG, IAPSO and IABO; Dynamic Planet 2005, Cairns, Australia

Völgyesi L 2006: Some possible physical reason of time variation of Earths gravity field (a possible proof of time change of gravitational constant). *Periodica Polytechnica Civ. Eng.*, 50(2), 161–170.

Völgyesi L, Tóth Gy 2004: Modelling gravity gradient variation due to water mass fluctuations. Gravity, Geoid and Space Missions GGSM 2004. IAG International Symposium Porto, Portugal, C Jekeli, L Bastos, J Fernandes eds, Springer Verlag Berlin, Heidelberg, New York; Series: IAG Symposia, Vol. 129, 364–368.

Völgyesi L, Szabó Z, Csapó G 2004a: Relation between the geological conditions and vertical surface movements in the Pannonian basin. Gravity, Geoid and Space Missions GGSM 2004. IAG International Symposium Porto, Portugal, C Jekeli, L Bastos, J Fernandes eds, Springer Verlag Berlin, Heidelberg, New York; Series: IAG Symposia, Vol. 129, 358–363.

Völgyesi L, Tóth Gy, Csapó G 2004b: Determination of gravity anomalies from torsion balance measurements. Gravity, Geoid and Space Missions GGSM 2004. IAG International Symposium Porto, Portugal, C Jekeli, L Bastos, J Fernandes eds, Springer Verlag Berlin, Heidelberg, New York; Series: IAG Symposia, Vol. 129, 292–297.

Völgyesi L, Tóth Gy, Csapó G 2005a: Determination of gravity field from horizontal gradients of gravity. A joint meeting of the IAG, IAPSO and IABO; Dynamic Planet 2005, Cairns, Australia

Völgyesi L, Csapó G, Szabó Z 2005b: Relation between time variation of gravity and pannonian sediment thickness in the Carpathian basin. *Reports on Geodesy, Warsaw University of Technology*, 73(2), 255–262.

Völgyesi L, Tóth Gy, Csapó G 2007a: Determination of gravity field from horizontal gradients of gravity. *Acta Geod. Geoph. Hung.*, 42, 107–117.

Völgyesi L, Földváry L, Csapó G 2007b: New processing of gravity network measurements in Hungary. Dynamic Planet 2005, Cairns, Australia, P Tregoning, C Rizos eds, Springer-Verlag Berlin Heidelberg; Series: IAG Symposia, Vol. 130, 202–207.

III. Commission 3 (Earth Rotation and Geodynamics)

1. Geodynamics of the solid Earth-Activities at the Geodetic and Geophysical Research Institute

(László Bányai, Gyula Mentes, Péter Varga, Geodetic and Geophysical Research Institute)

The main research activities of the Geodetic and Geophysical Research Institute (GGRI) in the field of geodynamics are:

1. Monitoring geodynamical processes in geodynamical observatories
2. Theoretical investigations in tidal research
3. Monitoring local geodynamical movements and deformations
4. Study of displacement fields of the Earth surface
5. Temporal variations of earth orientation parameters (EOP)

1. Quartz tube extensometers with electrical recording were continuously operating in the Geodynamical Observatory Sopronbánfalva (Sopron) and in Bakonya (Pécs). The extensometers in the Mátyáshegy Observatory (Budapest) were renewed and they are also operating since 2004 continuously (Mentes 2005, 2006, Mentes et al. 2006b).

In co-operation with the Geophysical Institute of the Slovak Academy of Sciences the extensometer in Vyhne (Slovakia) was further developed and together with the Hungarian instruments it was used for recording Earth tides and recent tectonic movements of the Pannonian Basin (Bednarik et al. 2003).

Atmospheric tide was recorded by the microbarograph developed in the Geodetic and Geophysical Research Institute to investigate the connection between deformations measured by extensometers and the atmospheric pressure variations (Mentes 2004a).

2. New mathematical methods were developed to eliminate the influence of the air pressure and temperature variations to the extensometric measurements. The

stability of the observatories in Hungary was compared using the developed methods (Mentes and Eper-Pápai 2006, Mentes et al. 2006a)

3. The movements of the Mecsekalja-fault were investigated by borehole tiltmeters and geodetic methods: GPS, precise levelling and electro-optical distance measurements (Mentes 2003a, Bányai 2003). Local disturbing effects influencing the accuracy of borehole tilt measurements were also studied in detail (Mentes 2003b, 2004b). In the vicinity of the fault an aquifer system formed by granite rocks was monitored by pore pressure measurements in wells. Data series from different levels of wells were analysed and tidal responses were determined in order to apply them for detailed structural investigations from hydrogeological and hydrodynamical points of view (Rotár-Szalkai et al. 2006).

