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ĢEODINAMIKA UN ĢEOKOSMISKIE PĒTĪJUMI

Konferences tēzes un zinātniskie raksti

75.

Latvijas Universitātes zinātniskā konference

LATVIJAS UNIVERSITĀTES 75. ZINĀTNISKĀ KONFERENCE
VALSTS PĒTĪJUMU PROGRAMMA RESPROD
LATVIJAS UNIVERSITĀTES ĢEODĒZIJAS UN ĢEOINFORMĀTIKAS INSTITŪTS

ZINĀTNISKĀ KONFERENCE

ĢEODINAMIKA UN ĢEOKOSMISKIE PĒTĪJUMI

KONFERENCES TĒZES UN ZINĀTNISKIE RAKSTI

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Latvijas Universitātes 75. zinātniskās konferences ietvaros Latvijas Universitātes Ģeodēzijas un ģeoinformātikas institūta organizētās konferences "Ģeodinamika un ģeokosmiskie pētījumi" apskata visai plašu zinātnisko pētījumu loku un ir virzīts uz pētījumu starpdisciplinaritāti, daudzpusību un iespējām šādā plašākā kontekstā veikt ievērojami nozīmīgākus atklājumus, tajā skaitā ar lietišķu pielietojumu. Konferencē apskatītie pētījumi ir dažādos to attīstības posmos un iepazīstina ar sasniegto un iecerēto nākotnē. Izdevums paredzēts pētniekiem, studentiem un pētniecības sociālajiem partneriem kā aktuālās informācijas avots un aicinājums pievienoties šo pētījumu realizācijā un tos atbalstīt.

Redaktors prof. Valdis Segliņš

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PRIEKŠVĀRDS

Latvijas Universitātes Ģeodēzijas un ģeoinformātikas institūts (GGI) sekmīgi ir atjaunojis savu darbu jau 1994. gadā pēc pusgadsimta mazāk pamanāma pētnieciskā darba, kas tieši turpināja Ģeodēzijas institūta (1924–1944) uzsāktajos pētījumu virzienos. Ģeodēzijas institūts tā izveides sākumposmā savulaik sekmīgi darbojās daudzās tā laika progresīvajās zinātnes un pētniecības jomās – nacionālā ģeodēziskā tīkla izveidē un izlīdzināšanā, fotogrammetrijā, Zemes vertikālo kustību izpētē, gravimetrisko un magnētisko mērījumu izpētē. Sekojot šiem augstajiem mērķiem un prasīgumam, arī šobrīd GGI pētniecība aptver galvenokārt satelītu ģeodēziju un ģeoinformātiku. Izceļams vadošais pētniecības vektors – lāzertālmēru sistēmu (SLR) montāžas un vadības programmatūras izveide. Tā, līdz 2010. gadam tika izstrādāti divi SLR prototipi, bet šobrīd tiek konstruēts trešais, uzlabotais modelis.

Salīdzinoši nesen GGI tika izstrādāts arī digitālās zenītkameras prototips vertikāles noviržu izpētei. Tā testa mērījumu rezultāti sasniedz 0,1 loka sekundes precizitāti, kas ir ļoti daudzsološs rādītājs Latvijas gravitācijas lauka modelēšanas kvalitātes uzlabošanai. Nesenā Nacionālā gravitācijas lauka modeļa versija, kas tika izveidota Ģeodēzijas un ģeoinformātikas institūtā, sasniedz aptuveni 2 cm precizitāti, kas ir daudz augstāka precizitāte nekā iepriekšējam Latvijā izmantotajam modelim (7–8 cm). Izceļams, ka lietišķos pētījumos augstas precizitātes gravitācijas lauka modelis ir ļoti svarīgs, jo tas ļauj sasniegt augstu normālā augstuma noteikšanas precizitāti ģeodēziskajos mērījumos, lietojot Globālās navigācijas satelītu sistēmas (GNSS). Šobrīd Ģeodēzijas un ģeoinformātikas institūtā ir uzsākti digitālā zenītteleskopa eksperimentālie lauka mērījumi.

Ģeodēzijas un ģeoinformātikas institūtā ir veikta Zemes vertikālo un horizontālo kustību pētījumi Latvijas teritorijai, analizējot 7 gadu laikā veiktos GNSS novērojumus LatPos un EUPOS-Rīga pastāvīgās darbības tīklos. Institūtā ir izveidota arī Latvijas un Latvijas pilsētu GIS datu bāze, izveidoti digitālie augstuma modeļi.

GGI institūta pētījumi ir labi pazīstami profesionālā vidē pasaulē, bet Latvijā ir institūts, kas spēj ap sevi vienot un pētījumos iesaistīt vadošos pētniekus no visas valsts, neatkarīgi no to pamata darbavietas, un ir kļuvis par sava veida neformālu koordinējošo centru pētījumiem nozarē. To apliecina arī Latvijas Universitātes 75. zinātniskās konferences ietvaros organizētās konferences "Ģeodinamika un ģeokosmiskie pētījumi" organizācija. Konference noritēja ļoti sekmīgi un 23 prezentētie pētījumi rezultāti, kas aptver valstī realizēto pētījumu visus galvenos virzienus, to apliecina. Īpaši izceļama ir ļoti plašā institūciju pārstāvniecība un atkārtoti pateicība izsakāma visiem, kas piedalījās un atbalstīja konferences norisi.

Īpaši izceļama daudzo pētījumu augstā zinātniskā kvalitāte un lietišķais raksturs, kas daudzas zinātniskās atziņas un risinājumus ļaus izmantot tautsaimniecībā jau tuvāko gadu laikā. Tajā skaitā teritoriju attīstības plānošanā un zemes dzīļu izmantošanā.

Profesors *Dr. geol.* Valdis Segliņš

2017. gada 16. februārī

SATURS

CONSISTENCY OF THE LATPOS, IGS RIGA AND EUPOS® – RIGA IN FRAMEWORK OF EPN NETWORK

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Since Year 2007 the daily coordinates of LatPos, IGS and EPN station RIGA and of the EUPOS® – Riga RTK network stations are computed at the Institute of Geodesy and Geoinformatics. The SINEX weekly solutions are regularly send to EUPOS® Combination Centre (Hungary) where they are deployed at reference frame maintenance and geodynamic studies relying on their homogeneously analysed long-term data series. The ongoing EPN (EUREF Permanent Network) densification targets the integration of the national continuously operating reference station (networks (CORS) and a homogeneous, dense position and velocity product is derived using the EPN as backbone infrastructure [1]. The derived position and velocity product will be an essential material for various geokinematic studies (PGR, intraplate and plate boundary zone investigations), and also for the better realization of ETRS89 over tectonically active regions. This work is very well inline with the goals of other European initiatives as European Plate Observation System (EPOS) and EUPOS® [1, 2].

10-year time series of coordinates of ETRS89 for all the Latvian stations mentioned above are computed at the Institute of Geodesy and Geoinformatics. Some of the stations had been removed to other sites. Therefore, not full 10-year time series available for them. However, 3 EUPOS® – Riga stations and 7 LatPos stations are on the initial sites. IGS and EPN station RIGA as well. The average per year values of North component of corresponding stations are depicted in Fig. 1. The most deformed curve belongs to station RIGA.

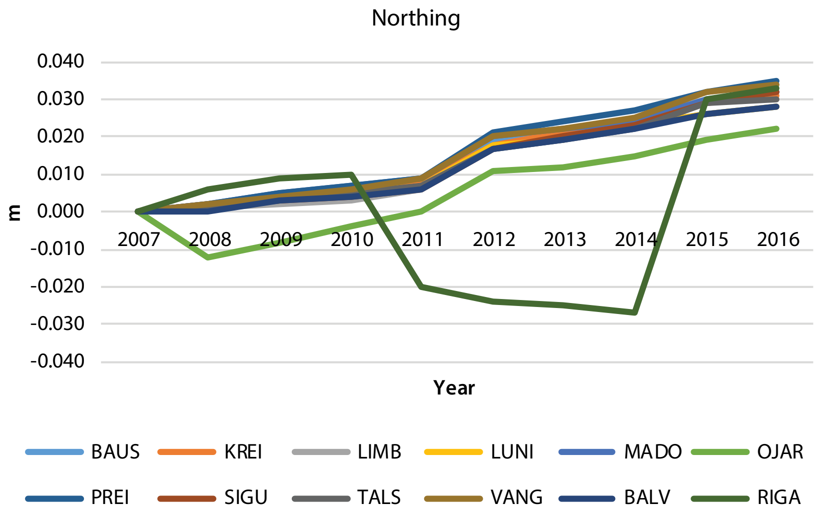

Fig. 1. Average per year Northing ETRS89 component

In 2011 the officials of EUREF decided to assume new values of RIGA antenna parameters without antenna calibration. In 2015 the new GNSS receiver was obtained by the Institute of Astronomy. Consequently, the positioning results are became similar to other stations.

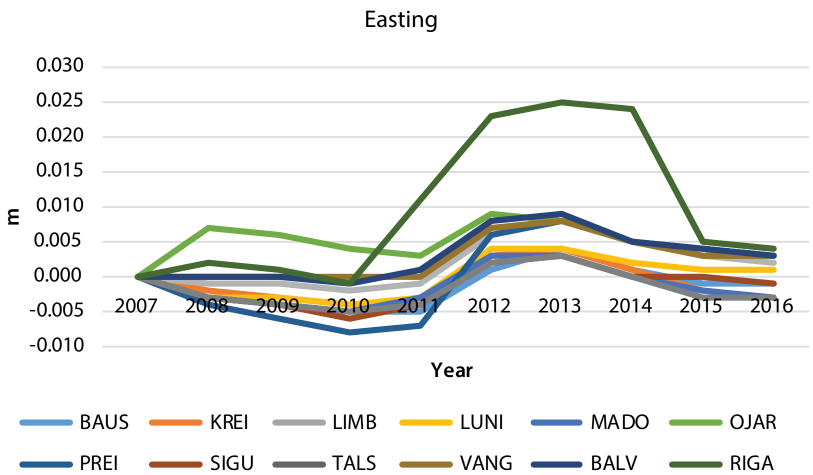

Fig. 2. Average per year Easting ETRS89 component

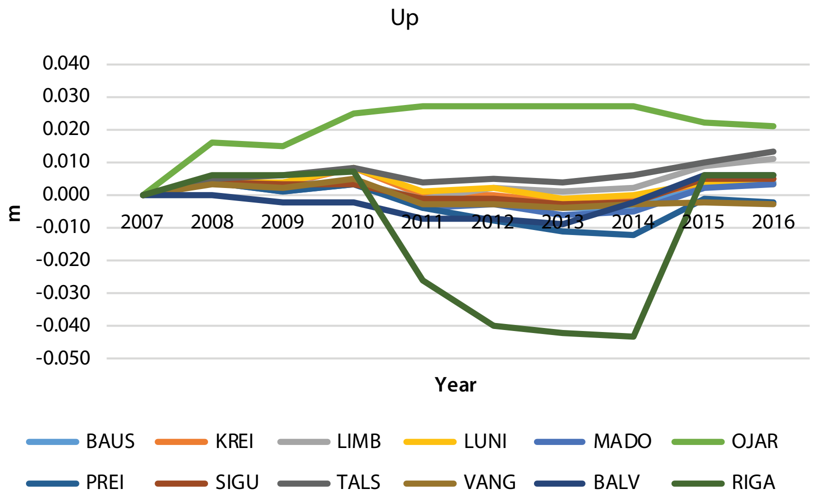

Fig. 3. Average per year Up ETRS89 component

In Fig. 2. depicted the Easting component and the behaviour of RIGA station is similar. The same behaviour is observed in Fig. 3. for Up component. Additionally, Up component is strongly deformed for LatPos station OJAR. The reason of antenna height changes is not discovered yet.

