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

Institute of Rock Structure and Mechanics, Academy of Sciences of the Czech Republic

Committee of Geodesy, Polish Academy of Sciences

Association of Students and PhD Students "Zenit-Nadir"

16th CZECH–POLISH WORKSHOP

ON RECENT GEODYNAMICS OF THE SUDETY MTS. AND ADJACENT AREAS

ABSTRACTS

Srebrna Góra, Poland
November 5-7, 2015

Organizing and Scientific Committee
of the

16th Czech–Polish Workshop

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ABSTRACTS

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FIRST RESULTS OF THE POLISH GEOLOGICAL SURVEY'S PROJECT "RECENT FAULTS AND GEOTHERMAL WATERS IN THE SUDETES AND THEIR FORELAND IN THE LIGHT OF STRUCTURAL, GEOCHRONOLOGICAL AND THERMOMETRIC INVESTIGATIONS"

Paweł Aleksandrowski[1], Janusz Badura[1], Szymon Ostrowski[2], Agnieszka Bochnacka[2], Marcin Lasocki[2], Magdalena Pańczyk[2], Bogusław Przybylski[1], Olga Rosowiecka[2], Katarzyna Sobień[2]

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ABSTRACT

The goal of the 2.5-years' (2014–2016) project is to localize, select and preliminarily explore several examples of sub-recent brittle faults and fault zones in the Polish Sudetes and the Fore-Sudetic block, using a number of geological and geophysical methods. The ultimate aim of the exploration is recognition of a potential capacity of the fault zones to serve as conduits for thermal waters of deep circulation.

An number of geophysical methods were applied along more than 20 survey profile lines of total length of c. 30 km, transecting most prominent topography discontinuities, considered to represent young fault zones. The investigation aimed to establish the precise position of fault planes as well as to recognize the geometry of geological bodies adjoining the hypothesized fault zones.

The VLF (Very Low Frequency) electromagnetic method was applied to preliminarily scan each of the survey lines. The VLF method yields one-dimensional scalar data, which, when put together, allows precise location of faults and aids planning and focusing further survey works.

2D seismic survey, locally supplemented with electric resistivity tomography, constituted the main part of the geophysical investigations. Seismic acquisition layout was optimized for obtaining shallow (down to ca. 300–400 m) reflection image. The method yielded satisfactory results that could be successfully interpreted over the Fore-Sudetic block where flat-lying Cenozoic sediments occurred, however over the Sudetic block reflection seismic images were mostly unsatisfactory due to the lack of significant reflectors in homogeneous rock media or in rocks with steeply dipping beds or foliation. The results of reflection seismic were supported by applying the seismic refraction tomography method to processing the data. The electric resistivity tomography (ERT) method was used in rough terrain conditions of limited accessibility. The ERT allowed imaging the electric properties of geological bodies in 2D sections, mostly reflecting the lithology.

The geophysical survey is complemented with experimental thermometric survey, which is still in progress. Simple temperature sensors were installed in the ground, at the depth of 1.5 to 2 m along six survey lines, at a distance interval of

50 m. Temperature of the ground is recorded monthly at each sensor. Statistical approach allows to reduce an impact of seasonal and local variations of the temperature in the ground and to determine zones of increased heat flow by simple means. Until now, 6 of the planned 12 measurement cycles were performed and in one location persistent thermal anomaly was identified.

Radiometric profiling was made along most of the survey lines, estimating the total value of gamma radiation for three energy levels (windows), assumed to represent the emissions of radioactive isotopes of K, Th and U, respectively. Out of these, it is mostly the potassium K40 isotope, whose concentration seem to record either the position of the fault zones or differences between unlike rock suites on both sides of the faults.

A systematic study of the available published and archival recent geological and geomorphological materials, including remote sensing data, has been performed in order to effectively plan our survey. The study revealed that manifestations of the present-day neotectonic mobility in Lower Silesia are not as widespread and ubiquitous as it was believed in the 1970's and 1980's. The main pulse of sub-recent tectonic activity was completed between Oligocene and Pliocene times. Rather insignificant Pleistocene mobility affected the major Sudetic faults and the course of a few rivers on the Fore-Sudetic block, whereas no direct symptoms of fault motions can be detected in the Pleistocene sediments. On indirect premises, the northern and central areas of Lower Silesia, both north of the Sudetes, can be inferred to have undergone minor uplifting motions during the Pleistocene, reflected mostly in a small thickness of Pleistocene deposits. Their average thickness does not exceed 15–20 m, except within frontal moraines and subglacial channels. The mountainous Sudetic area has been differentially uplifted during the Quaternary. Since the Pliocene, some mountain ranges became elevated by as much as 50–60 m, but the lack of correlative sediments significantly hampers precise estimation of the magnitude of vertical motions.

CORRELATION BETWEEN OBSERVED GRAVITY CHANGES AND TIME SERIES DERIVED FROM SATELLITE GRAVIMETRY IN SUDETEN REGION

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ABSTRACT

Measurements of gravity change plays an important role in contemporary geodynamics. Dedicated satellite gravity missions are used successfully to track these temporal changes of Earth's gravity. In areas with clear trend they allow precise monitoring as well as terrestrial methods. Since 1992 gravity measurements at geodynamical test fields in Sudeten Region were carried out. In 2005 reference points of those fields were connected to Polish Gravity Control (POGK).

The presentation will be focused on identification of trends in the absolute values of gravity in Sudeten region and indicating whether these trends are reflected in the observations of temporal changes performed using satellite techniques. For this purpose the products of GRACE (Gravity Recovery and Climate Experiment) and CHAMP (Challenging Minisatellite Payload) missions are used.

THE YANGTZE DAM IFLUENCE ON A LOCAL AND REGIONAL GEODYNAMICAL FLUCTUATIONS

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ABSTRACT

Due to the Three Gorges Dam appearance and fulfilling it with a 40 billion tons of water many geodynamical consequences are still observed. It is obvious, that global geodynamical changes are noticable, and, as well, exactly at Yangtze river area. Instead of the two mentioned, the authors also wanted to measure geoid changes for Europe and for Sudeten and adjacent areas. Globally such changes can be easily noticed and measured with the GRACE (Gravity Recovery and Climate Experiment) gradiometric satellites. As the data available thanks to GRACE is in a form of an expansion of a spherical harmonics, by adding a special filter ones can compute geoid changes in a specific locations. As a reference, EGM2008 model was used, on its basis geoid changes were determined.