4. Study of displacement fields of the Earth surface derived from geodetic observations are useful for the study of properties of the past and future potential earthquakes. With the use of Kostrov equation the sum of seismic moments was estimated for different seismic source zones characterized by variant deformation speeds. Displacement fields connected to seismo-tectonic activity for the intraplate part of Central Europe should be estimated with the use of strain observations (Varga et al. 2004b, 2004c). For this purpose however in case of GPS measurements 10–8 relative accuracy is needed on the base 30–40 km what is not possible at present. The necessity of such a theoretical work is connected with the very long (of the order of one millennium) return period of destroying events (M$\geq$6.5) of this region (Varga and Mentes 2006). It was shown that in the Pannonian Basin the seismic rates are 10^{-7}–10^{-6}. These values were derived from the local earthquake catalogues of the area of Komárom, Dunaharaszti (near Budapest) and Kecskemét (Varga et al. 2005a, 2005c).

5. Temporal variations of earth orientation parameters (EOP) were investigated in a band of periods sub diurnal (Schuh et al. 2003) to decadal (Varga et al. 2005b, 2006b). It was found that a seismic event (even the biggest one) is not able to influence the rotation speed of the Earth. It is likely that the seismicity does not generate measurable length of day (LOD) anomalies. On contrary: the variations of LOD have influence on seismic activity. This fact is expressed by the correlation between the annual number of the earthquakes with M>7 and LOD (Varga et al. 2005b). The variation of intensity of geomagnetic field in geological time-scale was also investigated (Schreider et al. 2005).

At present, we can accept that the values between 19.5 and 17.5 h are giving realistic estimation for the rotation period in the epoch just after of Earth formation. This means that during the whole history of the Earth the LOD has changed only $\approx$30%. The corresponding change in the rotational energy is more than 50%. Most of this rotational energy loss ($\approx 1.7 \times 1029$ J) is connected with Phanerozoic, i.e. with 13% of the total lifetime of our planet. What was the impact of this energy loss into the development of the Earth and of the Earth-Moon system? This question should be answered by future investigations (Varga 2006a, Varga et al. 2006a).

With the use of a new description of the moment of inertia (C) it was shown that 0.5 percent of the temporal variation of initial C value can be ascribed to mass redistribution within the Earth. In other words: only minor changes occurred during this time interval in the main features of the inner structure of our planet which was practically finished at the very beginning of the history of the Earth (Varga et al. 2004a). A generalized form of MacCullagh equation was obtained by Varga (2005). Denis et al. (2006) gives a mean value of the growth of the inner core. Varga (2006b) applied the differential equation system of elastic deformation of a sphere to the small Saturn's moon Enceladus to describe volcanic activity of this celestial body.

References

Bányai L 2003: Geodynamic investigations along the Mecsek-fault in Hungary using precise geodetic devices. In: Proceedings. 11th International Symposium on Deformation Measurements. Publication No. 2. Geodesy and Geodetic Applications Lab. Dept of Civil Engineering, Patras University, 65–70.

Bányai L 2005: Results in physical geodesy. *Acta Geod. Geoph. Hung.*, 40, 307–316.

Bednárik M, Brimich L, Dudášová V, Gubanová G, Kohút I, Latynina L A, Mentes Gy 2003: Interpretation of the extensometric measurements at the tidal station in Vyhne. The 5th Slovak Geophysical Conference, Abstracts. *Contributions to Geophysics and Geodesy*, 33, 75.

Denis C, Rybicki K R, Varga P 2006: Secular change of LOD associated with a growth of the inner core. *Astronomisches Nachrichten*, 327, 4, 309–313.

Mentes Gy 2003a: Monitoring local geodynamical movements and deformations by borehole tiltmeters in Hungary. In: Proceedings of the 11th FIG Symposium on Deformation Measurements, Santorini, Greece, 43–50.

Mentes Gy 2003b: Local effects disturbing the monitoring of tectonic movements of the Mecsekalja fault by shallow deep borehole tiltmeters in Hungary. *Acta Geod. Geoph. Hung.*, 38, 327–335.

Mentes Gy 2004a: Atmospheric tide obtained by the microbarograph developed at the Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences. *Acta Geod. Geoph. Hung.*, 39, 39–48.

Mentes Gy 2004b: Investigation of the stability of borehole tiltmeters working in unpacked boreholes inundated with ground water. *Acta Geod. Geoph. Hung.*, 39, 49–54.

Mentes Gy 2005: Results of tidal research. *Acta Geod. Geoph. Hung.*, 40, 293–305.

Mentes Gy 2006: Extensometric measurements in Hungary. Abstracts of the Workshop on International Gravity Field Research, Smolenice, Slovakia, CD, Geophysical Research Institute of the Slovakian Academy of Sciences, Bratislava, 69–78.

Mentes Gy, Eper-Pápai I 2006: Investigation of meteorological effects on strain measurements at two stations in Hungary. *J. Geodyn.*, 41, 259–267.

Mentes Gy, Berta Zs, Eper-Pápai I 2006a: Stability investigation of the new three-dimensional extensometric observatory in Bakonya, Hungary. *Marées Terrestres Bulletin d'Information, Bruxelles*, 141, 11253–11262.