The EUPOS® – Riga stations LUNI, KREI, VANG and VAIV are stable. The station SALP is not so good. Probably, because of the defected pillar.

The deformations properly have been studied by Dr. Diana Haritonova. More information is available in her doctoral thesis in Riga Technical University.

REFERENCES

1. Kenyeres A., Caporali A., Horvath T., Baron A., Doncker F., Droscak B., Duret A., Franke P., Georgiev I., Gianniou M., Hansen D., Huisman L., Morozova K., Nagl J., Pihlak P., Valdes M., Ryczywolski M., Zurutuza J. (2015) Global Reference Frame Realization on National Level Based on the Integration of National CORS Networks / Available in https://agu.confex.com/agu/fm15/g/papers/viewonly.cgi?password=860776&username=77549 Accessed 15 February 2017.
2. Kenyeres A., Horvath T., Bruyninx C., Mesmaker D., et al. (2015) Recent advances in the EPN densification: an overview. EUREFf2015 Syposium, Leipzig, 02–05 June, 2015. http://www.euref.eu/symposia/2015Leipzig/02-03-Kenyeres.pdf Accessed 15 February 2017.

ADAPTIVE TECHNOLOGY FOR IMAGES ANALYSIS – HIERARCHICAL CLASSIFICATION ENGINE

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Images and video files analysis is a vital problem and occupies a dominant position in such fields as: change detections and monitoring, disaster management, civil and military intelligence etc.

The theses reviews the recent works on developing an adaptive software for video files and images analysis based on hierarchical classification.

Automated image analysis is mainly based on pixel classification method or object-oriented segmentation. Most of these approaches adopt common image interpretation keys namely tone, texture, pattern, color etc. for feature matching [1][2].

Number of research papers have evaluate object-based approach as more accurate than pixel-based methods, both for remotely sensed image classification [3][4], because it takes into account not only spectral characteristics, but also such characteristics as shape, size, texture or neighborhood objects, super- and sub-objects [5].

Soft computing techniques such as neural networks, genetic algorithms, fuzzy logic, random field variations, wavelets, clustering, decision tree etc. have been applied for accurate registration and analyzing images [6][7].

Hierarchical classification tree and adaptive approaches of segmentation are used in satellite image analyses process in object oriented images (Fig. 1.)

A concept of the hierarchy based on Wu J. [8]. Advances have been made in exploring hierarchy in image analysis, for example in image segmentation [9].

The proposed solution is based on the creation of tree – based hierarchical recognition. In each tree element is determinate some of characteristic feature of the object, which excludes from the recognition data sets conflicting results.

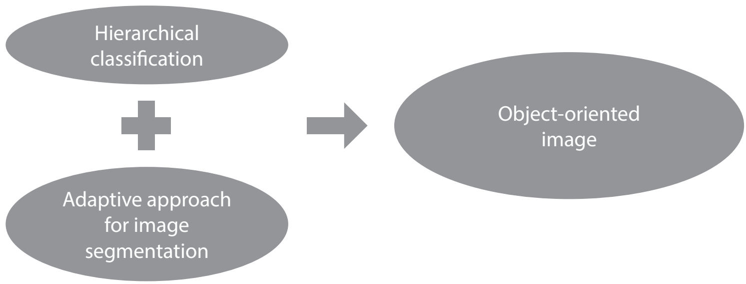

Fig. 1. Image analyses process

The first step is the determination of the object in the image using one of the image segmentation algorithms. From the segmented object is extracted object-specific properties adequate classifier. The properties of the object are classified with the adequate classifier. If the result conforms to the new classifier, then is conducted an appropriate iteration and operation is repeated. In case if the result of the object have not appropriate classifier, it is considered as the classification results. Additional results are saved in the results database as raw data for classifier quality inspection. As a classification method is chosen the most appropriate machine learning method for given data. For example, if the data is easily separable in this case can be used decision tree algorithms such as ID3, ambiguous detachable data – any of neural network algorithms or fuzzy logic decision trees such as CART or C4.5.

The results of the automated image analysis are showed in the example of satellite images analyses (Fig. 2.).

The results of classification by Hierarchical Classification Engine were compared with the results which were obtained by using commercial eCognition object-oriented fuzzy image processing software. In both cases, the results were similar.

The adaptive technology is also used in movement object counting tool with recognition, in real time industrial quality control and analyse, in flora and fauna recognition, as well as in precious agriculture etc.

The development of the Hierarchical Classification Engine contributed to the easy access to geospatial information from satellite and areal imageries, as well as flexibility and possibility integrate technology into user's software, GIS etc.

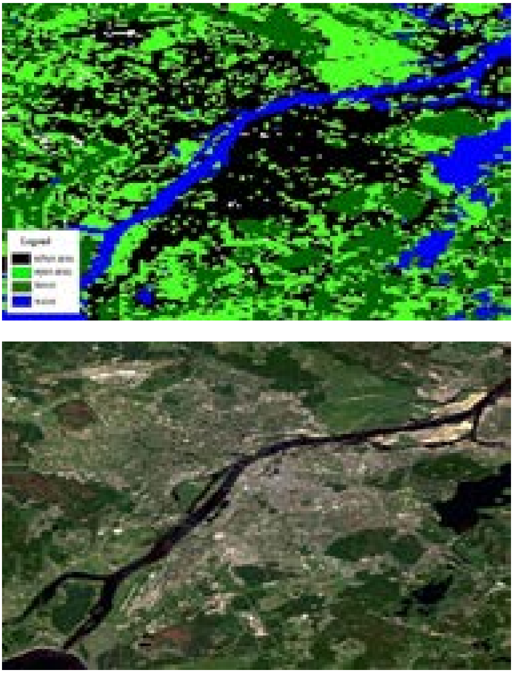

Fig. 2. Landsat – 8 satellite image automated analysis with adaptive technology

REFERENCES

1. Arun P. V.2013. A CNN hybrid approach towards automatic image registration. Geodesy and Cartography. 39(3): 121–128.
2. Wyawahare M.V., Patil P.M., Abhyankar H.K. 2009. Image registration techniques an overview. International journal of Signal Processing, Image Processing and Pattern Recognition 2(3): 11–28.
3. Niemeyer I. and Candy M.J. 2003. Pixel-based and object-oriented change detection analysis using high-resolution imagery, Proceedings of 25th Symposium on Safeguards and Nuclear Material Management (Stockholm, Sweden).
4. Myint S.W., Gober P., Brazel A., Grossman-Clarke S., Weng Q. 2011. Per-pixel vs object-based classification of urban and land cover extraction using high spatial resolution imagery. Remote Sensing of Environment 115(5): 1145–1161. http://dx.doi.org/10.1016/j.rse.2010.12.017.
5. Harcinikova T., Stankova H. 2014. The possibilities to support ZB GIS database update using object-based image analysis in Ecognition developer software. Geodesy and Cartography. 40(3): 122–132.

6. Liu J., Wu H. 2012. A new image registration method based on frame and gray information. Proceedings of 2012 International Conference on Computer Distributed Control and Intelligent Environmental Monitoring, CDCIEM-2012, China, 48–51.
7. Malviya A., Bhirud S.G. 2009. Wavelet based image registration using mutual information, in Proceedings of International Conference on emerging Trends in Electronic and Photonic Devices&Systems, ELECTRO' 09, IEEE computer society, India, 241–244.
8. Wu J. 1999. Hierarchy and scaling: extrapolating information along a scaling ladder. Can. J. Remote Sensing 25, 367–380.
9. Hay G.J., Dube A., Bouchard, Marceau D.J. 2002. A scale-space primer for exploring and quantifying complex landscapes. Ecol. Model. 153 (1/2) 27–49.

RESEARCH OF NATIONAL GEODETIC NETWORK IN BALTIC USING GNSS METHODS

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In 2012, 2013 and 2014 there were GNSS measuring done on 13 Latvian levelling network class 1 geodetic points in the same time and 4 hour long session; in 2016 to measuring campaign were added 5 Lithuanian national geodetic network points with an aim to check geodetic point heights (Fig. 1.).

Fig. 1. Using GNSS method measured geodetic network points in Latvia and Lithuania

Performing GNSS measurements in 4 hour sessions it is possible to get the average vector accuracy 2 cm for height value.

Measured and calculated GNSS and geometric levelling height differences confirm the accuracy of geoid model LV98 in range 6 to 8 cm.

If the geoid model accuracy will increase (1.5 to 2 cm) the validity of calculated height values also will increase.

For GNSS measurements use for height determination it is very significantly to use advanced measuring technologies and verified data processing methodology.

REFERENCES

1. Celms A., Bimane I., Reke I. (2014) *European Vertical Reference System in Baltic Countries.* In Baltic Surveying. Vol. 1, pp. 49–55.
2. Celms A., Kronbergs M., Cintina V. (2012) Accuracy Estimation of the Latvia First Order levelling Network. In International scientific and technical conference GEOFORUM 2012. Lvivska Politehnika, pp. 44–47.
3. Celms A., Kronbergs M., Cintina V., Baumane V. (2013) Precision of Latvia Levelling Network Nodal Point Height. In CIVIL ENGINEERING`13 4th International Scientific Conference, Vol. 4, Jelgava, pp. 310–317.
4. Celms A., RatkevicsA., Rusins J. (2014) *Research of National Geodetic Network Elevations at Eastern Part of Latvia.* In Baltic Surveying. Vol. 1, pp. 84–91.
5. Celms A, Reke I., Ratkevics A. (2015) European Vertical Reference System Influence in Latvia. In 2nd International Conference Innovative Materials, Structures and Technologies, 30 September – 2 October 2015. Riga: Riga Technical University, p. 30.
6. *Latvijas kvaziģeoīda modelis* (Latvian quasigeoid model). (2015) Retrieved 11 March, 2015, from http://map.lgia.gov.lv/index.php?lang=0&cPath=-2&txt_id=130 (In Latvian)
7. Lazdans J., Aleksejenko I., Kaminskis J., Celms A., Kalinka M., Klive J., Reiniks M. (2009) Aktualitāte Latvijas sasaistē ar Eiropas augstumu sistēmu (Current Events Latvia Connecting with European Height System). LatviaUniversity scientific conference No. 67.
8. Reiniks M., Lazdans J., Ratkus B. (2010) Valsts augstuma izejas līmeņa noteikšana (Determination of state height datum level). *Riga Technical University scientific articles.* Nr. 7, 7–13. lpp. (In Latvian).

PERFORMANCE OF LATPOS SYSTEM UNDER MAGNETIC STORM CONDITIONS

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To provide services for coordinate determination, Network-based Real Time Kinematic (NRTK) system called "LatPos" has been established and operated in Latvia since 2006. Fast and reliable coordinate determination with GNSS in real time is the main objective of continuous operating reference system (CORS) network users. Activity of ionosphere is one of the factors, affecting the performance of LatPos system services. Ionosphere is a layer of the earth's atmosphere with high concentration of free electrons, from about 60 kilometers up to 1000 km above the earth's surface, affected by space weather. Electron concentrations is spatially variated and depends on seasonal and solar cycle changes.