On a basis of the research we were able to conclude that geoid at the Yangtze river become more stable after fulfilling the Dam. In Europe only small changes were denoted at the Scandinavia region.

MODELLING OF SURFACE DEFORMATIONS ON TERRAINS UNDER THE INFLUENCE OF MINING

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ABSTRACT

The paper presents the most important stages of modelling ground surface spatial deformations on mining terrains using GIS tools. Two types of deformation models were developed: a model based on the determined displacements only (the approximation model) and a model based on the determined displacements, and data describing the mining-geological conditions(the regression model).

Approximation modelling of ground surface deformations caused by mining activities comprises of a number of steps, which include: data analysis, study of the displacements' distribution, analysis of the controlled points locations, choice of the grid size, analysis of the quality and accuracy of interpolated displacements and of calculated deformation parameters. In the multiple regression model the correlation between the explanatory variables (independent variables describing the mining-geological conditions) and the dependent variable (deformation parameters) were also examined. The study included selection of an appropriate regression model. The deformation models were developed for data obtained from selected mines in Lower Silesia (SW Poland).

Acknowledgments

This work has been financed from the National Science Centre Project "Development of a numerical method of mining ground deformation modelling in complex geological and mining conditions" UMO-2012/07/B/ST10/04297 executed at the Faculty of Geoengineering, Mining and Geology of the Wroclaw University of Technology (Poland).

TIME DOMAIN CROSS-CORRELATION ANALYSIS FOR INVESTIGATION OF ATMOSPHERIC AND HYDROSPHERIC SIGNALS IN GPS TIME SERIES

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ABSTRACT

Keywords: GPS, periodic signals, atmosphere, hydrosphere, cross-correlation

The circulation of surface geophysical fluids (e.g. atmosphere, ocean, continental hydrology, etc.) induces global mass redistribution at the Earth's surface, and then surface deformations and gravity variations. The deformations can be reliably recorded by permanent GPS observations nowadays. The loading effects can be precisely modelled by convolving outputs from global general circulation models and Green's functions describing the Earth's response. Previously published papers showed that either surface gravity records or space-based observations can be efficiently corrected for atmospheric loading effects using surface pressure fields from atmospheric models. In a similar way, loading effects due to continental hydrology can be corrected from precise positioning observations. We evaluated 3-D displacement at the selected ITRF2008 core sites that belong to IGS network due to atmospheric, oceanic and hydrological circulation using different models. Atmospheric and induced oceanic loading estimates were computed using the ECMWF operational and reanalysis (ERA Interim) surface pressure fields, assuming an inverted barometer ocean response or a barotropic ocean model forced by air pressure and winds (MOG2D). Hydrological loadings were provided using MERRA land (Modern-Era Retrospective Analysis for Research and Applications), NASA reanalysis for the satellite era using a major new version of the Goddard Earth Observing System Data Assimilation System Version 5 (GEOS-5)) for each station. After that we compared the results to the GPS time series of North, East and Up components from PPP (Precise Point Positioning) solution (JPL processing) with GIPSY-OASIS software. The time series were modelled with wavelet decomposition using Meyer orthogonal mother wavelet. Here, nine levels of decomposition were applied and eighth detail of it was interpreted as changes close to one year. PPP time series were presented as curves with amplitudes and phases being time changeable. The same analysis was performed for atmospheric (ATM) and hydrospheric (HYDR) models. All quasi-annual curves (modelled from GPS, ATM and HYDR) were then compared to each other using cross-correlation analysis to investigate whether GPS observations contain or not the atmosphere and hydrosphere correlated signals and in what way they may disrupt the GPS-derived time series.

RECENT VERTICAL MOVEMENTS OF GEOLOGICAL STRUCTURES ALONG A SUDETEN MARGINAL FAULT

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ABSTRACT

The paper presents the results of investigations of vertical movements along geological structures Sudeten Marginal Fault (SMF) during the last half-century. The study used the results of repeated measurements leveling nine lines 1 and 2 class crossing SMF. In each analysed leveling line ware determined relatively stable benchmark. In relation to its defined vertical displacement and the speed of movements (mm/year) remaining points located on the wing hanging and thrown to SMF. Average speed change points on both wings fault was the basis for the separation of the three segments of geological structures along SMF.

These considerations are also an attempt to refer the findings to the Sudeten terranes.

THE PRECISE POSITIONING IN GEODYNAMIC RESEARCH USING THE MODIFIED AMBIGUITY FUNCTION APPROACH

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ABSTRACT

The Modified Ambiguity Function Approach (MAFA) method can be applied to precise positioning in geodynamic research. The significant advantage of this method is its robustness to the "cycle slip" effect in subsequent observation epochs. An algorithm of this method does not include the separate step of ambiguity resolution although the final results take into account their integer nature. This is guaranteed through the formulation of the appropriate mathematical model of precise positioning. The conditions included in that model ensure that ambiguities are integer. However by ensuring only the integer value of ambiguities, it cannot be guaranteed that the solution is correct. The ambiguities should take the correct integer values. In the case of single-epoch positioning the functional model is relatively weak. Therefore different techniques for optimizing computational process were developed. These techniques guarantee appropriate convergence of the computational process and reduce the number of computations. The optimization techniques are presently an integral parts of the MAFA method. The paper contains detailed description of each of them. The MAFA method, complemented with the optimization techniques, is an efficient tool for single-epoch positioning. In the paper the foundations of this method are presented. Feasibility of a single-epoch precise positioning has been tested. The results of numerical tests based on a real data are presented. The results are discussed and finally some conclusions are derived.

ACCURACY AND SENSITIVITY OF A METHOD OF IMPULSE DETECTION, EVALUATED BY SIMULATED TIME SERIES

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ABSTRACT

The modern knowledge in geosciences is based on permanent observations during the last decades. They consist mainly of quasi harmonic oscillations with variable phases and amplitudes and small irregular variations, containing abrupt changes due to several natural sources of impulse excitations. These small irregular variations may be due to various geophysical impulses and in some cases to the observation inaccuracy of data consisting from many different instruments spread all over the world. The natural sources of the observed quasi impulse variations with duration from seconds to days are earthquakes, hurricanes and tornadoes, geomagnetic jerks, landslides, solar eruptions etc. The data jumps in the long time series may due be to the inaccuracy of classical instrumental techniques or to the changes of the networks arising from the adding and removing of the observational stations and replacement of the instruments. The direct determination of the data jumps is difficult, because their values are very small in relation to the amplitudes of the seasonal, interannual, short and long terms of the observed periodical variations. A new high-sensitive method of small jumps determination in long time series has been formulated recently (Chapanov et al. 2014). This method detects any sudden changes of the mean data value and velocity, whose magnitude is significantly less than the level of the random noise. The accuracy and sensitivity of this method is evaluated by simulated time series of Earth orientation parameters and climatic data. The accuracy of the method is determined by the differences between the initial and estimated values of data jumps. The sensitivity of the method is determined as a level of jumps, detectable for any specific technique of data collection. The possibility of application of the method in the field of geodesy, geophysics and other geosciences is discussed.