Mentes Gy, Eper-Pápai I, Kis M, Újvári G 2006b: New results of the extensometric measurements at Budapest observatory. *Marées Terrestres Bulletin d'Information, Bruxelles*, 141, 11263–11269.

Rotár-Szalkai Á, Eper-Pápai I, Mentes Gy 2006: Well level data analysis in Hungary near a fault region. *J. Geodyn.*, 41, 183–189.

Schreider A A, Schreider Al A, Varga P, Denis C 2005: Magnitude of geomagnetic field in the time- interval of chrons C1-M43. *Okeanology*, 45, 785–789.

Schuh H, Varga P, Seitz T, Boehm J, Weber R, Mentes Gy, Závoti J, Westerhaus M 2003: Sub-semidiurnal variations of the EOP observed by space geodesy compared with other geophysical phenomena. In: Proceedings of International Earth Rotation Service, N Capitaine ed., 95–99.

Varga P 2005: On the physical meaning of the zonal components of the geopotential. *J. Geodyn.*, 39, 569–577.

Varga P 2006a: Temporal variation of geodynamical properties due to tidal friction. *J. Geodyn.*, 41, 140–146.

Varga P 2006b: Volcanic activity and tidal heating of Saturn's moon Enceladus. *Marées Terrestres Bulletin d'Information*, 141, 11227–11234.

Varga P, Mentes Gy 2006: Strain data and seismicity, *Marées Terrestres Bulletin d'Information*, 141, 11287–11292.

Varga P, Engels J, Grafarend E 2004a: Temporal variations of the polar moment of inertia and the second degree geopotential. *J. Geodesy*, 78, 187–191.

Varga P, Bus Z, Kiszely M 2004b: Strain rates, seismic activity and its temporal variations within the Pannonian basin. *Reports on Geodesy*, 2(69), 149–156.

Varga P, Kiszely M, Bus Z 2004c: Study of the temporal variation in seismic activity within the Pannonian Basin. *Acta Geod. Geoph. Hung.*, 39, 327–338.

Varga P, Bus Z, Gribovszki K 2005a: Use of geodetic informations in seismology. *Reports on Geodesy*, 2(73), 61–66.

Varga P, Gambis D, Bus Z, Bizouard Ch 2005b: The relation between the global seismicity and the rotation of the Earth, Observatoire de Paris, Systémes de reference temps-espace UMR8630/CNRS, 115–121.

Varga P, Bus Z, Gribovszki K 2005c: Use of geodetic informations in eismology. In: Proceedings of CEI Workshop "Natural Risks: Earthquakes and Co-seismic Associated Risks", Bratislava, 184–189.

Varga P, Rybicki K R, Denis C 2006a: Comments on fast tidal cycling and the origin of the life. *ICARUS*, 180, 277–280.

Varga P, Gambis D, Bizouard Ch, Bus Z, Kiszely M 2006b: Tidal influences through LOD variations on the temporal distribution of earthquake occurences. In: "Journées 2005, Systémes de Réference Spatio-Temporels, Space Research Centre Polish Academy of Sciences, 233–236.

2. Research in the field of recent vertical movements

(István Joó, College of Geoinformatics, University of West Hungary)

At the last four years of Hungarian activity on recent vertical movements concentrated on the following two fields: creation an up-to-date new vertical movements digital map for the hole area of Carpathian Region, and moreover, analysis and modelling of movement velocities (v) with some geologo-geophysical characteristics as basement depth (D), gravity anomaly (G), terrestrial heat flow (H).

The remeasurements of national geodetic (levelling) poligon networks provide a data set on recent crustal movement rates. The study of recent vertical crustal movements data (Joó et al. 1979 and 1985) shows a detailed picture about the vertical movements in the Carpatho-Balkan Region.

Later a more detailed face on Carpathian Basin's vertical movements has been made by Joó (1995). This map shows a pronounced subsidence in the Pannonian