In order to check the performance of LatPos system NRTK services, a complex test procedure in the field is carried out at least once a year. The test procedure is divided in four field measurement stages, to obtain maximum realistic data collection. In the field following characteristics are tested:

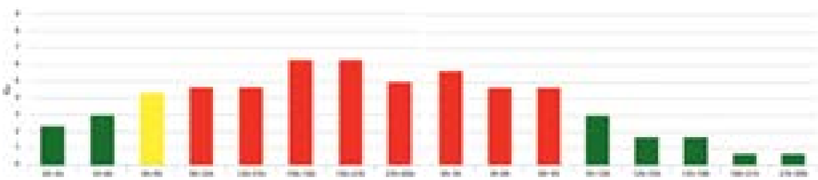
1. Time to rover receiver initialized position (Time-to-FIX);
2. Coordinate repeatability by independent initializations;
3. Stability of RTK corrections;
4. Position by static observations.

All measurements are made on 2nd order geodetic network control points. During the test procedure four RTK correction solutions – *iMAX, MAX, VRS* and SINGLE *SITE* were tested. Test procedure has been carried out in year 2016 from October 11 till October 13. During the measurement sessions and result evaluation process, it was noticed, that test was not passed on October 13. Strong geomagnetic storm was registered by scientific organizations on that day.

The geomagnetic storm is a major disturbance of Earth's magnetosphere that occurs when there is a very efficient exchange of energy from the solar wind into the space environment surrounding the Earth. The largest storms are associated with solar coronal mass ejections (CMEs) where a billion tons with its embedded magnetic field, arrives at Earth. Geomagnetic storms creates strong horizontal variations in the ionospheric density that can modify the path of radio signals and create errors in the positioning information provided by GNSS. The geomagnetic storm on October 13 was the third strongest of 2016 [1].

Ionospheric activity conditions depending on mentioned factors can be analyzed by LatPos system data. The effect of geomagnetic storm on October 13 can be clearly seen by indicators of LatPos test procedure measurements and also by LatPos system continuous network calculation status. Comparison of test procedure measurements from October 11– 12 (quiet ionosphere) and October 13 (active ionosphere) show that depending of the ionosphere activity status, the average Time-to-FIX can increase from 18 sec to 42 sec. Also the initialized positions during high ionospheric activity can cause coordinate offsets ~10 cm (normally it is ~2 cm). The strength of geomagnetic storm during the timespan October 13–14 is shown by planetary *Kp*-index (Fig. 1.a)) and its effect on LatPos system continuous network calculation status at station IRBE (Fig. 1.b)).

a)



b)

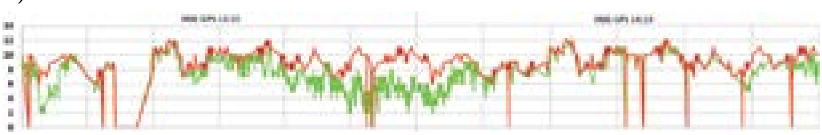


Fig. 1. a) Planetary Kp-index calculated by GFZ Potsdam [2],
b) LatPos system continuous network calculation status in station IRBE
(Number of tracked satellites in red color and number of satellites with fixed ambiguities in green color.)

The geomagnetic storm effect on GNSS signals can also be analyzed by VTEC (Vertical Total Electron Content) calculations from LatPos system observed data. A major increase of the ionospheric VTEC occurred on October 13 associated with the arrival of the CME of the October 9. Above Latvia there was up to +19 TECu (110%) of differences with respect to the TECu of the October 12. The geomagnetic storm last all day long and continued at night with ionospheric TEC instabilities.

Such ionospheric events caused by geomagnetic storms lead to significant errors in GNSS positioning and also the NRTK system usability. Reliability and accuracy of measured coordinates decreases significantly and may reach the situation when RTK positioning is not possible at all.

REFERENCES

1. Top 50 geomagnetic storms of 2016, SpaceWeatherLive initiative of Astro Event Group. (available at: https://www.spaceweatherlive.com/en/auroral-activity/top-50-geomagnetic-storms/year/2016).
2. GFZ Potsdam official Kp-index, viewing archive of 13–14 October 2016. (available at: https://www.spaceweatherlive.com/en/archive/2016/10/14/kp).

USE OF SATELLITE BASED MARITIME SURVEILLANCE SYSTEM CLEANSEANET FOR DETECTION OF MARINE POLLUTION AND VESSEL MOVEMENT MONITORING IN LATVIA

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Since 2007 the satellite based maritime surveillance system CleanSeaNet is used as the main tool for detection of marine pollution and related vessel movement monitoring in Latvia. This system is based on cooperation of four organizations – satellite operator, service provider (KSAT), earth observation data center (European Maritime Safety Agency) and end user (Latvian Naval Flotilla Coast Guard Service) [1]. For acquisition of satellite images covering the Latvian Territorial Sea and Exclusive Economic Zone in the Baltic Sea the following synthetic aperture radar (SAR) satellites have been used in the past or are being used now:

Table 1. List of satellites used for the detection of marine pollution in the Latvian Territorial Sea and Exclusive Economic Zone in the Baltic Sea [2].

Launch year	Satellite	Operational band	Incident angle	Polarization
1995	Radarsat-1 (Canada)	C (5.3 GHz)	20°-50°	HH
2002	Envisat (Europe)	C (5.3 GHz)	15°-45°	HH, HV, VV, VH
2007	Radarsat-2 (Canada)	C (5.3 GHz)	10°-60°	HH, HV, VV, VH
2007	TerraSAR-X (Germany)	X (9.7 GHz)	15°-60°	HH, HV, VV, VH
2014	Sentinel-1A (Europe)	C (5.4 GHz)	20°-45°	HH-HV, VV-VH

Principle of SAR radar image acquisition is based on reception of backscattered component of the electromagnetic wave from the sea surface, which distinguishes smoother or rougher surface indicating areas of potential marine pollution as well as showing actual vessels in real time with a standard resolution of 30 meters. A real time satellite image is delivered to the end user within 30 minutes after the satellite overpass.

The end user of the CleanSeaNet service in Latvia is the Latvian Naval Flotilla Coast Guard Service, which carries out the final evaluation of the acquired satellite image, performs investigation of each case, when marine pollution has been detected, takes decision on further action, as well as carries out physical inspection of the potentially polluted area in situ at sea. Also information on detected vessels (using Automatic Identification System) is compiled and pollution drift modelling performed.

In 2016 there have been 280 satellite images acquired using the CleanSeaNet service covering the Latvian Territorial Sea and Exclusive Economic Zone in the Baltic Sea. Within 15 of these images potential marine pollution has been detected and in 6 of these cases physical inspection of area at sea has taken place. However in none of these cases physical inspection has found evidence of harmful polluting substance present on water surface. At the same time in 8 cases a match has been found with trajectories of detected passing vessels while inspections of these vessels showed either permitted discharge of tank washings from cargo vessels or fish slime from fishery vessels. In some cases indications of algae bloom on water surface was found.

In conclusion, it is suggested that more efficient marine pollution and vessel movement monitoring surveillance systems, such as Side looking airborne radar (SLAR) based on aerial platform, such as Remotely Piloted Aircraft System (RPAS) should be used to verify potential marine pollution detected by CleanSeaNet system in the Latvian Territorial Sea and Exclusive Economic Zone in the Baltic Sea.

REFERENCES

1. Antunes Sonia, Introduction to CleanSeaNet (2016), CleanSeaNet Basic Training for Duty Officers, European Maritime Safety Agency.
2. Gade Martin, SAR Marine Applications, Basics and History (2016), ESA Training Course on Radar&Optical RS, IES, University of Hamburg.

EFFECT OF THE EARTH'S CRUST UPLIFT IN THE TERRITORY OF LATVIA IN VARIOUS INTERPRETATIONS

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Land uplift is the most notable geodynamic process in Fennoscandia. The Earth's crust is rising continuously since the deloading of the ice sheets at the end of the Ice Age. This phenomenon is well known as the postglacial rebound or the postglacial land uplift [3]. The land uplift maximum is near the city of Umeå, where the current absolute uplift is about 10 mm/yr, and during the last century the uplift rate relative to the sea reached almost 9 mm/yr [4].

The latest model of land uplift is the semi-empirical model NKG2016LU (Nordic Geodetic Commission), which has been computed based on the geophysical GIA (Glacial Isostatic Adjustment) model, GNSS time series, NKG levelling data, and without tide gauge observations [7]. The previous official model is NKG2005LU [1][6], which doesn't include Latvian levelling data. To represent the difference between two models in the territory of Latvia, the Fig. 1. is given.

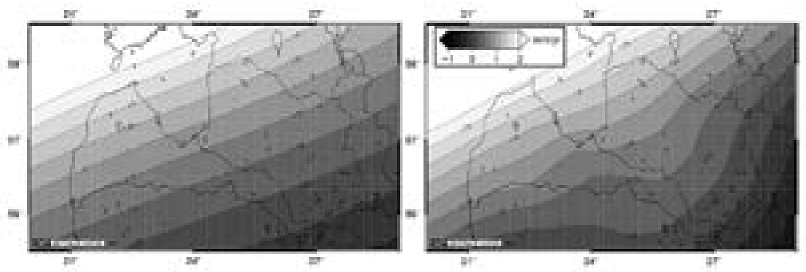

Fig. 1. Deformation models NKG2005LU_abs (left) and NKG2016LU_abs (right) in the territory of Latvia (abs: absolute land uplift)

The Fig. 1. shows the absolute land uplift, i.e. the land uplift relative to the Earth's centre of mass. Movements of the Earth's crust relative to the mean sea level are shown in Fig. 2. The background of Fig. 2. represents the apparent land uplift, which has been obtained subtracting the constant 1.32 mm/yr (the absolute sea level rise) from the model NKG2016LU_lev. The last reflects levelled land uplift, i.e. the uplift relative to the geoid.

The velocities of vertical displacements (see Fig. 2.) have been derived for the Latvian GNSS permanent stations of two networks: LatPos and EUPOS®-Riga, using GNSS observations for the period from 2012 to 2015. The research was performed within the frames of the doctoral thesis [2]. Here GNSS station vertical velocities are expressed using formula:

$$\dot{H}_{app\_GNSS\_sol} = \dot{H}_{abs\_GNSS\_sol}/1.06 - 1.32,$$

where the factor 1.06 reflects the geoid rise and 1.32 mm/yr – the absolute sea level rise.

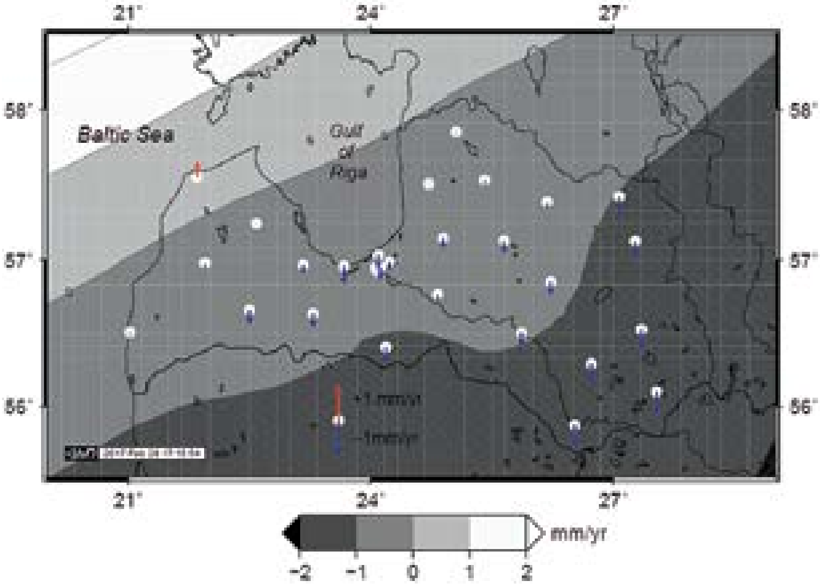

Fig. 2. Movements of the Earth's crust relative to the mean sea level: data of NKG2016LU and GNSS daily solution are used

The resulting range of vertical velocities for the territory of Latvia according to the GNSS solution comes up to 1.16 mm/yr in the case of absolute uplift, and 1.09 mm/yr in the case of apparent uplift; that is less in comparison with the uplift range of the both NKG models and the model based on the data of precise levelling given by [5].