ROCK FAILURE DUE TO TOPOGRAPHIC STRESS IN THE SUDETES MTS: A THREE-DIMENSIONAL NUMERICAL MODEL

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ABSTRACT

The ambient tectonic stress can be largely perturbed close to the Earth's surface due to the effect of gravity and topography. Theoretical models show that stress perturbation can be large enough to induce additional failure and influence regional fracture patterns. The near-surface distribution of rock fractures controls land-shaping processes such as slope stability, erosion and groundwater circulation. Few studies have considered the effect of measured three-dimensional topography on the shallow stress field.

We present a three-dimensional numerical model of the shallow stress field beneath the Sudetes Mts. including the effect of topographic and tectonic loads. The surface mesh is refined towards the region of interest and we construct it by adaptively resampling the data from the global SRTM database and high-resolution LiDAR data for the Sudetes Mts. The rock medium is treated as elastic and we use a self-developed finite element method code to compute the stress field. The results are analyzed to assess the distribution of potential failure and a comparison is made with the observed fracture patterns.

THE GEODETIC MONITORING OF THE FOREST OPERA IN SOPOT – A PRACTICAL SOLUTION OF THE PROBLEM IN 3D SPACE

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ABSTRACT

Keywords: measurement of displacement, instability of the test stand, alignment lattice

The paper will present issues related to automated monitoring systems measuring movements in 3D space. Special attention was focused on the problem of instability of the position of mark systems, and the manner in which we may limit the impact of this phenomenon on the results of measurements.

This article presents the solution implemented in the Forest Opera in Sopot. The main element of the monitoring system is a Total Station used to measure the displacement of a roof. Due to spatial reasons it was decided to place the system on a specific platform attached to the facilitated structure. In many ways it is a custom action because usually engineers prefer stable system, free from displacements.

The article deals also with analysis related to the appointment of the position total station and change this position based on fixed points of reference.

Proposed solution assumes that determine the position of the position based on the alignment of angular-linear spatial networks. In the various measurements epochs total station performs observations of angles and distances related to the reference points and on this basis are calculated its current coordinates. Such an approach allows for a reasonable estimation of the accuracy and reliability of the obtained values of displacements that are not affected by changing the position of TPS. The principal assumption adopted during calculations assumes full stability of the reference points.

The article presents the analysis performed for the data obtained from the monitoring system installed in the Forest Opera in one day.

In summary, the solution presented in the article is a universal method, possible to apply to each object in which there is a problem of instability of the test stand. A prerequisite is the only appropriate choice of reference points.

DETERMINATION OF CHANGES IN THE CHARACTERISTICS IN SELECTED CRACOW'S MOUNDS ON THE BASIS OF GEODETIC SPOT MONITORING RESULTS

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ABSTRACT

Historic Krakow mounds (prehistoric: Krakus and Wanda and relatively recent: Kościuszko and Piłsudski) make a group of the largest anthropogenic objects of this type in Poland. The monuments of Krakow, despite their size, only superficially cause the impression of stable constructions, resistant to outside factors. Made from the grounds of loess-originating bulk, they are very susceptible to atmospheric factors, i.e. showers and wind, which cause serious damage making the mounds temporarily out of use. First of all it refers to relatively new mounds (Kościuszko and Piłsudski), often described as "made of heart". It means that despite good projects, at the stage of their construction, people often did not stick to important for the mounds' stability directives. This caused damage over the time. Carried out so far ways of stabilizing the slopes, despite large costs and implementation of many modern geotechnical measures did not bring a desired result. Particular susceptibility to the forces of nature requires detail analyses of preventive measures. Both plunge methods and surveying methods enable geotechnical services to take measures aimed at halting deformation in zones particularly threatened by landslide. Geodetic point monitoring based on classical measurement methods, i.e.: traverses and precise levelling, sometimes supplemented by GNSS and the network of control points located on the surface of ground cones, facilitates defining the temporal changes in geometry and the directions of these changes. Surveying has been carried out for several years in the framework of geodetic monitoring. Surveying data confirm and explain specific characteristics of these changes. Apart from subsidence of the surface and the phenomenon of torsion of the solids marked based on the vectors of horizontal dislocations, one can make attempts to define the correlation of the magnitude of these changes with the sum of atmospheric precipitation and mean directions of wind. In the article the authors presented similarities in the characteristics of these changes in the relation to the main atmospheric factors such as precipitation and wind.

APPLICATIONS OF LEICA DNA03 DIGITAL LEVEL TO THE PRECISE VERTICAL AND HORIZONTAL MEASUREMENTS OF INANIMATE NATURE OBJECTS

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ABSTRACT

During surveying on inanimate or engineering objects are very common nuisances of observations. The source of these nuisances may be the following reasons:
environment:

- difficult access to the measurement points due to some overrides;

instruments:

- the impact of instrumental errors (eg. different length intentional) on the results of observation;

equipment:

- dimensions and shapes of geodetic equipment unsuited to the conditions of the measuring space occurring on the measuring object.

Geodetic observations are performed often on small areas of closed objects. The most common shortcoming is varied conditions of access to place on the object of measurement points. In these cases, often it is necessary to determine horizontal distances and height measurements with an accuracy of at hundredths of a millimeter.

In order to increase the possibility of measuring the authors developed the project and built the prototype of the device mirror that could be used to perform leveling observations using the broken (polygonal) lines of sight into points directly unavailable. Also the authors developed the project and built a prototype prismatic adapter, which was used together with the DNA03 leveling to measure the horizontal distances between the marks mounted on the examined object.