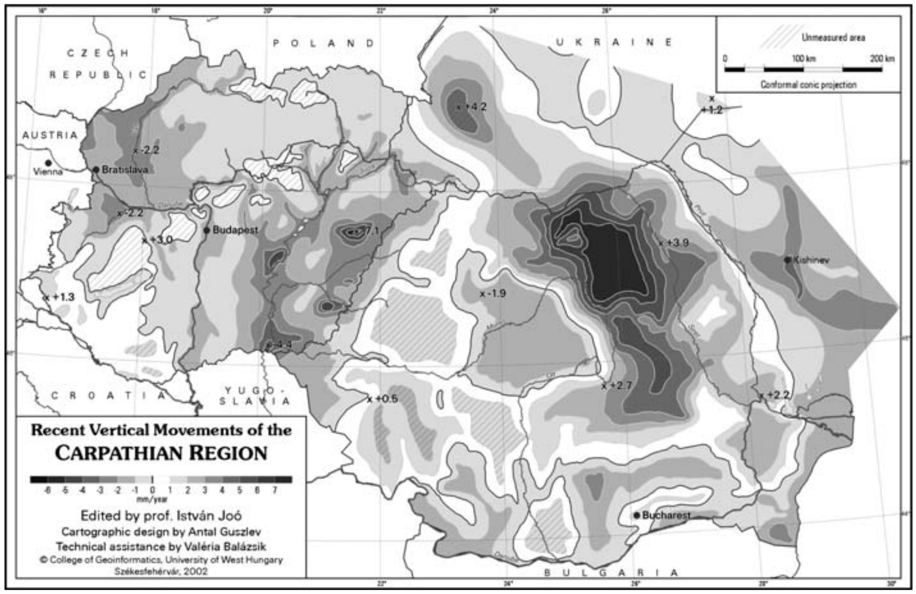

Fig. 3. Recent vertical movements of the Carpathian Region (edited by Joó)

Basin (Little Hungarian Plain and Great Hungarian Plain) with the velocity volumes of 4.0 mm/a till 7.1 mm/a. The uplift rates are from 1.6 mm/a (South-Western Hungary) till 3.0–4.0 mm/a at the area of Transdanubian Mountains.

The latest study produced a new map for the area of Carpathian Region (Joó 2006) (see the Fig. 3). The maximum uplift volumes are as follows:
– northern Western Carpathians; 4.2 mm/a and
– Eastern Carpathians 6.0–7.0 mm/a.

Coming back to the use of correlation — regression analysis on recent vertical crustal movements, short information is hereby given about the Hungarian activity in this respect.

This special research work began already more than ten years ago. The target of the study is to know more about the supposed correlations of velocity with selected characteristics (D, G, H).

There are two types of investigation: either along a precise levelling line or at a given territory.

The method: regression — correlation analysis and multivariable linear modelling.

The result can be: correlation coefficients and A, B, C (and so on) parameters. The experience shows the following:

— the influence of gravity anomaly can be high in the case, if the basement depth is $\geq 3.5 - 4$ km,

— in the same area, the influence of terrestrial heat flow can also be high,

— in some cases, the influence of basement depth can be higher than gravity (see south-eastern Hungary).

We also have some new results in connection with the use of quotients for the visualisation. Furthermore, we are expecting new results in the case, when using selected geologic layers (depth, thickness etc.).

References

Joó I 2004a: Result and problem in the investigation of recent vertical movements in the Carpathian region (in Hungarian). *Geodézia és Kartográfia*, 56, No.2, 12–19.

Joó I 2004b: Resolving into components the vertical movements's velocities and quotients according to geologo-geophysical acting (in Hungarian). *Geodézia és Kartográfia*, 56, No.10, 16–20.

Joó I 2006a: Possibility and problems of the Hungarian precise altitude measurements (in Hungarian). *Geodézia és Kartográfia*, 58, No.1, 5–12.

Joó I 2006b: Further contribution to the topic of Hungarian high precise levelling network (in Hungarian). *Geodézia és Kartográfia*, 58, No.8, 38–40.

Joó I 2006c: The recent vertical movements in the Carpathian Region. Crustal and lithospheric structure of the Carpathian Pannonian Region, geophysical perspective: Regional geophysical data on the Carpathian – Pannonian lithosphere; L Pospisil, and A Adam, American Association Petroleum Geologists (AAPG), AAPG Memoir 84, 651–697.

Joó I, Balázsik V, Guszlev A, Végső F 2006: Application of the new way "Resolving into Components the Velocities and Quotients" at the Investigation on Recent Vertical Movements (in Hungarian). *Geodézia és Kartoráfia*, 58, No.4, 17–23.

Komjáti G, Joó I, Balázsik V 2004: Investigation and modelling of the recent vertical movements int he southern part of the Great Hungarian Plain (in Hungarian). *Geodézia és Kartográfia*, 56, No.11, 10–17.

Pájer T, Joó I, Balázsik V 2004: Investigation on relationship of the recent vertical movement velocities whit three geologic characteristics in the surrounding area of the rivers Middle Tisza and Körös (in Hungarian). *Geodézia és Kartográfia*, 56, No.7, 3–15.

Papp B, Joó I, Balázsik V 2005: Investigation and modelling of the recent vertical movements in the space between Danube and Tisza river (in Hungarian). *Geodézia és Kartográfia*, 57, No.6, 11–18.

IV. Comission 4 (Positioning and Applications) Activities at the Geodetic and Geophysical Research Institute

(Gyula Mentes, Geodetic and Geophysical Research Institute)

SC4.2 WG4.2.2 Dynamic Monitoring of Buildings

Nowadays the stability investigation of large objects, such as towers, buildings, bridges, etc. without disturbing their function plays a very important role in disaster prevention. It was investigated how natural effects (wind, micro-seismic vibrations) can be used as input signals for health and earthquake risk assessment of large, dangerous objects (Mentes 2004a, 2004b, 2004c, 2005a). It was detected that large objects as high towers, etc. gain the tidal signal like a pendulum and the movements of the objects are transferred to the ground in its vicinity. These increased deformations can be measured on the objects and in their surroundings by sensitive instruments (Mentes 2005b, 2005c). To investigate this technical possibility, long-term tidal measurements were carried out at the TV tower and at the church Kecske in Sopron (Mentes 2006a). The changes in the response of the object to the periodical tidal exciting signal could give us information about the health of the whole structure of the object. The relationship between the object and the ground deformations can be probably used for earthquake risk assessment of the object.