REFERENCES

1. Ågren, J. and Svensson, R. Postglacial land uplift model and system definition for the new Swedish height system RH 2000. LMV-Rapport 2007: 4. *Reports in Geodesy and Geographical Information Systems*, Gävle, 2007: 124.
2. Haritonova, D., 2016. *Evaluation of high-precision technique application for observations of Earth's crust movements in Latvia*. Doctoral thesis. RTU, Riga: 136.
3. Kakkuri, J., ed. *Geodesy and geophysics* 115, Finnish Geodetic Institute, Helsinki, 1993: 200.
4. Poutanen, M. and Steffen, H., 2014. Land uplift at Kvarken Archipelago / High Coast UNESCO World Heritage area. Geophysical Society of Finland, *Geophysica* 50 (2): 49–64.
5. Reiniks, M., Kalinka, M., Lazdans, J., Klive, J. and Ratkus, B., 2010. Valsts augstuma izejas līmeņa noteikšana. *Scientific Journal of Riga Technical University*, *Geomatics*. Vol. 7. Riga: 7–13.
6. Vestøl, O., 2006. Determination of postglacial land uplift in Fennoscandia from leveling, tide-gauges and continuous GPS stations using least squares collocation. *Journal of Geodesy* 80 (5): 248–258.
7. Vestøl, O., Ågren, J., Steffen, H., Kierulf, H., Lidberg, M., Oja, T., Rüdja, A., Kall, T., Saaranen, V., Engsager, K., Jepsen, C., Liepiņš, I., Paršeliūnas, E. and Tarasov, L., 2016. NKG2016LU, an improved postglacial land uplift model over the Nordic-Baltic region. *NKG Working Group of Geoid and Height Systems*. Presentation (30 June 2016).

GEOMAGNETIC STORMS AND THEIR INFLUENCE ON GNSS TIME SERIES

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10-year GNSS daily solutions for EUPOS-Riga and LATPOS continuously operating GNSS RTK reference network stations have been performed at the University of Latvia, Institute of Geodesy and Geoinformatics using Bernese GNSS software. It is a huge amount of data which enables for deeper investigations of various phenomena affecting the GNSS observation results. The research initiative has been undertaken in order to explain some discrepancies in GNSS observation results. Currently the attention paid to the Earth magnetic field and geomagnetic storms.

The Earth's magnetic field is generated in the Earth's fluid outer core due to slow movement of molten iron. The magnetic field observable at the Earth's surface has sources also in the crust and in the ionosphere and magnetosphere. The geomagnetic field varies on a range of scales, in the order of low frequency to high frequency variations, in both the space and time domains. As well as the regular variations the Earth's magnetic field also exhibits sudden and irregular disturbances called magnetic storms. These disturbances are caused by interaction of the solar wind with the Earth's magnetic field. The solar wind is a stream of charged particles continuously emitted by the Sun and its pressure on the Earth's magnetic field creates a bounded comet-shaped region surrounding the Earth called the magnetosphere. Although magnetic storms are irregular, they exhibit some patterns in frequency of occurrence. The main pattern is the correlation with the 11-year solar cycle and the 27-day recurrence of some storms related to the 27-day rotation of the Sun as seen from Earth.

The ionosphere plays an important role in GNSS applications because it influences radio wave propagation. The ionosphere delay can be directly measured and mitigated using dual frequency GNSS receivers. However, GNSS signal fading due to electron density gradients and irregularities in the ionosphere must be considered.

Total Electron Content (TEC) is the total number of electrons integrated between two points, along a tube of one meter squared cross section. For different wavelengths along the same path, different signal delay can be observed. The TEC depend on local time, latitude, longitude, season, geomagnetic conditions, solar cycle, and troposphere conditions. One more parameter which characterizes ionosphere is the ROTI (Rate of TEC index). It characterizes small-scale and rapid variations of TEC, and is strongly related to scintillation [5]. If electron density irregularities cover a big area above receiver, there is a high probability that a receiver can lose more than one satellite signal simultaneously.

However, the most significant geomagnetic disturbances are in higher latitudes. Here one of the possible causes of GPS disturbances are polar cap patches, which are convecting clouds of enhanced plasma density [4]. The plasma density of polar cap patches is more than twice that of the background. They are either transported across the polar cap from the dense ionospheric plasma at the sunlit side of the Earth or created by particle precipitation in the cusp. To disturb GPS signals, patches must contain small-scale plasma structures, with scale sizes of decameters to kilometres [3].

A new insight into many natural processes will be provided by the Swarm which is a European Space Agency (ESA) mission to study the Earth's magnetic field. Swarm mission was launched on 22 November 2013. There are three identical Swarm satellites measuring magnetic field's signals that stem from Earth's core, mantle, crust, oceans, ionosphere and magnetosphere. The Swarm data will help to improve the accuracy of navigation systems, to advance earthquake prediction, to improve the efficiency of drilling for natural resources etc.

A common practice for eliminating ionospheric effect is using ionosphere free linear combination during post-processing. It is a linear combination of observables on two frequencies such as GPS L1 and L2 and it eliminates about 99% of the total ionospheric effect, also called the first order ionospheric effect [1]. The higher – second and third, order ionospheric effects can degrade the accuracy of GNSS solutions and they depend mainly on the level of the solar activity and geomagnetic and ionospheric conditions [2].

10-year GNSS daily solutions have been obtained using Bernese GNSS software. The resulting time series were combined with the information about 50 strongest geomagnetic storms for each year. To obtain conclusions about geomagnetic storm influence on GNSS time series it is proposed to use ARIMA (Autoregressive Integrated Moving Average) type modelling and Intervention analysis. It can be assumed that geomagnetic storms might have a temporary (one day) impact on GNSS time series. ARIMA modelling gives a possibility to predict time series value for definite days with high geomagnetic activity. Intervention analysis determines how the mean level of a series changes due to an intervention, assuming that the same ARIMA structure for the series holds both before and after the intervention.

Also a 5 minute kinematic GNSS network solutions were performed for several time periods with high geomagnetic activity. Here a significant influence of geomagnetic storms was observed. Different stations showed varied behaviour during geomagnetic storms. For example, strong geomagnetic storm on 17 March 2015 created disturbances up to one meter during several hours for LATPOS stations IRBE, JEK1, LIPJ, PREI, REZ1 and VAL1.

REFERENCES

1. Elmas Z.G., Aquino M., Marques H.A., and Monico J.F.G. Higher order ionospheric effects in GNSS positioning in the European region. *Ann. Geophys.*, 29, 1383–1399, 2011.
2. Hoque M.M., Jakowski N. Estimate of higher order ionospheric errors in GNSS positioning, *Radio Sci.*, 43, RS5008, 2008.
3. Jacobsen K.S., Andalsvik Y.L. Overview of the 2015 St. Patrick's day storm and its consequences for RTK and PPP positioning in Norway. *J. Space Weather Space Clim.*, 6, A9, 2016.
4. Jin Y., Moen J.I., Miloch W.J. GPS scintillation effects associated with polar cap patches and substorm auroral activity: direct comparison. *J. Space Weather Space Clim.*, 4, A23, 2014.
5. Pi X., Mannucci A.J., Lindqwister U.J., Ho C.M. Monitoring of global ionospheric irregularities using the worldwide GPS network. *Geophys. Res. Lett.*, 24 (18), 2283–2286, 1997.

ACCESSIBILITY OF GEOSPATIAL INFORMATION. OPEN OR CLOSED?

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If the data created by the public sector in the performance of its administrative functions are available for reuse, undoubtedly it will promote public awareness and bring real economic benefits.

Recreating data that already exist means that resources are wasted to acquire basic geospatial information instead of creating added-value data products.

Geospatial information is the basis for exact positioning of objects or events since everything has its location.

Reuse of information is facilitated by opening data and providing freely accessible information free of charge, without reuse restrictions and open for editing and automated processing by means of freely available applications.

Latvian geoportal www.geolatvija.lv contains no open geospatial data layers. It means that despite declarations about openness and transparency of information in reality all geospatial information is held in hidden or secret information space.

REFERENCES

1. Directive 2003/98/EC of the European Parliament and of the Council of 17 November 2003 on the re-use of public sector information.
2. Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE).

EUROPEAN SPACE SYSTEM COPERNICUS. UPCOMING NEWS IN 2018

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Copernicus is a European system for monitoring the Earth which provide users with optical and synthetic aperture radar data from satellites. It is a complex set of systems which collect data from multiple sources: satellites and in-situ sensors. The collected data are then processed and transformed into reliable and up-to-date information which is provided to users as a set of services related to environmental and security issues [1].

Copernicus is divided in six services, which covers following thematic areas: land, marine, atmosphere, climate change, emergency management and security. Corresponding services are: Land Monitoring Service (CLMS), Marine Environment Monitoring Service (CMEMS), Atmosphere Monitoring Service (CAMS), Climate Change Service (C3S), Emergency Monitoring Service (CEMS) and Security Service (CSS). The data is freely available for everybody the only exception is the security service. For detailed information on all the services reader is referred to [1]. Copernicus is system which is being dynamically developed and the user needs are included into system during its evolution.

Use of data depends on specific needs of the user, but as main fields of interests can be named: spatial planning, forestry, water sources management, climate changes, agriculture, marine safety, meteorology and climatology, emergency, natural disaster, multiple issues of security risks and many others.

Forests have significant impact on Earth and humans, due to the impact on the global carbon cycle. It is important to monitor the situation with forests globally to minimize the climate changes and in such way providing healthier environment for future generations [2]. After the launch of all satellites (Sentinel) Copernicus will provide the satellite revisit time as short as two days and it will benefit all the branches where the up-to-date information is crucial.

Forestry is not the only branch which affects global environment. Global changes have important role to understand the Earth environment. It also provides information how the human activities affect the environment we live in. It is crucial to understand and figure out the reasons for the global changes to prevent further escalation and decrease the negative effects [3]. Research show that in this case satellite earth observation data is very useful, especially considering the possibilities of the modern remote sensors mounted on the satellites.

Water has not only direct impact to the humans, but also indirect. If there are not enough moisture in soil where crops are growing it may cause the drought and the crops will die. In such a way moisture of soil is important factor which can cause or prevent such crisis like local or global hunger. Copernicus provides possibility to monitor the moisture of the soil also. It can be stated that water contributes to all aspects of economic and social development [4]. Copernicus is powerful tool for water resources management.

Copernicus deals also with security issues, such as: border surveillance, maritime surveillance and support to EU External action. In mentioned areas, main objectives are to reduce number of illegal immigrants entering the EU, to reduce death toll of illegal immigrants, to increase security of the EU, safety of maritime navigation, fisheries control, marine pollution, support third countries in a situation of crisis or emerging crisis, prevention of global and trans-regional threats having a destabilizing effect [1][5][6].