PRECISE MEASUREMENTS OF ROCK BLOCKS MOVEMENTS WITH THE USE OF LEICA NOVA MS50 MULTISTATION AND AUTOREFLECTION METHOD

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ABSTRACT

Autoreflection (self-reflection) is currently one of the most accurate methods of measuring of angles. This method is used to check the geometry of engineering and inanimate objects. The measuring range of this method is limited to several tens of meters. The accuracy of angle measurement is at the level of individual seconds of arc. Autoreflection method relies on observations image of a target plate on the background of telescope crosshairs of surveying instrument.

In the proposed solution we used:

- precise multistation Leica MS50,
- the author's self-reflection plate,
- and high-quality prismatic reflector.

Using this equipment allows you to take images of the autoreflective plate after reflection from the surface of the prism. The recorded images after working enable us to determine displacement of a point controlled object with a submillimetre accuracy.

The work presents the construction of a set of MEASUREMENT, the principle of measurement and the results of the preliminary experimental research. The study confirmed the functionality and very high measuring accuracy (± 0.02 mm), determined on the basis of multiple observations.

STRUCTURALLY CONTROLLED LANDSLIDE (TOCZEK MT., INTRASUDETIC SHEAR ZONE)

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ABSTRACT

During mapping of the western part of the **Upper Nysa Kłodzka Trough**, on the northern slopes of the **Toczek** hill a vast landslide colluvium was stated. The extent of the last has been determined based on *LIDAR* derived *Digital Elevation Model* as well as detailed geological mapping and shallow geophysical prospection using ground penetrating radar. In the course of works at least 3 colluvial lobs were determined and a source zone supplying landslide was located. There was however not confirmed the thesis about the existence of 3 independent landslides in the study area (see Różycka et al., 2015).

The source zone creates a steep escarpment founded on a system of fractures and faults that cut sedimentary cover composed mostly of middle Turonian sandstones and calcareous siltstones and marls of middle and lower Turonian age. On the back of the main escarpment, there are recently forming **opened cracks** and **hollows**, what facilitates intensive **infiltration** of the rain and snowmelt waters into the bedrock and lead to formation of **rotational** and **blocky landslides**. Rock blocks become more and more crumbled downslope and next they often are redeposited forming **debris flows**.

A few different methods were used to the 3D reconstruction of the landslide zone (Fig. 1). The *kriging* and *minimal curvature*, usually recommended methods for interpolation of irregular nets of points (cf. Goldsztejn & Fiddler, 2004) were used, as well as the *natural neighbor*, and *triangulation with linear interpolation* to the regular grids were applied. The calculations of volume in the two applications gave similar results (Tab. 1). Estimated colluvium area is ca. 655 000 m^2. The maximum thickness of colluvium is in the southern part of app. 70 m, while the northern parts app. 35 m.

FIRST INTEGRALS IN THEORY OF MOTION OF GNSS SATELLITE BASED ON THE GPTFC

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ABSTRACT

The presented algorithms of computation of orbital elements of the GNSS satellite are based on the asymmetric variant of the Generalized Problem of Two Fixed Centers (GPTFC). The force function of this problem provides a good approximation of the gravitational potential of the Earth and the equations of motion can be integrated analytically by using the separation of variables. First, the canonical equations of Hamilton in oblate spheroidal coordinates are derived. Next, the solution of these equations is obtained with the help of the Hamilton–Jacobi method. The formulae of the three first integrals (integral constants) and their derivatives with respect to the time are discussed. Knowing the independent first integrals we can draw some important conclusions concerning the behavior of solutions without completing the integrals. The expressions for integral constants give also a convenient way for calculation of the orbital elements. Moreover, the formulae of Gaussian form of perturbation equations are presented. The elegance of derived formulae is emphasized by the fact of their precise inversion into formulae of Keplerian motion, if small parameters, lead to zero.

APPLICATION OF SINGULAR SPECTRUM ANALYSIS FOR DETERMINATION OF THE GPS TIME SERIES SEASONAL COMPONENTS

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ABSTRACT

Seasonal variations in GPS time series have significant impact on reliable determination of station's velocity. Incorrectly defined seasonal signals for stations which data was used during reference frame processing can bias the frame realization. The aim of this research is to extract seasonal oscillations from GPS time series in order to better investigate on spectral content of the non-linear station movements. In this research, the authors used daily position time series of Central European stations. Time series are from PPP (Precise Point Positioning) solution produced by the JPL (Jet Propulsion Laboratory) which uses GIPSY-OASIS software. The authors tested two different approaches to seasonal signal extraction: the Singular Spectrum Analysis (SSA) and Least-Squares Estimation (LSE). SSA is a non-parametric method which can be applied to short or long data without prior knowledge about dynamics of movements within. In contrast to LSE, it describes seasonal signal as the one with varying amplitudes and phases over time, which is undisputable advantage. In this presentation, the authors focus on the comparison of SSA and LSE in terms of reliable investigation of seasonal components with varying amplitudes. A simultaneous extraction of complex trends and periodicities will be given. It is shown, that seasonal signal identified for vertical component with the SSA using first six reconstructed components has larger correlation than LSE extracted signal with respect to the original time series. Correlation coefficient is greater for SSA-determined curves by 0.03 to 0.10 depending on time series characteristic. The root-mean-square deviation between seasonal signal and original time series is lower by 0.1 to 0.6 mm when SSA approach is applied.

ORTHOGONAL TRANSFORMATION IN EXTRACTING OF COMMON MODE ERRORS FROM CONTINOUS GPS NETWORKS

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ABSTRACT

Common mode errors (CMEs) are the sum of environmental and technique-dependent systematic errors in GPS position time series. The CME, which is a kind of the noise correlated in time, can be seen in the time series from regional GNSS networks of hundreds of kilometres extent. This presentation concerns the results of studies regarding to necessity of spatiotemporal filtration of time series to determine highly reliable velocities of permanent stations for the geophysical (plate motion or earthquakes) studies or to maintain the kinematic reference frames. In this research the JPL (Jet Propulsion Laboratory) PPP solutions processed in GIPSY-OASIS software were taken. Trend and seasonal signals were removed with least-squares estimation to form the residual time series. Then, the internal structure of residual time series with orthogonal transformations was revealed. This structure of spatially and temporally correlated residuals of GPS time series can be identified with CME. The authors examined two methods of multivariate analysis: the Principal Component Analysis (PCA) and Karhunen-Loève Expansion (KLE). These will be compared with stacking and spatial filtering approach. The results confirmed the theoretical assumptions of advantage of KLE approach when stations with local effects are located in network. The results of noise analysis performed on residual time series show that spatial filtering using PCA and KLE approaches reduces noise amplitudes from 1 to 3 mm for horizontal components and from 3 to 7 mm for Up component. The uncertainty of velocity decreases by 20 or even 60% for North, East and Up.