SC4.2 WG4.2.4 Monitoring of Landslides and System Analyses

In the frame of the EU 5 OASYS project a geodetic test area was established to investigate the movements of the high loess wall on the bank of the river Danube in a small town, in Dunaföldvár. The aim of this research was to study the interaction between different (geological, geophysical, hydrological, etc.) phenomena causing landslides in order to develop an early alert system (Mentes and Eperné 2004). The geological structure (Mentes et al. 2004, Papp et al. 2004) and the seismic hazard (Szeidovitz and Gribovszki 2004) of the test site were detailed investigated. Connection between recent tectonic movements and tilt of the loess wall was detected (Mentes 2006b). GPS measurements, precise levelling and borehole tilt measurements were carried out (Bányai 2003a, 2004, Mentes 2004d). A Geographic Information System was developed (Gyimóthy 2004) to help the interpretation of the measured data (Mentes 2004e).

In the field of positioning and applications, a new full roving GPS observation strategy was developed for the investigation of antenna main phase centre offsets (Bányai 2005), which proved to be a good calibration method on micro GPS networks. The method also proved to be a useful procedure in the cease of local deformation networks, where the phase offsets differences as biases can be estimated together with the station co-ordinates (Bányai 2006).

References

Bányai L 2003: Stability investigations of the high bank of river Danube in the area of Dunafoldvar. In: Proceedings. 11th International Symposium on Deformation Measurements. Publication No. 2. Geodesy and Geodetic Applications Lab. Dept of Civil Engineering, Patras University, 65–70.

Bányai L 2004: Methods and results of geodetic monitoring in Dunaföldvár. In: Landslide monitoring of loess structures in Dunaföldvár, Hungary. Gy Mentes, and I Eperné eds, Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences, (ISBN 963 8381 21 3), Sopron, 47–65.

Bányai L 2005: Investigation of GPS antenna mean phase centre offsets using a full roving observation strategy. *J. Geod.*, 79, 222–230.

Bányai L 2006: Application of full roving GPS observation strategy for monitoring local movements. CD-ROM Proceedings of the 3rd IAG Symposium on Geodesy for Geotechnical and Structural Engineering and 12th FIG Symposium on Deformation Measurement. Baden, Austria. Vienna University of Technology. ISBN: 3-9501492-3-6

Gyimóthy A 2004: GIS for landslide monitoring in Dunaföldvár. In: Landslide monitoring of loess structures in Dunaföldvár, Hungary. Gy Mentes, I Eperné eds, Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences (ISBN 963 8381 21 3), Sopron, 77–82.

Mentes Gy 2004a: Features of the end users need for monitoring bridges. In: Proceedings of the 7th Samco Workshop, Laboratorio Stampa D.G. Roma, X.1–8.

Mentes Gy 2004b: Measurement and Analysis of Cyclic Deformations and Movements of the TV Tower in Sopron. 1st FIG International Symposium on Engineering Surveys for Construction Works and Structural Engineering. Workshop on Measurements and Analysis of Cyclic Deformations and Structural Vibrations. University of Nottingham, Nottingham, United Kingdom, CD, International Federation of Surveyors, Frederiksberg, Denmark (ISBN 87-90907-35-3), TS8.2, 1–13.

Mentes Gy 2004c: Health Monitoring of structures Using Natural Effects as Excitation Signal. Proceedengs of the 3rd International Conference on Engineering Surveying and FIG Regional Conference for Central and Eastern Europe INGEO 2004. Bratislava, Slovakia, CD, International Federation of Surveyors, Frederiksberg, Denmark (ISBN 87-90907-34-5), TS5, 1–9.

Mentes Gy 2004d: Landslide monitoring by borehole tiltmeters in Dunaföldvár. In: Landslide monitoring of loess structures in Dunaföldvár, Hungary. Gy Mentes, I Eperné eds, Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences, (ISBN 963 8381 21 3), Sopron, 67–76.

Mentes Gy 2004e: Summary and interpretation of the results of the landslide monitoring in Dunaföldvár. In: Landslide monitoring of loess structures in Dunaföldvár, Hungary. Gy Mentes, I Eperné eds, Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences, (ISBN 963 8381 21 3), Sopron, 83–84.