It is planned that 3 new Sentinel satellites will be launched in 2017 (Sentinel-2B, Sentinel-5P and Sentinel-3B). New satellites will provide additional data and in such way, the existing products will be improved. The useful tool for the users will be the Copernicus product catalogue, it is planned that product catalogue will be active in first half of 2017. At this moment catalogue runs in testing mode and there are nearly 600 products listed in it. User will be able to search products by keywords.

Copernicus will provide multiple new products in its services in 2018. Drought observatory will be included under CEMS (it will help to fight with droughts and its impact to economics – drought is a global hazard with significant economic, societal and environmental impacts, approx. 3 billion Euros/year in Europe), CSS will introduce multiple new products such as: support to ice monitoring (iceberg detection and sea ice monitoring), lost container detection and tracking, detection of missing aircraft (debris, jet fuel spill) and several improvements in border surveillance.

REFERENCES

1. http://copernicus.eu
2. Achard F., Hansen M. C. GLOBAL FOREST MONITORING FROM EARTH OBSERVATION. CRC Press, Taylor & Francis Group, 2012, 354 p.
3. Chuvieco E., Li J., Yang X. ADVANCES IN EARTH OBSERVATION OF GLOBAL CHANGE. Springer, Netherlands, 2010, 298 p.
4. Garcia L., Rodriguez J. D., Wijnen M., Panulski I. EARTH OBSERVATION FOR WATER RESOURCES MANAGEMENT. World bank, Washington DC, 2016, 233 p.
5. http://externalaction.security-copernicus.eu/
6. http://maritimesurveillance.security-copernicus.eu/

IMPROVEMENT OF DFHRS V.4.3 SOFTWARE

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Quasi-geoid is an equipotential surface which defines best mean sea level and is orthogonal to force of gravity at any point. The definition of precise quasi-geoid model plays an important role, as new techniques such as GNSS technologies give an opportunity to determine ellipsoidal heights and in the result using quasi-geoid model, determination of normal heights become much faster and easier in comparison with levelling measurements. In order to compute precise quasi-geoid model DFHRS software is used and development and further improvement is described in this article.

DFHRS (Digital Finite-element Height reference surface (HRS)) software development was commenced in 1998 in Karlsruhe University of Applied Sciences, Institute of Applied Research [5]. The principle of the software is the computation of quasi-geoid model using parametric modelling. HRS surface is computed from geometrical observations (GNSS/levelling points and vertical deflections) and physical data (gravitational acceleration). The principle of a GNSS-based height determination H requires submitting the GNSS-height h to the DFHRS(B,L,h)-correction N, reading (Eq. 1):

The region of interest is divided into finite elements, or so called meshes and *p* polynomials are computed. These *p* parameters are stored in DFHRS_DB database in order to get an access to parametric HRS model. In order to reduce an effect of medium-wave or long-wave length, DFHRS concept allows to subdivide region of interest into patches or so called "geoid-patches". Each patch has a datum and associated transformation parameters *d*. Continuity conditions should also be considered, boundaries between two meshes should be the same, so that meshes represent the whole continuous area [2].

The further development of DFHRS v 4.3. was commenced in 2013 under Visual Studio 2012 environment using C++ programming language [3]. This version allows the use of vertical deflections derived from Global

Potential Model (GPM), e.g. EGM2008, as well as observations from digital zenith cameras. This article performs some bugs that were investigated in this software and described the reasons of these bugs and its corrections.

There are different global potential models which are implemented in this software, e.g. EGM96, EGG97, EIGEN05, EGM2008. All these models except EGM2008 are equal to degree and order of 360 and include satellite, gravity and altimetry data. EGM2008 model is equal to 2190 degrees and order and include satellite data (GOCE, GRACE, LAGEOS), gravity and altimetry data [6]. As EGM2008 model is of the highest degree and order, a problem concerning threads was faced, because in the result EGM2008 application was impossible, and DFHRS software was not responding. In order to correct this problem, the number of threads was changed in order CPU would use about 75% of memory. New EIGEN6C4 model that was developed in 2014 was implemented in DFHRS v.4.3. This model includes satellite data (GOCE, GRACE, LAGEOS), gravity and altimetry data and is equal to 2190 degree and order.

The next bug concerns the use of observations from digital zenith camera. At the moment Institute of Geodesy and Geoinformatics has made 5 tests observations from digital zenith camera in Riga region. In order to use this data, some code changes have been done. The residuals from zenith camera observations at the moment are equal to approximately 0,15 seconds. After all bugs were corrected there have been made comparisons of quasi-geoid model for Riga region between using EGM2008 and EIGEN6C4, the comparison between quasi-geoid computed from EGM2008 with/without vertical deflections derivatives, and the comparison between quasi-geoid computed from EGM2008 with/without zenith camera observations. Standard deviations of different solutions are performed in table 1.

Table 1

Solutions of quasi-geoid model for Riga region

Used data	Standart deviation (m)
EGM2008 model + observations from digital zenith camera	0,0112
EGM2008 model	0,0109
EIGEN6C4 model	0,0110
EGM2008 model with derrived vertical deflections	0,0127

The next step of the development of the software concerns spherical-cap-harmonics (SCHA) as the designed carrier function of the gravity potential V represented by *S'* and *C'* coefficients (Eq.2):

$$V(r,\lambda',\theta') = \frac{G*M}{a}\sum_{a}^{k\,max}\left(\frac{a}{r}\right)^{n(k)+1}\sum_{m=0}^{k}\left(c'_{n(k),m}*cosm\lambda' + S'_{n(k),m}*\right.$$
$$\left.*\,sinm\lambda'\right)P_{n(k),m}(cos\theta')) \quad (2)$$

where

$$tan\lambda' = \frac{cos\varphi\sin(\lambda-\lambda_0)}{sin\varphi cos\varphi_0 - cos\varphi sin\varphi_0 cos(\lambda-\lambda_0)}$$

$$cos\theta' = sin\varphi sin\varphi_0 - cos\varphi cos\varphi_0\cos(\lambda-\lambda_0)$$

It allows the computation of both a full gravity field modeling and quasi-geoid determination. The advantage of spherical-cap- harmonics (SCH) modelling in comparison with spherical harmonics (SH), is that less number of parameters are needed for the same resolution for spherical cap area, as only region of interest is taken into account, so in the results it is not so much time consuming process any more and needs less memory requirements for the computation [1]. DFHRS software is worldwide unique and can be used for both gravity field modelling and quasi-geoid determination, as well as integrated geodetic networks of all types. DFHRS v 5.0 software allows the use of geometrical data (GNSS/levelling heights), physical data (gravity accelerations) and Global Potential Models (GPM) [4]. The next step of the development of DFHRS software is dealing with the design optimization for the use of gravity measurements and vertical deflections data observed from digital zenith camera based on spherical cap harmonics modelling. This version will be developed under Visual Studio 2012/2015 using object-oriented C++ language.

REFERENCES

1. Ghadi K. A. Younis, Reiner Jäger, Matthias Becker Transformation of global spherical harmonic models of the gravity field to a local adjusted spherical cap harmonic model (2011) *Arabian Journal of Geosciences.*
2. Jäger R., Kaminskis J., Strauhmanis J. and Younis G. 2012. Determination of quasi-geoid as height component of the geodetic infrastructure for GNSS positioning services in the Baltic States *Latvian J. of Physics and Technical Sciences* 35–15.

3. Owusu-Banahene, William: Further development of the DFHRS concept and software (C++) under Visual Studio 2012 and computation of the Geoid for Albania. Master's thesis *University of Applied Sciences* (2013).
4. Younis, Ghadi: Regional Gravity Field Modeling with Adjusted Spherical Cap Harmonics in an Integrated Approach. *Schriftenreihe Fachrichtung Geodäsie der Technischen Universität Darmstadt (39)*. Darmstadt. ISBN978-3-935631-28-0 (2013).
5. http://dfhbf.de/
6. http://icgem.gfz-potsdam.de/ICGEM/

SENTINEL DATA FOR CHANGE DETECTION

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Since European Space Agency was launched Copernicus program, everyone can use a big amount of data free of charge. Those data discover new possibilities for scientists, engineers and for people who are not the specialist in Earth Observations. The most important part of Copernicus program is Sentinel program. This program content satellite systems which covering a board range of applications in support to six thematic areas: land, marine, atmosphere, climate change, emergency management and security.

Sentinel data is possible to download from different sources. European Space Agency provides data download from Scientific sentinel data hub since the year 2015. Now in the year 2017 is possible to download data from new data services (Amazon (Fig. 1.), Planet, Google Earth Engine, etc.) which provide duplicate and adapted data for special tasks.

Sentinel 1 data global coverage can be achieved within 6 days, therefore only Sentinel 1 data volume for one year is 156 TB. Therefore is necessary to build one local data storage, where will store data and adapt for users in Latvia. This will solve a problem, those different government organizations (Land Support Service, Land State Service, etc.) and private companies do not copy data to own servers.

Sentinel 1A and 1B provide radar data with a resolution from five to 100 m. It depends on scanning angle. Mostly data are with 30 m resolution. Sentinel 2A and 2B provide optical images with a resolution from 10 to 60 m. Sentinel 2 images are with 13 different resolutions bands, therefore resolution depends on bands. Very important that Sentinel 2 satellite swaths are 250 km. For change detection, it is important that area captured in short periods with big swath. In Latvia lot of days in summer are with clouds, therefore is problem to monitor soil moisture. To solve this problem for change detection most useable is radar data [1]. Sentinel 1 mission carrying a Synthetic Aperture Radar operating at a frequency 5.405 GHz

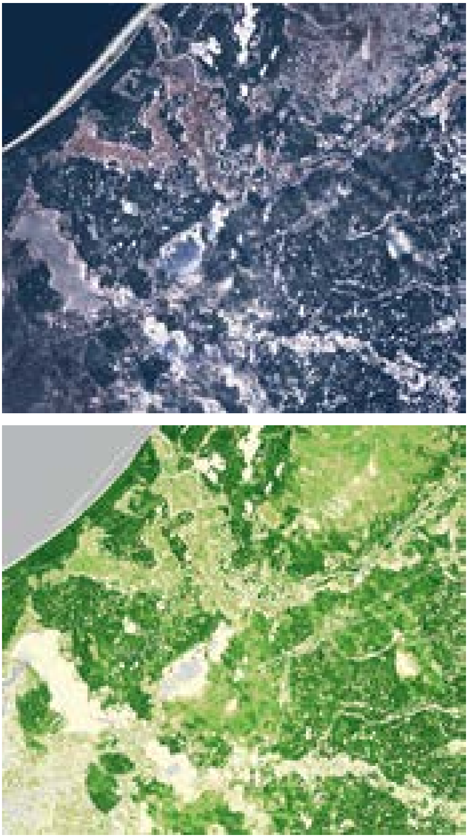

Fig. 1. Amazon service images of Latvia: (a) Sentinel 2 RGB image, (b) NDVI from satellite image

(C-band). Radar data signal penetrate true clouds and therefore on cloudy days is possible to achieve data with short time series. From radar data processing, the theory is possible to achieve height differences from half of wavelength, therefore Sentinel radar data is possible to use for vertical movement change detection from 2.7 cm [2].

Copernicus program includes services for marine, land monitoring and other industries. Those services provide already done solutions for clients, but for some cases, it is not enough. Therefore, Sentinel data is possible to post processing with commercial software's like Hexagon ERDAS and others, which include radar and optical sensor data processing tools. European Space Agency have interest for wider Sentinel data usage, therefore made free software SNAP [3]. This software can use for radar and optical sensor data processing. In addition, open source program Quantum GIS have special plugins for optical sensor data classification.