RESEARCH OF THE VERTICAL GROUND SURFACE DISPLACEMENTS USING INSAR TECHNIQUE ON THE SOUTH-EASTERN PART OF THE CENTRAL EUROPEAN SUBSIDENCE ZONE

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ABSTRACT

The study is a continuation of the geodynamic research in the south-eastern part of the Central European Subsidence Zone (CESZ). This zone extends from the North Sea along the Hamburg – Berlin – Wrocław line and coincides with The Elbe Fault System (EFS) that also includes the Middle Odra Fault Zone (MOFZ) in SW Poland. Width of the MOFZ in the analyzed part of the area is approx. 20 km, and the length approx. 100 km.

Current state of knowledge on the tectonic activity in this region is based on the analysis of measurements in national levelling lines and GNSS epoch measurements carried out in the 1998–2010 period. The research carried out in the 1956–2000 period on the border of the Fore-Sudetic Block and Fore-Sudetic Monocline (southern boundaries of the MOFZ) and on the MOFZ's northern border in the area of the Poznań – Oleśnica faults, indicate significant vertical displacements. GNSS epoch measurements from the 1998–2010 period revealed horizontal intraplate velocity of approximately 0.5 mm/year.

Currently, analyses of vertical height changes using radar interferometry technique (INSAR) have been carried out. Calculations of the vertical displacements based on data from the 1995–2010 period have been done. Velocities of vertical displacements range up from - 6 to + 6 mm/year. In the paper a model of vertical displacements determined using INSAR techniques in relation to the geological-tectonic conditions and results of previous geodynamic studies have been presented.

USING GNSS REMOTE SENSING FOR COMPLEX REPRESENTATION OF STATION ENVIRONMENT

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ABSTRACT

Keywords: GNSS remote sensing, multipath, Signal-to-noise ratio

The current demands on reliability and accuracy of the results from processing of GNSS permanent stations require the greatest possible knowledge of disturbing effects. Regarding to station dependent errors it means mainly knowledge about GNSS multipath effect and relevant time variations. Presented article is focused on possibilities to use GNSS reflected signals to determine the complex characteristics of station vicinity. Computation of multipath observable variable MP was performed at selected GNSS permanent sites in Slovakia, namely at GANP, LIE1 and KAME. These values can be used to identify obstacles in the vicinity of the station or for monitoring temporal changes in multipath effect due to different weather conditions (rain, drought, or snow cover). Snow cover depth calculation based on analysis of the SNR (signal-to-noise ratio) values was performed and the existing calculation using the GPS signal was extended to navigation satellite systems GLONASS and Galileo. Results from GNSS reflected signals were compared with data from meteorological service.

ANALYSIS OF THE IMPACT OF METEOROLOGICAL FACTORS ON THE TIME SERIES OF GNSS COORDINATES

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ABSTRACT

Keywords: time series, coordinates, correlation

The aim of the analysis is an attempt to determine the impact of changes in temperature, pressure and humidity, as well as changes in the level of groundwater at the coordinates (N, E, Up) permanent stations GNSS. These analyses will be realized by using correlation function. In this analysis used coordinates time series from EPN stations (LAC WUT) located on area of Poland, meteorological data (data from EPN stations) and precise of piezometer data which located near WROC station (Institute of Geodesy and Geoinformatics).

TECTONIC ACTIVITY OF ŚWIEBODZICE DEPRESSION AND THEIR PROBABLY CONNECTIONS IN TIME-DOMAIN WITH STRONG AND DEEP SEISMIC EVENTS IN LUBIN COPPER MINING REGION

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ABSTRACT

Keywords: geodynamics, tectonic activity, mine surveying, tectonics of the Sudetic region, geodetic and geophysical measuring system

Recent tectonic activity of Świebodzice Depression is observed since seventies years of the last century. In this time in Książ was constructed Geodynamic Observatory of Space Research Center (SRC). Permanent clinometric observations executed since 1975 with use of quartz horizontal pendulums (KW) as well as measurements of tiltings and vertical motions executed since 2003 by two long water-tubes tiltmeters provided numerous observations of tectonic activity. Collected observations contain irregularly occurring events (lack of seasonality) of rapid variations of equilibrium position of KW as well as large variations of water level in KH hydrodynamic systems.

For quite different tiltmeters (KW and KH) the magnitudes of registered tectonic effects achieve 10 times of tidal signals magnitudes. The executed investigations allow us to eliminate all non-tectonic effects as a possible reason of these phenomena. The source of strong signals observed by KH and KW are recent tectonic motions in Sudetic region.

Additionally, tectonic activity is confirmed by system of secondary faults visible in underground corridors of Książ massive as well as characteristic pictures of deformations of Pełcznica river meander which result from present activity of a lot of faults.

Permanent observations provide data of various effects of irregularly occurred epochs of cinematic activity of Świebodzice Depression orogen.

This activity is produced by approach of stress waves to the Świebodzice Depression area. Observations in similar time epoch of activity in the Bohemian-Sudetian missives suggest that the stresses waves are of large dimension. We expect that epoch of activity in Książ massive is correlated with cinematic activity of adjacent areas among others in copper mining region of Fore-Sudetic monocline.

The high energy seismic events from Lubin as well as depths of hypocenters 3–4 km are difficult to be explained by post-mining compensation effects only. Strong seismic events indicate on natural origin of seismic effects which are associated with natural activity of the massif. Therefore, the epoch of strong cinematic activity of orogen in Świebodzice Depression can be applied as indicator of increasing of probability of seismic event approached.

CHANGE OF THE CHARACTERISTICS OF THE TECTONIC EVENTS EFFECTS RECORDED BY INSTRUMENTS OF THE GEODYNAMIC LABORATORY IN KSIĄŻ (CENTRAL SUDETES, SW POLAND) IN THE CONTEXT OF IMPACT ON THE ARCHITECTURE OF THE KSIĄŻ CASTLE

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ABSTRACT

Recent tectonic activity in the Książ area (area of geological-structural unit of Świebodzice Depression, SW Poland) is a phenomenon confirmed by many years of clinometric observations (over 40-year-old series of measurements coming from quartz horizontal pendulums). Qualitatively and quantitatively best source of information about tectonic movements are indications of new instruments installed in the Geodynamic Laboratory in Książ – two arms of water-tube tiltmeter. They provide permanent data on vertical movements and tiltings of blocks of rock on which the apparatus is installed (Chojnicki and Blum, 1996; Kaczorowski, 2006, 2007, 2009; Kaczorowski and Wojewoda, 2011).