Mentes Gy 2005a: Investigation of the deformations and movements of the TV tower in Sopron influenced by weather variations and ground motions. In: Proceedings of the Third European Conference on Structural Control. R Flesch, H Irschik, M Krommer eds, Vienna, Austria, Schriftenreihe der Technischen Universität Wien, (ISBN-3-901167-90-0), Volume II, pp. S6-72–75.

Mentes Gy 2005b: Role of Tidal Phenomenon in Measurements for Structural Control of Objects. In: Proceedings of the SAMCO Summer Academy on Structural Assessment, Monitoring and Control. CD. VCE Holding GmbH. Vienna, Austria, 1–10.

Mentes Gy 2005c: Investigation of the Possibility of Using Tidal Signals for Health Monitoring of Objects. *Acta Geod. Geoph. Hung.*, 40(3-4), 367–378.

Mentes Gy 2006a: Investigation of the deformation and movements of objects caused by Earth tides. In: Proceedings of the 3rd IAG Symposium on Geodesy for Geotechnical and Structural Engineering, 12th FIG Symposium on Deformation Measurement, H Kahmen, A Chrzanowski eds, Baden, Austria, CD, (ISBN: 3-9501 492-3-6), Engineering Geodesy, Vienna University of Technology, 1–10.

Mentes Gy 2006b: Investigation of the connection between recent tectonic movements and landslides at the high loess wall on the bank of River Danube. In: Proceedings of the 3rd IAG Symposium on Geodesy for Geotechnical and Structural Engineering, 12th FIG Symposium on Deformation Measurement, H Kahmen, A Chrzanowski eds, Baden, Austria, CD (ISBN: 3-9501 492-3-6), Engineering Geodesy, Vienna University of Technology, 1–9.

Mentes Gy, Eperné P I eds 2004: Landslide monitoring of loess structures in Dunaföldvár, Hungary. Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences, (ISBN 963 8381 21 3), Sopron

Mentes Gy, Eperné Pápai I, Szőcs É 2004: General description of the Hungarian test site in Dunaföldvár. In: Landslide monitoring of loess structures in Dunaföldvár, Hungary. Gy Mentes, I Eperné eds, Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences (ISBN 963 8381 21 3), Sopron, 7–22.

Papp G, Benedek J, Kalmár J 2004: Gravity investigations on Dunaföldvár test area. In: Landslide monitoring of loess structures in Dunaföldvár, Hungary. Gy Mentes, I Eperné eds, Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences, (ISBN 963 8381 21 3), Sopron, 37–46.

Szeidovitz Gy, Gribovszki K 2004: Seismic hazard of Dunaföldvár. In: Landslide monitoring of loess structures in Dunaföldvár, Hungary. Gy Mentes, I Eperné eds, Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences (ISBN 963 8381 21 3), Sopron, 23–35.

V. Inter-Commission Committee (Theory)

(József Závoti, Geodetic and Geophysical Research Institute)

Geometric invariance has been widely used for object recognition, matching and reconstruction. To eliminate uncertainties in relative orientation, sometimes it becomes advantageous to include additional information on geometric structures, which remain invariant under changes in camera calibration and viewing positions. Such structures may be lines, circles, etc. Combined with robust estimation of the orientation parameters, we can substantially reduce the effects of outliers. In the paper of Battha (2004) two kinds of robust solutions are considered: L1 norm and Cauchy-function.

Závoti (2004) presented the mathematical description of the interpolation method especially for modeling the orbit of artificial satellites. The tracks of the satellites were approximated by cubic splines. He has given new identities for the spline interpolation of points with second degree derivatives positioned in the end-points of the intervals of interpolation. Model-computations have shown that — utilizing only the positional parameters — this method is suitable to determine the velocity-vector and the acceleration-vector, and it can be seen that the given spline-method is more reliable than the Newton-interpolation. The generalized method was successfully applied for modeling geodynamical processes, for example for describing the motion of the Earth's poles.

Závoti et al. (2005) summarized the results of the research in mathematical geodesy during the 50 years of the GGRI. Geodetic research work can only be successful if up to date tools of mathematics are applied. Research has been done mainly in two areas: theoretical foundation of the evaluation of geodetic measurements and the practical application of theoretical results. These include interpolation methods, robust estimation, time-series analysis. Results of the research have been applied in areas such as photogrammetry, digital terrain model, polar motion and geodynamics.

Závoti and Jancsó (2006) compared in their studies the method of linearized least squares' solution with the non-linear Gauss-Jakobi combinatorial solution for the problem of 7 parameter datum transformation. As a result, both methods presented the same residuals, but the nonlinear algorithm was numerically more stabile than the traditional process. The nonlinear solutions for this problem presented in the study are important, because gross errors can be detected with the process, the equations don't need the linearization and the iteration, and the co-variant connections of the two co-ordinate systems (local-global referential system) are automatically used. This study presents the mathematical theory of the Gauss-Jakobi combinatorial algorithm, and it is represented with two different solutions for the over-determined 7 parameter 3D transformation, and it introduces the practical application of the method with some numerical examples. The problem plays a significant role both in geodesy and in photogrammetry.