In near future free data with open source processing software's will growth earth observations sector and for EUR 1 spend the European Union will return EUR 1.8 from economic benefits [4].

REFERENCES

1. Henri Maitre Processing of Synthetic Aperture Radar Images (2008) *John Willey&Sons.*
2. Giorgio Franceschetti, Riccardo Laneri, Synthetic Aperture Radar Processing (1999) *CRC Press.*
3. http://step.esa.int/main/toolboxes/snap.
4. http://www.copernicus.eu, Copernicus_Market_Report_11_2016.pdf.

VIETĒJAIS ĢEODĒZISKAIS TĪKLS RĪGAS PILSĒTAS TERITORIJĀ. GNSS EUPOS RĪGA

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Vietējā ģeodēziskā tīkla (VT) 2012. un 2013. gada apsekošanas rezultāti. VT pilnveidošanas koncepcijas līdz 2020. gadam sastādīšana (2013.), galvenais secinājums – konstatēts, ka mērniecībā Rīgas teritorijā pārsvarā tiks izmantotas GNSS metodes. Iedalīti rajoni, kur pavadoņu signālu uztveramība ir apgrūtināta, tādās vietās plānots attīstīt VT ar klasiskām metodēm.

VT aprakstu (projektu) sastādīšana (2012.–2015.).
Iepriekšējos gados ģeodēziskie mērījumu darbi tika veikti atbilstoši precizitātei, kas atbilst 497.MK noteikumu prasībām:

- Bijušā 2. Klases nivelēšanas tīkla pārrēķināšana.
- 2006., 2008. un 2010. gadā veikta poligonometrijas pārrēķināšana. Papildus tika veikti kontrolmērījumi, kas apliecina iespēju, izmantot punktu pārrēķinātās koordinātas un augstumus.

Jauna VT izveide teritorijā Vecrīga un Torņakalns – Āgenskalns.
Objektu nodošana aizkavējusies, šobrīd tie atrodas nodošanas stadijā.

VT pilnveidošanas procesa pieredze:

- Nepieciešams rūpīgāk gatavot konkursa apraksta dokumentāciju, tajā skaitā konkrētāk norādīt tehnisko specifikāciju un citas prasības.
- Konstatēts atsevišķu normatīvo aktu iztrūkums – maz tādu normatīvo aktu, kuros detalizēti aprakstīta mērījumu metodika.
- Latvijā pietrūkst mērniecības uzņēmumu, kuri ir spējīgi paveikt VT pilnveidošanu kvalitatīvi un ātri.

Nākamiem plāni un perspektīvas:

- pabeigt uzsāktu VT pilnveidošanas objektu.
- uztaisīt nivelēšanu visai pilsētas teritorijai ar N2 klases precizitāti.

EUPOS-RĪGA pēdējās aktivitātes:

- 2015. gada pavasarī Rīgas domes Pilsētas attīstības departaments (RDPAD) pārņēmis EUPOS-RĪGA tīkla uzraudzību.
- 2016. gada pavasarī mainīti EUPOS-RĪGA bāzes staciju nosaukumi.
- 2016. gada pavasarī mainīts datu apstrādes servera risinājums - veikta pāreja uz virtuālā servera platformu.
- 2016. gada pavasarī atsākta regulāra GEO++ GNSMART programmatūras atjaunināšana.
- No 2016. gada pavasara EUPOS-RĪGA datu pakalpojumi (RTK, DGPS, RINEX) jebkuram speciālistam vai interesentam kļuva pieejami bez maksas.

EUPOS-RĪGA plāni:

- Jaunu datu pakalpojumu nosacījumu izstrāde.
- EUPOS-RĪGA bāzes staciju modernizācija.
- Ciešāka sadarbība ar EUPOS organizācijas partneriem.
- Pastāvīga lietotāju informēšana par visām ar EUPOS-RĪGA saistītajām aktivitātēm.
- EUPOS-RĪGA kā elementa iesaiste Rīgas vietējā ģeodēziskajā tīklā.
- EUPOS-RĪGA pieejamība jebkuram interesentam bez maksas.

PAKĀPJU PIRAMĪDAS STABILITĀTE NETIEŠIE VĒRTĒJUMI

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Ievads

Augstvērtīgu akmens būvju stabilitātes novērtēšanai par pētījuma objektu tika izvēlēta valdnieka Džosera Pakāpju piramīda Sakāras nekropolē Ēģiptē. Tā ir visai sarežģīta būve, kas savu pašreizējo izskatu ir ieguvusi vairāku pakāpenisku pārbūvju rezultātā. Šeit sena un ļoti liela solveida virszemes kapene (mastaba) pārbūves procesā tika paplašināta divos posmos, kurus noslēdz 4-pakāpju piramīdas izbūve virs paplašinātās mastabas. Pēc tam, virs 4-pakāpju piramīdas tika izbūvēta vēl lielāka un plašāka 6-pakāpju piramīda. Vēlāk ir sekojušas vēl vairākās būvniecības un daļējas rekonstrukcijas stadijas

Pašreizējā veidolā piramīdas pamatne ir 121 x 109 metri, un augstums sasniedz 63 metrus, bet mūsdienās noteiktais piramīdas tilpums ir aptuveni 330 400 kubikmetru. Tomēr ir jāņem vērā, ka piramīdas iekšienē un zem tās ir vairākas visai ievērojamu izmēru šahtas un pazemē ir izveidots vairāk kā 6 km garš tuneļu un dažādu telpu tīkls, kā arī 28 metrus augsta apbedījuma šahta (Lehner, 2004).

Valdnieka Džosera piramīda nav viendabīga un tās izbūvē ir izmantoti dažādi, tajā skaitā, būvniecībai nepiemēroti materiāli. Tas bija zināms jau senatnē, un tādēļ šeit vairākkārtīgi tika veikti iespaidīgi rekonstrukcijas un pārbūves darbi. Vienlaicīgi izceļams, ka Sakāras plato, kur izvietots Pakāpju piramīdas komplekss, atrodas seismiski aktīvā zonā. Šeit zemestrīces tiek fiksētas vairākas reizes gadā un ir zināms, ka 1992. gada zemestrīces rezultātā šeit aizbruka ne tika atsevišķi pazemes tuneļi, bet ievērojami cieta arī Džosera piramīdas fasādes daļas. Lielākā bojājumu daļa tika mehāniski nostiprināta ar cementa masu un lietu betonu, kas atšķirīgo īpašību dēļ vietām turpina negatīvi ietekmēt kopējo būves stabilitāti. Tās novērtēšanai tika veikts piramīdas būves monolītuma iepriekšējs novērtējums, kas ļautu izvelēts piemērotu būves saglabāšanas stratēģiju nākotnē.

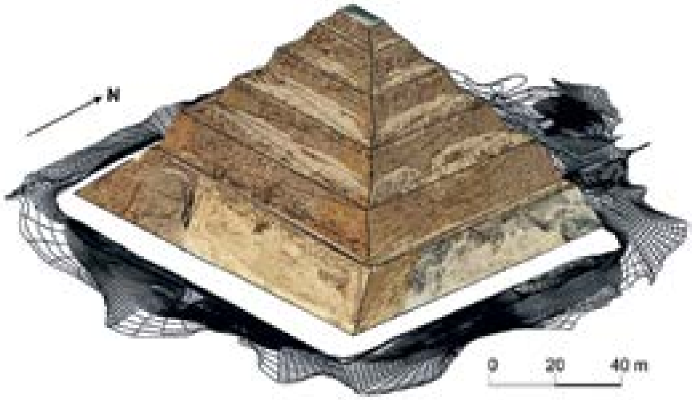
Pētījums

Piramīdas fasāžu fotodokumentēšana tika veikta ar SONY DSC-R1 10,3 Mpix digitālo fotokameru. Visas pētījuma vajadzībām pieejamās Džosera piramīdas fasāžu fotogrāfijas (uzņemtas laika periodā kopš 2005. līdz 2011. gadam, kopā apmēram 2300 fotoattēli) tika klasificētas sākotnēji pēc uzņēmuma iegūšanas laika (gads, mēnesis), pēc tam – piesaistot uzņēmumus piramīdas konkrētām fasādēm un stūriem (šķautnēm). Papildus tika atzīmēti dati par attēla lielumu, kameras specifikācija, kā arī norādītas papildus ziņas par fotografēšanas apstākļiem. Datu bāzē apkopotās digitālās krāsainās fotogrāfijas veido datu pamatmasīvu.

Piramīdas ģeotelpiskais modelis tika izstrādāts Bentley MicroStation datorprogrammu vidē. Modeļa tehniskai izveidošanai dr. M. Kaļinka izmantoja Latvijas zinātniskās ekspedīcijas laikā iegūtos 3D lāzerskenera datus par Džosera piramīdas pirmajām divām pakāpēm, piramīdas trešās, ceturtās, piektās un sestās pakāpes izveidei par pamatu tika izmantots jau esošs modelis, kas veidots ar Google SketChup programmu, veicot tā koriģēšanu, balstoties uz Džosera piramīdas arhīva dokumentos pieejamiem datiem. Ģeotelpiskā modeļa noslēguma versiju dr. A. Kukela veidoja, izmantojot datorprogrammā MicroStation V8i iestrādāto virsmas veidošanas algoritmu *smartsurface*.

Piramīdas atsevišķu fasāžu foto mozaīkas (foto montāžas) izveidei un tās tālākai integrācijai izstrādātajā 3D modelī no izveidotās datu bāzes tika atlasīti atbilstoši fasāžu fragmentu fotoattēli. Attēlu mozaīkas novietošana, kā arī dēdēšanas veidu un to intensitātes attēlošana uz piramīdas ģeotelpiskā modeļa tika īstenota ar datorprogrammas MicroStation V8i moduli "*Descartes*". Šī datorprogramma paredz arī iespēju aprēķināt izzīmēto laukumu platības. Par cik Džosera pakāpju piramīdas ģeotelpiskais modelis ir izveidots mērogā, ievērojot piramīdas reālos izmērus un dimensijas, izzīmētos dažādas dēdēšanas un intensitātes laukumus ir iespējams izteikt skaitliski (kvadrātmetros).

Piramīdas ģeotelpiskais modelis tika veidots pēc iespējas precīzs, pamatojoties uz datiem, kurus bija iespējams iegūt par objektu ar ierobežotu pieejamību pētījumiem un dokumentācijai. Papildus apgrūtinājums ir būtiska Pakāpju piramīdas pārbūve, kuras rezultātā tiek pilnībā liegta iespēja iegūt atjaunotus vai papildinātus datus. Izveidotajā piramīdas ģeotelpiskajā modelī tika iestrādāta izveidotā piramīdas fasāžu mozaīka (1. attēls), tādējādi veidojot pamata bāzi specifiskās informācijas slāņu integrācijai.