Records using water-tube tiltmeters began in 2002. With over 10 years of continuous observations tens of events characterized by large ground tiltings and vertical movements have been separated. They are identified by amplitude much larger than tidal and random moments of appearance, not correlated with the changes of the seasons or physicochemical conditions of the Laboratory microenvironment (temperature, pressure, humidity). These observations provide the basis for the interpretation of these phenomena as geodynamic effects generated by recent tectonic activity in the region of the Sudetes. Sudetes tectonic activity occurs by displacement of rock blocks on the surfaces of discontinuity identified in the Książ area (Kaczorowski and Wojewoda, 2011; Kasza et al., 2014).

All tectonic events recorded until 2008 had similar characteristics, amplitude and duration. Moreover, after every event, an compensation effect of rock blocks displacements occurred. Between 2007 and 2008 the tectonic movements softened. Strong tectonic effects were observed again in 2009, but their nature has changed significantly. The observations clearly indicate a change of movements and tiltings of foundation image, suggesting activation of a class of faults with different orientation than ever before (Kasza et al., 2014). The dislocation zones of generalized course SW–NE used up have been replaced by faults of the course E–W. Another change is the very nature of the signal. The originally recorded results in the form of asymmetrical clear changes of the vertical line lasting over dozen days have been replaced by signals of smaller amplitude and of much longer duration (till several months).

Different course of both classes of faults under the castle buildings suggests the possibility of other than previously observed damages (cracks).

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ACCELERATION OF GNSS STATIONS IN NOISE ANALYSIS

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ABSTRACT

The plate motion models are being created basing on horizontal velocities of GNSS permanent stations placed on stable parts of tectonic plates. These, when not interrupted by any local condition, linearly move together with tectonic plate. The ones, which are seated in the subduction zones are being rarely characterized by such linear trend (velocity) and often show a non-linear behavior for entire period of observations. Moreover, it does not only refer to horizontal velocities, but also vertical can be affected, e.g. for antennas near active ice sheets. These non-linearity or so-called acceleration of GNSS stations may be modeled with different methods as piece-wise functions or wavelet decomposition. Unfortunately, when above are not being implemented together with least-squares model describing the data, but just fixed at the beginning of analyses, they may cause that uncertainties of determined parameters are underestimated. In this presentation the authors focus on the GNSS stations processed by the Jet Propulsion Laboratory (JPL) in a PPP mode, which behave in non-linear way. We will show how to implement the acceleration term in least-squares model and what impact it has on determined uncertainties of estimated parameters upon the colored noise assumption. At the end, the comparison of commonly implemented linear as well as proposed non-linear approach in terms of noise analysis will be given.

VERIFICATION OF THE ALGORITHM TO IDENTIFY DISCONTINUITIES IN TIME SERIES DATA ON THE EXAMPLE OF GNSS DATA

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ABSTRACT

Determination of the rate of height change based on GNSS data requires reliable data. One of the products being created on the basis of GNSS data are time series. In those time series we can identify some discontinuities both in time and in data values. The quality of determined speeds depends on correction of discontinuities, caused by the vertical jump in the data. Those jumps are caused by changes of: antennas, software, stabilization and coordinate systems, and other, undefined reasons. Several solutions of identifying locations of vertical data jump have been evolved. The main aim of the article is verification of the algorithm which identifies data discontinuities in time series on the GNSS data example. The article also shows solution of how the value of the jump can be determined.

GEODYNAMICALLY ACTIVE FAULT-RELATED LANDSLIDE ON THE DROGOSZ HILL (INTRASUDETIC SYNCLINORIUM)

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ABSTRACT

The structures indicative for a landslide colluvium were recognized on the northern slope of the Drogosz Hill located in the area of the "Łączna Brachyanticline", a geological regional unit distinguished by Jerzykiewicz (1969). The landslide colluvium has an area of c.a. 8,7 ha. Its presumable thickness, as determined from the geomorphometric data, does not exceed 24 m. The Drogosz Landslide occurs in the close vicinity of NW branch of the Lipienica–Łączna Fault (Don et. al. 1981), within the tectonic zone interpreted earlier as the "Southern Marginal Flexure" of the Krzeszów Brachysyncline (Jerzykiewicz *op. cit.*). Detailed mapping and structural measurments suggest that outcrops of redeposited and slightly rotated blocks of calcareous sandstones within the colluvium, were probably a reason of misleading interpretations of the area discussed. A sinistrial oblique-normal slip fault trending NW–SE constitutes a continuation of the main scarp of the landslide. This fault was probably the main factor that influenced the development of the slip surface within strongly fractured glauconitic and siliceous mudstones of Cenomanian age. A strike of fractures in these rocks coincides with orientation of the main landslide scarp. The area affected by mass movements including the main scarp of the landslide, reflects a high recent geodynamic activity. This is evidenced by: (1) debris slides below the upper edge of the main scarp, (2) fractures and slides on the road pavement transcutting the central part of the landslide colluvium and (3) well preserved subordinary scarps and extension cracks within the colluvium.

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"ŁĄCZNA ANTICLINE" (INTRASUDETIC SYNCLINORIUM) – A NEW STRUCTURAL AND GEODYNAMIC INTERPRETATION

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ABSTRACT

Permian, Triassic and Cretaceous sediments build a morphological elevation on the boundary of two regional structural units within the Intrasudetic Synclinorium – the Police and Krzeszów subbasins. The pointed area was traditionally considered as a structural tectonic elevation and it was named by Petrascheck (1933) as "Łączna Aticline" and also by Jerzykiewicz (1969) as "Łączna Brachyanticline". Detailed mappings as well as structural/sedimentological investigations were carried out. Studies did not confirm the occurence of continous deformations such as marginal flexures, which were postulated among others on the northern slope of the Drogosz Hill (Jerzykiewicz *op. cit.*). Existance of relatively large in amount landslide colluvium was probably a main reason of misleading previous interpretations of geology of this area (Kowalski 2015, this paper). Changes in orientation and dip angles of sedimentary rocks are strictly related to main tectonic zones. This is also confirmed by the change of joints orientation within sandstones. Conjugate sets of normal and oblique-normal slip faults trending NW–SE or NNW–SSE, results in formation of negative flower structures (among others *Róg Flower Structure* or *Łączna Flower Structure*). Strike-slip faults are accompanied by low-angle Riedel Shears (R') and slickensides with slickenfibres indicating dextral strike-slip movements.