In Monhor's (2005) paper new closed formulae for the probability density and distribution functions of the sum of independent uniform random variables with unequal supports were derived. Any probability distribution obtained from these formulae is strongly unimodal which is one of the favourable properties for modeling and processing measurement data errors. Along with these, a brief outline of the relevance of convolutions of uniform distributions to the theory of errors related to astronomy and geodesy is given in historical setting.

Nevertheless, the concept of outlier has a long history and frequent appearance in geodetic literature, there has been no exact definition of it. This is a quite conflicting situation; it gives contingency for subjective judgments and misunderstandings. The present paper (Monhor and Takemoto 2005a) contributes to the correction of this unfavourable situation by introducing a new generic and categorizing definition. The categorization integrates the diverse and heterogeneous appearance of outliers and helps the comprehensive grasp of the concept of outlier, since any kind of outliers falls to one of the three categories given by the authors.

The outlier problems have so far been treated only in statistical and/or "semi-empirical" way without paying proper attention to probabilistic-theoretic background. Taking into account this observation, the authors consider outliers in the light of achievements of the modern theory of probability. This novel attitude is realized through the methodologically new way of the unified presentation of the law of large numbers, central limit theorem, Berry-Esseen theorem and theory of large deviations. In terms of the theory of large deviations the new probabilistic-theoretic model of outliers is given. It is the first time that the theory of large deviations is considered in the literature of geodesy, geophysics and astronomy. It is established that Chebyshev inequality gives a numerically applicable estimate for the probability that the discrepancy between the random variable and its mathematical expectation is large enough.

Using such historical source materials as Astronomische Nachrichten, the paper of Monhor and Takemoto (2005b) establishes an interesting fact that a characteristic property of normal distribution discovered by Förster, a geodesist and Pólya, a mathematician gave rise to the theory of stable distributions which is an important new branch of modern probability theory. The authors' observations on the theorem of Förster and Pólya are new results in both the studies on history of theory of errors and the modernization process of theory of errors; the paper sheds new light on the role of the theory of errors, consequently, also on that of geodesy and astronomy in the emergence of the new branch in modern probability theory. The very essence of stable distributions is introduced in an easy-to-understand way, giving a modified formulation of the theorem of Förster and Pólya in terms of modern theory of probability and its interpretation is given in terms of the theory of errors. Using the theory of stable distributions, the structural similarity between the normal and Cauchy distributions is shown. This fact clarifies the important role of the Cauchy distribution for data processing in theoretical setting.

References

Battha L 2004: Relative orientation with constrains for invariant geometric elements. *Acta Geod. Geoph. Hung.*, 39, 61–68.

Monhor D 2005: On the relevance of convolution of uniform distributions to the theory of errors. *Acta Geod. Geoph. Hung.*, 40, 59–68.

Monhor D, Takemoto S 2005a: Understanding the concept of outlier and its relevance to the assessment of data quality: Probabilistic background theory. *Earth Planets Space*, 57, 1009–1018.

Monhor D, Takemoto S 2005b: Geodetic and Astronomical Contributions to the Invention of the Normal Distribution: Some Refinements and New Evidences. *J. Geod.*, 51, 175–185.

Závoti J 2004: Generalization of spline interpolation for geodynamic models. *Acta Geod. Geoph. Hung.*, 39, 477–480.

Závoti J, Jancso T 2006: The solution of the 7-parameter datum transformation problem with and without the Gröbner basis. *Acta Geod. Geoph. Hung.*, 41, 87–100.

Závoti J, Somogyi J, J Kalmár, L Battha 2005: Research in mathematical geodesy. *Acta Geod. Geoph. Hung.*, 40, 283–292.

VI. Communication and Outreach Branch

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1. Introduction

In the past period (since July 2003, Sapporo, the foundation of the COB), the infrastructure investment indicated in our proposal for the Executive Committee Meeting in Nice (April 2003) has been fully realized. Thus the technological background of the COB at the Department of Geodesy and Surveying of the Budapest University of Technology and Economics (BME) has been fully realized and is supported by the department and the Research Group for Physical Geodesy and Geodynamics of the Hungarian Academy of Sciences. All administrative work for registration of the new IAG Website address (www.iag-aig.org) has been done.

The Terms of Reference and program activities of the COB and a short report on the IAG website were published in the Geodesists Handbook 2004 (Ádám and Rózsa 2004a, 2004b).

The COB's Steering Committee held meetings five times in the last two years:

a) Sapporo, Japan, 8 July, 2003

b) Nice, France, 29 April, 2004

c) Budapest, Hungary, 1 February, 2005

d) Cairns, Australia, 23 August, 2005

e) Vienna, Austria, 2 April, 2006.

2. Status of the new IAG website

A new Compaq server has been purchased and the backend of the website has been developed. Hence all of the documents can be edited and maintained through a simple web browser. The documents are stored in a MySQL database, which enables fast data retrieval and also searching in documents. The graphical front-end is also ready.