1. attēls. Piramīdas ģeotelpiskais modelis ar integrēto piramīdas fasāžu fotomozaīku

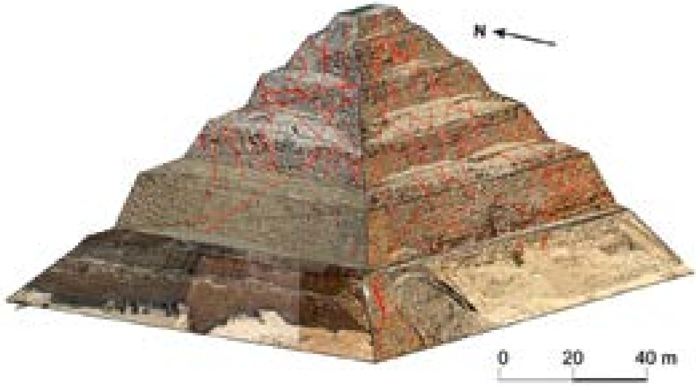
Turpmāk pētījuma ietvaros izstrādātajā piramīdas 3D modelī tika integrēti specifiskās informācijas slāņi – dēdēšanas veidi un to intensitāte, kā arī būvē konstatētās plaisas un pārrāvumi.

Pakāpju piramīdas stabilitāte

Sakāras plato teritorija ir sen zināma kā seismiski aktīva zona, kur katru gadu tiek fiksētas zemestrīces vidēji ar 4 baļļu magnitūdu. Diemžēl sistemātiski seismiskās aktivitātes novērojumi šeit netiek veikti, bet esošo seismisko staciju dati neatbilstošas kvalitātes dēļ nav iekļauti nevienā no starptautiskajiem seismisko novērojumu tīkliem.

Zemestrīču ietekme un postījumi ir visai nozīmīgi un īpaši uzskatāmi tie ir ne tikai pazemē, bet arī Džosera piramīdas ārsienās. Veiktais Džosera piramīdas plaisu un pārrāvumu pētījums balstās uz 2006.–2011. gadā vairākkārtīgi veiktiem piramīdas fasādes augstas izšķirtspējas fotodokumenēšanas darbiem un iegūto attēlu detalizētu analīzi. Pētījumā plaisas un pārrāvumi ir konstatēti visās piramīdas fasādēs, tie ir atpazīstami visās fotodokumentācijas pētījumu sērijās vairāku gadu laikā.

Pētījumā izmantotais 3D modelis ir būtisks ieguvums un rada priekšrocības kā datu piesaistei, tā arī šo datu un rezultātu interpretācijai (Seglins, Kukela, 2012). Pašu nozīmīgāko plaisu un lūzumu analīzes rezultāts ir parādīts 2. attēlā.



2. attēls. Noteikto lūzumu un plaisu izvietojums uz piramīdas fasādēm

Secinājumi

Apzinātās plaisas un lūzumi piramīdas fasādēs ir konstatējamas, sākot no plaisām atsevišķos būvakmens blokos un to grupās. Vairāki lūzumi ir konstatēti un pārbaudīti dabā un aptver visu piramīdas pakāpienu. Ir konstatēti tādi lūzumi, kas šķērso piramīdas fasādes lielāko daļu. Blakus apskatītajiem lūzumiem īpaši analizējami ir visās piramīdas fasādēs konstatētie diagonāli vērsti lūzumi. Daudzi no tiem ir izsekojami ne tikai vairākās pakāpēs, bet arī vairāk nekā trešajā daļā no fasādes platuma. Minētais norāda uz būves viendabīguma zudumu un tas ir uzskatāms par ļoti nopietnu apdraudējumu objekta saglabāšanai nākotnē.

3D modelis uzskatāmi norāda galvenos plaisu orientācijas virzienus un ļauj prognozēt visas būves deformācijas nākotnē. Būves atrašanā seismiski salīdzinoši aktīvā zonā tikai paaugstina riskus, kā arī norāda uz plašāku instrumentālu pētījumu nepieciešamību visā būvē.

IZMANTOTĀ LITERATŪRA
1. Gupta, R.P. 2003. Remote Sensing Geology, 2nd ed. Book. Spinder Verlag, Germany, p. 655.
2. Lehner, M. 2004. The Complete Pyramids. Book. The American University in Cairo Press, p. 256.
3. Seglins, V., Kukela, A. 2012. Damage assessment and 3D visualization: an example of the Step Pyramid, Egypt. In Proceedings of the International Multidisciplinary Scientific Geo-Conference Surveying Geology & mining Ecology Management, SGEM2012, Bulgaria, pp. 1005–1011.

ĢEORADARU PRAKTISKAIS PIELIETOJUMS INŽENIERKOMUNIKĀCIJU CAURUĻVADU NOVIETOJUMA PRECIZĒŠANAI

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Digitālais laikmets, jaunākās izbūves tehnoloģijas un nepieciešamība sakārtot datus par pilsētas inženierkomunikāciju tīkliem nostāda pietiekami augstas prasības pret šo tīklu ģeogrāfiski precīzu novietojuma attēlojumu. Pārsvarā pilsētas inženiertīkli ir izvietoti pazemē neveicot rakšanu, tīklus grūti apsekot vai noteikt novietojumu. Arhīvos uzglabātie dati par tīkliem mēdz būt pretrunīgi sakarā ar ilgo pastāvēšanas vēsturi un vairākkārtējo pārbūvi avāriju likvidāciju nolūkos.

Pazemes inženierkomunikāciju cauruļvadu uzmeklēšanai pielieto dažādas ierīces: pazemes komunikāciju lokatorus, korelātorus, metāla detektorus virszemes elementiem, ģeoradarus un c. Katra no šīm ierīcēm darbojas pēc saviem principiem, katrai ir savs šaurs pielietojums, savas priekšrocības un trūkumi. Par šobrīd visbiežāk pielietoto vai populārāko ierīci var nosaukt pazemes komunikāciju lokatoru paveidus. Šie lokatori uzmeklē elektromagnētiskos signālus, kas rodas ap metāla komunikācijām un var darboties gan pasīvajā, gan indukcijas režīmā pielietojot ģeneratoru. Tā pat kā citas, šī ierīce nav universāla un arī tās darbības zona mēdz būt ierobežota. Tieši tāpēc ir svarīgi caurskatīt ierīces ar atšķirīgu darbības principu, kas pie paralēlas un neatkarīgas izmantošanas varētu kompensēt nepilnības.

Ģeoradari pasaules praksē arī cenšas iekarot savu vietu, to pielietojums dažādās jomās ir iespaidīgs. Neskatoties uz vizuālām atšķirībām un komplektācijas variācijām, ģeoradaru darbība balstās uz dažādu frekvenču izstaroto un uztverto impulsu principa. Atkarībā no izstarotās frekvences impulsa var variēt zondēšanas dziļums. Zondēšanas rezultāts parādās attēla veidā un literatūrā tam ir atrodami vairāki nosaukumi: ģeofizikālais profils, ģeoskenēšanas profils, radaragramma.

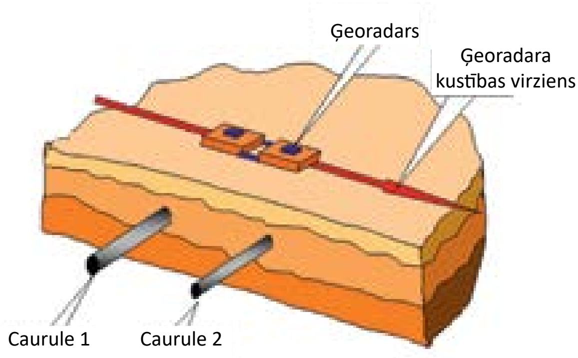
Kopumā pieredze ar ģeoradariem inženierkomunikāciju cauruļvadu novietojuma precizēšanas gadījumos nav plaši un detalizēti aprakstīta, rezultāti mēdz būt pretrunīgi vērtēti un ir grūti noteikt šīs ierīces pielietojuma lietderību. Lai varētu iegūt personīgo pieredzi un izmēģinātu ierīces darbību noteiktajos ģeoloģiskajos un apbūves apstākļos, SIA "Rīgas Ūdens" kā ūdensapgādes un kanalizācijas tīklu turētājs, Rīgā 2015. un 2016. gados īstenojis dažus eksperimentus un apkopojis iegūto pieredzi.

Izpētes darbiem tika izvēlēti apgabali dažādās Rīgas pilsētas vietās. Vecrīgā izvēlētais apgabals atradās blakus prezidenta pils krastmalas pusē. Centrālajā rajonā tika izvēlētas vietas ar lielu komunikāciju blīvumu, biezu kultūrslāni un sarežģītiem pazemes cauruļvadu mezgliem. Tika pētīta smilšaina un mitra Zaķusalas teritorija ar nelielu komunikāciju skaitu un vidējiem ūdensvadu diametriem. Izpētē piedalījās arī teritorija Ķekavā, kur daļa no maģistrāliem vadiem bija atrakta un precīzi uzmērīta, tur cauruļvadu trases tika "paturpinātas" izmantojot pazemes komunikācijas lokatorus un ģeoradaru. Visbeidzot tika apskatīta smilšaina teritorija aiz Juglas ezera uz Baltezera pusi, kur atrodas liela diametra maģistrālie vadi ar virszemē maz redzamiem armatūras elementiem un turklāt tie ir izvietoti lielos attālumos viens no otra.

Apkopojot šajos eksperimentos iegūto pieredzi, var droši apgalvot, ka ir ļoti svarīga sagatavošanās fāze ģeoskenēšanas darbiem un tā ietver:

1. Pētāmā apgabala noteikšanu, ģeoloģisko un apbūves apstākļu pārzināšanu;
2. Pētāmo pazemes komunikāciju cauruļvadu konstrukciju pārzināšanu;
3. Arhīva materiālu apkopošanu;
4. Tīklu virszemes elementu sameklēšanu;
5. Jāizmanto topogrāfisko un citu komunikāciju datus viennozīmīgai tīklu identificēšanai.

Veicot lauka izpētes darbus būtu vēlams līdz ar ģeoskenēšanas darbiem no sākuma vai paralēli izmantot pazemes komunikāciju lokatorus, it īpaši esot tuvumā pazemes tīklu virszemes armatūrai (lokatoru izmantošana ļauj sameklēt un pārliecināties par cauruļvada virzienu, kā arī salīdzināt iegūto ieguldīšanas dziļumu datus). Visvienkāršākā ģeoradara komplektācijas gadījumā (izmantojot sitas ierīces- ģeoskenēšana var notikt savādāk) skenēšanai jānotiek virzoties no vienas armatūras līdz nākošai, ar izvēlēto intervālu, perpendikulāri caurules virzienam un fiksējot novietojumu un dziļumu (1. Attēls). Atrodoties tieši virs iespējamās caurules, veikt pozīcijas piesaisti (GPS) vai atzīmēt trasi ar marķieri.



1. attēls.

Apkopojot SIA "Rīgas Ūdens" iegūto pieredzi un balstoties uz ģeoradaru darbības principiem var izsecināt:

1. Ir svarīgi teritorijas ģeoloģiskie apstākļi, gadsimtos mērojama pilsētas apbūves vēsture ar sarežģītu un biezu kultūrslāni var stipri ietekmēt ģeoskenēšanas rezultātus. Labi rezultāti ir sasniedzami rajonos ar neilgu apbūvi, pilsētas vēsturiskajā daļā rezultātiem uzticēties ir grūti;
2. Maza diametra caurules ir sliktāk identificējamas, tomēr lielu diametru (maģistrālo) vadu gadījumā iegūtie rezultāti bija ļoti apmierinoši;
3. Tīklu mezgli var būt dešifrēti kļūdaini, konstrukcijas dēļ;
4. Vislabākos rezultātus var sasniegt taisniem cauruļvadu posmiem ar pietiekami lielu diametru- maģistrālo vadu novietojuma precizēšanai ģeoradaru var uzskatīt par labu alternatīvu šurfēšanas darbiem.