In the the Upper Cenomanian sediments, synsedimentary deformation structures were recognized. Their distribution directly coincides with modern tectonic zones, especially in the Libna region (ČR). Preservation of the saprolite-type Triassic deposits in the top of the Buntsandstein and the aluvial, Middle Cenomanian sandstones, which are not present in adjacent depressions, may suggest tectonic activity and migration of maximum subsidence centres. Intensified mass movements within tectonic zones delimited by cartographic methods well preserved fault scarps and privileged orientation of dry valleys, which locally constitute the watershed zone (!), can also indicate contemporary geodynamic activity of the area.

The area between Krzeszów and Police Subbasins constitutes a structural and morphological elevation, which developed due to propagation of faults. This elevation forms an intrabasinal high which usually develop in the central parts of extensional basins, in particular within the strike-slip style. The term "elevation" is applied to areas which are in similar tectonic position in the Intrasudetic Synclinorium (Wojewoda 2007).

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PROCESSING OF REGIONAL NETWORKS WITH SINGLE-FREQUENCY GPS DATA SUPPORTED WITH HIGH-RESOLUTION REGIONAL IONOSPHERE MODEL

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ABSTRACT

National, regional and global continuously operating GNSS reference station networks are usually equipped with multi-frequency receivers. These networks are used for a number of applications, including reference frame maintenance, positioning and navigation, estimation of atmospheric parameters, etc. Also, regional permanent monitoring networks are being established for geodynamic studies. In this study we evaluate the possibility of employing lower cost single-frequency GNSS receivers to establish such regional networks for geodynamic studies. It is assumed that the processed baselines in such networks are usually of several tens of km and rarely exceed 100 km. Therefore, processing of such baselines requires accurate ionosphere models in order to reduce the adverse influence of the ionospheric delay.

In this study a high-resolution regional ionosphere model is developed and applied to processing of the single-frequency GPS data from regional geodynamic network. In particular, resulting ambiguity resolution success, coordinate repeatability, and tropospheric ZTD estimates are analyzed. The processing is carried out in Bernese GNSS Software 5.2 using modified GPSEST module that allows importing IONEX files. The results are compared to those obtained with the application of global and regional CODE models.

NEW PROSPECTS FOR AUTOMATED GEOLOGICAL MAPPING WITH SENTINEL-2 MULTISPECTRAL INSTRUMENT

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ABSTRACT

This paper introduces the new prospects for the automated geological mapping using Sentinel-2 Multispectral Instrument data. The Sentinel-2 was launched on June 2015 as a second mission for Europe's Copernicus environment monitoring programme. The multispectral imager provides no-cost, high-resolution data in 13 spectral bands, including the visible, near infrared and shortwave infrared bands. Based on the early sample products, the authors have analysed the possible uses of the data for mineral prospection. As an example of Sentinel data interpretation, an automatic identification of rocks, mineral groups and dense green vegetation for the areas of North part of Republic of Austria was performed.

In the performed analysis the laboratory reference spectra obtained for Landsat 7 cameras were used for evaluation of indexes necessary for mineral identification. These indexes are related to particular groups of minerals. They were prepared for Landsat 7 data and then converted to Landsat 8 and Sentinel spectral bands. The obtained results were compared to Landsat 7 ETM+ and Landsat 8 OLI data for the same area. The detailed comparison of all results was presented and discussed in details. The main differences are result of higher spatial resolution of Sentinel imaginary and additional channels located in short infrared band.

THE STUDY OF MASS MOVEMENT OF ROCK BLOCKS ON STOŁOWE MOUNTAINS AREA

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ABSTRACT

The movements of rock blocks of the Stołowe Mountains are caused by different processes: exo- and endogenous. Beginning of these movements took place in the Upper Cretaceous and their culmination was in the late Tertiary. Results of geodetic and geodynamic studies testify to the fact, that these movements are also present nowadays. The study will present the results of periodic measurements of horizontal and vertical movements, measured on small networks localized in both the Polish and Czech parts of Stołowe Mountains. These measurements were performed using the precise leveling and precise tachymetric measurements. They have been performed at three locations on the "Szczeliniec Wielki" (near the mountain shelter, in the area "Piekiełko" and southern terraces) and in the Czech part of the Stołowe Mountains on Ostaš.

The results of measurements carried out in difficult terrain conditions will be compared with results obtained from control network. Shape and observations structure of control network is close to optimal.

RESEARCH OF BENCHMARK HEIGHTS CHANGES ON THE WROCŁAW AREA

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ABSTRACT

Geodetic networks should be continuously controlled as the spatial reference in the geodetic task. Monitoring should take into account current state of the coordinates and technical condition of the points. It is particularly important for levelling network, where the benchmarks elevations may change due to anthropopression and geodynamic movements. The current benchmarks heights are necessary for large scale maps updating, geodetic investments service and for research of ground surface deformations.

In the paper the change of benchmarks height in the levelling network on the area of Wrocław have been presented. The base of vertical displacements calculation were data from archival catalogues from years 1931, 1979 and 1999, and recent precise levelling measurements from 2013–2015 period. Levelling measurements were made by students of Wrocław University of Environmental and Life Sciences and partly by GRADUS, WROGEO and ARGEOM surveying companies. The results of analysis of benchmark height changes may provide arguments to decide about the next levelling network modernization on the area of Wrocław. Network adjustment, displacements calculation and visualization were made in C-GEO, Matlab and ArcGIS software.

THE STUDY OF VERTICAL DISPLACEMENT OF THE BEAR CAVE ROCK MASS SURROUNDINGS IN THE AREA OF "ŚNIEŻNIK KŁODZKI"

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ABSTRACT

To study vertical displacements in the area of the "Jaskinia Niedźwiedzia", in 1984 a network of research benchmarks was founded, covering both the interior and surroundings of the Cave. The main reason for taking up the research were visible damage and cracking of the rock formations inside the cave, probably caused by mining works carried out in a nearby quarry. The measurements of vertical displacements of controlled benchmarks are performed annually to this day. Last measurement was taken in summer 2014. Precise leveling measurements were carried out initially using conventional self-leveling levels: Ni007, Ni002, Ni005, and now are conducted using precise code levels: DNA03 and DiNi03. The results of these measurements were one of reason to suspend the works at a nearby quarry in 1993. Since that time stabilization of vertical changes of controlled benchmarks can be observed.