After providing the IT background for creating and maintaining the web content, the editing of the old web content has been started. All the old documents must have been partially re-edited in order to fit into the new structure of the IAG website. Due to this, the migration of the old website to the new one was going a bit slower than previously expected. The Geodesist's Handbook (1999, 2000) have also been migrated to the new website.

The layout of the website has been changed a few times according to the proposals accepted at the Steering Committee Meetings. Direct links to services, old sections, commissions, etc. have been added to the front page. The event calendar has been shortened, it contains only the next five important events. Additional

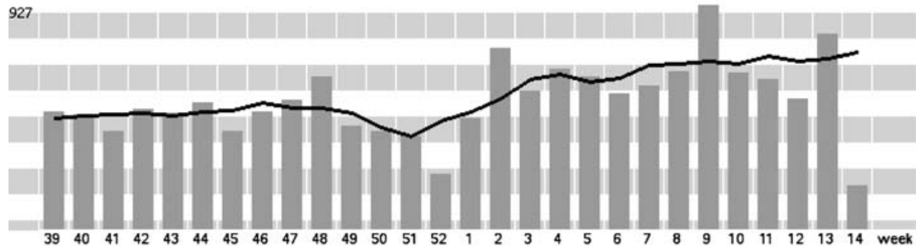

Fig. 4a. Weekly number of visits

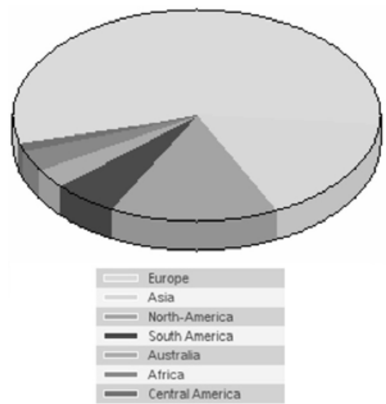

Fig. 4b. Geographical distribution of visitors

advertisements have been also added to the front page. The recent Membership Application Form as well as the IAG Newsletters can be downloaded for the opening page.

The number of visitors is steady. The weekly number of visitors is about 600 (Fig. 4a). The geographical distribution of the visitors shows that the webpage is mostly visited from Europe (52,271), Asia (15,302) and North-America (13,914) out of the total 94,918 visits since May 28, 2003. Only 2935 visits came from the African Continent (Fig. 4b).

Visitors could be registered from 153 countries worldwide. The list can be found at http://webstats.motigo.com/s?tab=1&link=3&id=2359395&cou=all .

The IAG website includes the Members' Section, which can be accessed by IAG Members only. IAG Members have received a password to enter this restricted area. Each IAG Member is entitled to read articles in this area as well as to query the contact database of the IAG members. The Members may update their own contact details, and specify their fields of interests, too.

3. The IAG Newsletters

Altogether 39 IAG Newsletters have already been published till March 2007 and can be accessed on the IAG new website in HTML, HTML print version and in PDF formats. The web addresses in the text can now be reached also from the PDF file. The IAG Individual Members received it monthly in PDF and text attachments, with a link in the e-mail message to access the actual HTML Newsletter on the IAG website. A new subscriber list of the Newsletter for developing countries was set up in a web-based database, independently from the IAG Individual Members subscriber list for promoting interest in the activities of IAG. Now the electronic IAG Newsletter is distributed to these e-mail addresses as well. Selected content of the electronic Newsletters were compiled and have been sent to Springer for publication for already 25 issues of the Journal of Geodesy (Vol 77/12-81/4).

4. Membership development and outreach activities

The Membership Application form (MAF) has been updated and put in the new IAG website. It contains all the information for the credit card payments and it can be filled using Adobe Acrobat Reader.

Initially about 2600 e-mail addresses were stored in a database. The validation of e-mail addresses as well as web integration for future mailing lists management tasks is currently taking place. Unfortunately many duplicate and invalid e-mail addresses had to be removed from the aforementioned database.

The COB designed a brochure for promoting the IAG to the geoscientific community. The main objective of this brochure is to introduce the activities of IAG to the geoscientific community and to encourage individuals to be a member of the Association. In the first run 1500 copies have been printed. The brochure was available at the IAG, AGU, EGU Assemblies and at different IAG Symposia.

The Communication and Outreach Branch in co-operation with the Department of Geodesy and Surveying, Budapest University of Technology and Economics and the Research Group for Physical Geodesy and Geodynamics of the Hungarian Academy of Sciences organized the 6th International IGeS School on "The Determination and Use of the Geoid", Budapest, Hungary, 31 January – 4 February, 2005.

References

Ádám J, Rózsa Sz 2004a: IAG on the Internet (http://www.iag-aig.org). The Geodesists' Handbook. *J. Geod.*, 77, 576–577.

Ádám J, Rózsa Sz 2004b: Communication and Outreach Branch. The Geodesists' Handbook. *J. Geod.*, 77, 677–678.