Formulējot priekšnosacījumus veiksmīgam rezultātam var apgalvot, ka ir svarīga gan ģeoizpētes operatora pieredze, gan teritorijas un tīklu apstākļi, Jāatvēl pietiekamu laiku gan arhīva datu apkopošanai, gan lauka darbiem, gan sekojošai lauka datu apstrādei.

COMMON SITE CALIBRATION PARAMETER CALCULATION OF TRIMBLE VRS MEASUREMENT METHOD FOR USE IN THE TERRITORY OF LATVIA

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Abstract

According to nationa regulations national coordinate system LKS-92 and LAS 2000.5 height system must be used. Problem is that National Geodetic network is locally fixed to ETRS89 (epoch 92.75), but have no known transformation parameters. Trimble VRS Now TEC network is fixed to the same datum, but different epoch (epoch 89.0). For practical use of Trimble VRS Now TEC coorection service in local coordinates it is necessary to connect measurements to local reference. Aim of the research was to determine common Site Calibration parameters for use in all territory of Latvia [1].

GNSS data post processing, network adjustment and site calibration parameters is calculated using Trimble Business Center software version 3.70.1, output date 2016.04.01. GNSS vectors are processed using data registration interval 30 seconds, elevation mask 10 degrees above horizon. All GNSS vectors have fixed solutions. GNSS vectors are processed using IGS precise orbits. Network adjustment is done using Least square adjustment. Network consist of 91 vector [2]. IN this scheme with red color there are error ellipses. Site calibration parameters is computed using calculated geodetic parameter pairs of common GNSS antenna in both reference systems [3][4][5].

ETRS89 (epoch 89.0) coordinates is used as geodetic coordinates in degrees minutes and seconds format, national coordinates of the same station is used LKS-92 Transversal Mercator projection coordinates and elevation determined from quasi geoid model.

Results

As a results of the calculation horizontal and vertical calibration parameters was calculated.

Translation Translation X direction is 0.005 m, Y direction 0.035 m at the origin point. Scale is calculated 0. 9999999809.

Vertical translation is 0.040 m, slope X direction -0.124 ppm, slope Y direction -0.079 ppm. Origin point is computed automatically. Residual diferences show the expectabble precision of the determined parameters (Table 1).

Mean residual differences between GPS and knewn coordinates was calculated to evaluate calculated parameter precisions. Residual differences is 4 mm in plane, 5 mm in height and 7 mm in 3D. Maximum residual differences is in plane 10 mm in station Kuldiga, in height 13 mm and in 3D 14 mm in station Ojars (Table 2).

Table 1

Horizontal and vertical calibration parameters

Translation X:	0.005 m	**Vertical translation at origion:**	0.040 m
Translation Y:	0.035 m	**Slope X:**	-0.124 ppm
Rotation:	-0°00’00”	**Slope Y:**	-0.079 ppm
Origion X:	313460.987 m	**Origion X:**	266705.147 m
Origion Y:	553425.707 m	**Origion Y:**	316436.124 m
Scale:	0. 9999999809	**Vertical translation at origion:**	0.040 m

Table 2

Residual Differences Between GPS and Known Coordinates

	Root Mean Square residual	Point	Maximum residual
Horizontal	0.004 m	KUL1	0.010 m
Vertical	0.005 m	OJAR	0.013 m
Three-dimentional (3D)	0.007 m	OJAR	0.014 m

Site calibration parameter verification is done using another GNSS data set with the same length but from different time period in December 2016. The results of the verification calculation show almost the same parameters. Difference in vertical translation at the origin was 6 mm. Verification of the results showed that the calculated parameters is close to root mean square residual.

Conclusions

1. Using calculated site calibration parameters it is possible to get coordinates at 14 mm level.
2. Site calibration parameters and precision fully consistent with national regulations for topographic and geodetic survey for cadastral purposes.
3. Calculated site calibration parameters can be used all over the territory of Latvia.
4. Site Calibration is the basic methodology used to ensure uniformity of measurements made by different surveyors.
5. State Geodetic network should be monitored and connection parameters should be kept up to date by governmental organisations.
6. Applied surveying must be instantly suppported by govermental organisations.

REFERENCES

1. Žagars J., Zvirgzds J., Kaminskis J. Globālās navigācijas satelītu sistēmas (GPS), p. 157–169.
2. http://tbchelp.trimbleinsphere.com/tutorial/, Processing GNSS Baselines, ProcessingGNSSBaselines.zip
3. http://tbchelp.trimbleinsphere.com/tutorial/, Calibrating a site, CalibratingaSite.zip
4. http://www.can-net.ca/index.php?option=com_content&view=article&id=32&Itemid=74, Site Calibrations
5. http://apps.trimbleaccess.com/help/en/TrimbleAccess=2016.12, General Survey Help v2016.10.pdf

DIGITAL ZENITH CAMERA PROJECT RESULTS AND PERSPECTIVE

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Design of digital zenith camera in Institute of Geodesy and Geoinformatics of the University of Latvia started in 2010 [1]. A simple prototype camera, employing manual rotation and leveling mechanisms, was constructed. Tests of it demonstrated necessity of computer control over most functional activities. Improvements of camera design included motorized rotation, leveling and focusing mechanisms. In order to simplify communication between the control computer and multiple actuators and data acquisition devices, an on-board control computer was added to the layout. The improved design (Fig. 1.) was finished in 2015, extensive field tests were carried out in 2016. Presently, although some technical aspects still need improvements, we consider the camera ready for regular observations.

Like other digital zenith cameras [2][3], the main part of our design is rotating platform, on it are mounted a 203 mm (8″) telescope, equipped with imaging device (8 Mpix CCD assembly), tiltmeter, leveling mechanism, rotation gear and control equipment. Similar platform below is used as base of leveling and rotation; it is mounted on a field tripod. The weight of rotating assembly is about 12 kg; it is easily detachable from tripod with the lower platform, and is transported in a separate case. The camera needs 12v / 3A power supply.

Observation procedure consists of a sequence of instrument rotation positions. In each position it is leveled with a few arcsecond accuracy, then a number of zenith area star field images are obtained along with tiltmeter readings. A typical observation session takes up to one hour. Astrometric processing of image data [5] provides coordinates of projection of ellipsoidal zenith on the image. Calculation of vertical deflection value is based on analysis of the pattern, made by ellipsoidal zenith projections (corrected for residual tilt of instrument). If the instrument would be ideally leveled in each rotation position, plumb line would project in a

Fig. 1. Zenith camera. All measuring devices and actuators are on the rotating upper platform

single point in CCD coordinate system (with location, determined by tiltmeter zero-point offsets and tiltmeter orientation relative to imaging subsystem). Trajectory of ellipsoidal zenith would be a circle around plumb line's projection [1]. Parameters of this circle (radius and phase) would give components of vertical deflection value. In reality, leveling can never be ideal, therefore corrections, obtained from tiltmeter measurements during frame exposure, must be applied to calculated ellipsoidal zenith coordinates. Besides, in order to compensate (at least, partially) effects of thermal expansion in instrument assembly and various zero-point and sensitivity drifts, linear drift members are added to data model.

On-board computer running Windows is used for data acquisition control. Control and data processing software is designed as a single program. On-board control process is monitored and controlled on a remote console (a laptop) via RemoteDesktop connection. A timer-activated control loop is implemented in the control program, regularly performing query on active devices. If new data is present, it is read, interpreted and visualized, any necessary actions are executed or scheduled. Measurement data are saved in file system and post-processed later.

A number of test observation sessions at a fixed site were carried out in order to find actual capabilities of instrument and select optimal observation methodology. It was found, that, in most aspects, performance is close to expected. Vertical deflection values from about 30 observation sessions (May 2016- January 2017) are within ±0.2 arcsecond limits (rms of average 0.15 arcseconds). Presence of some anomalous refraction effects are suspected, further research should provide more information on it.

In order to test the instrument in real field conditions, 6 observation sessions in different locations were performed. The properties of results were similar to the test site. One of locations was selected because of well-known astronomical longitude that could be used for external test of the instrument – the site of former Time Service transit instrument in Riga. The result was close to value, calculated as difference of astronomical and geodetic longitudes (diverged from it by 0.13″). In general, test results show similar accuracy properties as reported for other digital zenith cameras [2][3]. Now our intention is to proceed with field observations in various sites. Also, some improvements in instrument construction, accessories and control software are planned.

REFERENCES

1. Abele, M.; Balodis, J.; Janpaule, I.; Lasmane, I.; Rubans, A.; Zariņš, A. 2012. Digital zenith camera for vertical deflection determination, *Geodesy and Cartography* 38: 123–129. https://doi.org/10.3846/20296991.2012.755324
2. Hirt, C.; Burki, B.; Somieski, A.; Seeber, G. 2010. Modern determination of vertical deflections using digital zenith cameras, *Journal of Surveying Engineering* 136(1): 1–12. https://doi.org/10.1061/(ASCE)SU.1943-5428.0000009
3. Tian, L.; Guo, J.; Han, Y., *et al.* 2014. Digital zenith telescope prototype of China, *Chinese Science Bulletin* 59: 1978–1983. https://doi.org/10.1007/s11434-014-0256-z
4. Zariņš, A.; Rubans,A.; Silabriedis, G. 2016. Digital zenith camera of the University of Latvia *Geodesy and Cartography* 42: 129–135. https://doi.org/10.3846/20296991.2016.1268434
5. Zariņš, A.; Janpaule, I.; Kaminskis, J. 2014. On reference star recognition and identification, *Geodesy and Cartography* 40: 143–147. https://doi.org/10.3846/20296991.2014.987456

SIA "HADLAT INVEST" piedāvā Latvijas tirgū TOPCON ražotos produktus kopš 2010. gada un SOKKIA mērniecības instrumentus kopš 2014. gada. TOPCON ir viens no pasaules vadošajiem mērniecības, lauksaimniecības un mašīnkontroles produktu ražotājiem. SOKKIA Latvijas mērniecības tirgū vienmēr sevi ir pierādījusi tikai no labākās puses – un lietotāju atsauksmes ir labākā reklāma.

TOPCON lauksaimniecības sistēmas spēj kontrolēt visa veida lauksaimniecības tehniku: traktors, miglotājs, sējmašīna, kultivators, arkls, kombains – to visu iespējams kontrolēt ar TOPCON precīzās lauksaimniecības sistēmām ar 2cm precizitāti.

TOPCON mašīnkontroles sistēmas ļauj kontrolēt rakšanas līmeni ekskavatoram, ļauj "redzēt" buldozera precīzo atrašanas vietu būvlaukumā, izmantojot reāla laika korekcijas, spēj greiderim ātri un precīzi iegūt vajadzīgo līmeni jau pirmajā reizē.

TOPCON un SOKKIA mērniecības instrumenti ir vieni no vadošajiem mērniecības tirgū. TOPCON piedāvā mērniekiem pilnu mērniecības instrumentu klāstu: GPS uztvērējs, robots, tahimetrs, nivelieris, tajos visos ir tikai TOPCON augstākās tehnoloģijas. SIA "HADLAT INVEST" piedāvā mērniecības instrumentu garantijas un pēcgarantijas servisu. Mūsu mērniecības instrumentu serviss spēj veikt visa veida instrumentu apkopes un remonta darbus.

Tas viss ļauj mums rast jaunus risinājumus, kas ievērojami palielinātu Jūsu darba produktivitāti – mērniecībā, ceļu būvē, lauksaimniecībā un celtniecībā.

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