ANALYSE OF GEODYNAMIC RESEARCH RESULTS BASED ON GNSS MEASUREMENTS OF "STOŁOWE MTS." NETWORK

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ABSTRACT

The area of the "Stołowe Góry" is the object of many studies, geodetic and geodynamic, for decades. Geological history of the area, the atmospheric, tectonic and seismic factors influence, forces to proceed geodetic and geodynamic research in this area. "Góry Stołowe" measurement network, which consists points on both the Polish and Czech side, is observed by GNSS technique since 1993. Authors use the results of the measurements made during sessions held in the years 1993, 1994, 1996, 2002, and 2015 and presents the analysis of geodynamic activity of the tested area of "Góry Stołowe". The study will present spatial displacement eight points, two of which (204, 205) are located in the upper parts on the Czech side and the other two (110, 113), also in upper parts, but on the Polish side. Other points (202, 203, 204, 206) are located at the foot of the "Góry Stołowe", and their localization was chosen by taking into account the geological - tectonic situation.

SENTINEL-1 SAR INTERFEROMETRY FOR SUBSIDENCE MONITORING ON MINING AREAS, USCB CASE STUDY

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ABSTRACT

The paper presents preliminary analysis of SAR interferometry data from Sentinel-1 satellite. The Sentinel-1 is radar imaging satellite launched in 2014. It is the first Sentinel-1 satellite launched as part of the European Space Agency's Copernicus programme. The aim of Sentinel-1 programme is land monitoring, marine monitoring and emergency services. A single Sentinel-1 satellite is potentially able to map the global landmasses in the Interferometric Wide swath mode once every 12 days, in a single pass (ascending or descending). The two-satellite constellation will offer a 6 day exact repeat cycle.

The investigation area is Upper Silesian Coal Basin which is characterized by a complicated geological structure as well as affected by the over 200-year hard coal mining. The negative aspect of such a magnitude of exploitation is visible on the surface in the form of surface deformation, subsidence and induced seismicity and it necessitate monitoring the USCB area. With the use of an established geodetic network in the first case, and by means of a seismic network in the second case. The availability of satellite data resulted in the development of novel methods, which can significantly affect the monitoring quality of an endangered area.

The main aim of this paper was preliminary analysis of possibilities for monitoring subsidence on mining areas with new Sentinel-1 data. There were analyze subsidence through development but without connect to mining exploitation.

LANDSLIDE SUSCEPTIBILITY MAPPING USING STATISTICAL METHOD WEIGHT OF EVIDENCE

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ABSTRACT

Landslides belong to the most common geohazards in Poland having even features of natural disasters. Mass movements occur mainly in the Carpathian Mountains. In this region over 95% of all landslides in Poland are located. Up to 30–40% of the whole Carpathian Mountains areas are considered as the most prone areas to mass movement.

In the mountains, the activation of mass movements takes place almost every year and causes injuries and damage to buildings and infrastructure. Landslide susceptibility mapping is very essential for warming against the dangers of landslide rational risk management.

Airborne laser scanning (ALS) is meanwhile almost standard technique widely used in geological research. Spatial analysis performed using digital elevation model (DEM) interpolated from ALS data are very helpful in landslide studies. In this work we used more than 20 factors (layers), which characterized the topographic terrain surface and which can indicate on the landslide activity or on the landslide susceptibility of the area under investigation. Among them we can distinguish: elevation, slope aspect, hillshade, isolines density, semivariogram, topographic position index, topographic wetness index, gradient of the slope, area solar radiation, offset from the surface fitted into the DEM, roughness, slope orientation. Furthermore, we included factors, such as: distance from waterways and water reservoirs, distance from roads, land use and geological structure.

For landslide susceptibility mapping we used the statistical method weight of evidence. Our investigation was performed on the study area that is very prone to mass movement. This area with size of 30km^2 is located in the central part of the Outer West Carpathians within the Ciężkowice Foothills, along the eastern bank of Roznów Lake. The study area is covered by ALS data with resolution of 4 points per m^2.

A landslide susceptibility map was created using a statistical indicator calculated based on the density of existing landslides in the specific class and in the specific layer. On the map five classes of landslide susceptibility were distinguished: very high, high, medium, low and very low. The vast majority of existing landslides are located in very high and high susceptible areas which indicates that the proposed method is correct.

COMBINED BDS + GPS PRECISE RELATIVE POSITIONING

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ABSTRACT

Development of new GNSS systems makes possibility of integration of multi system observations in one relative positioning functional model. Combined multi-GNSS positioning has undeniable advantage over standard single GNSS system utilization in terms of accuracy, reliability, availability and convergence of position solution. Benefit of multisystem observations is especially visible in obstructed environments. Thus, integration of multiple GNSS systems signals is nowadays the crucial issue in the development of satellite positioning algorithms. Chinese GNSS system – BDS has become regionally operational and it is expected that it will reach its full operational status in the next few years. Therefore application of fully operational and well recognized GPS system together with dynamically developed BDS may be of interest for scientific as well as for land surveying community. Separate GNSS system signals integration may be performed in a loose combining approach. In this method, mathematical model requires separate reference satellites – one for each system. This decreases the number of the unknown parameters in the least squares adjustment in contrary to tightly combined approach due to absence of the additional inter system biases parameters. On the other hand, additional reference satellite decreases the number of double-differenced observations. This study investigates combining of multi-GNSS observations on the basis of GPS and BDS systems. Quality assessment of both strategies based on kinematic and static positioning results is presented. The observational data were obtained from GNSS stations located at the area of China.

MULTIPATH DETECTION AND MITIGATION METHOD WITH DIRECT (ON POINT) MODELS OF TERRAIN OBSTACLES

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ABSTRACT

The GNSS methods of precise positioning are nowadays widely used despite the fact that the accuracy and reliability of those methods are limited to open sky localizations. The presence of terrain obstacles, for instance in urban, mountain or forest environments, significantly effects the accuracy of GNSS measurements due to signal reception blockage and the multipath effect. The multipath remains a domain source of ranging errors in satellite positioning and cannot be eliminated by differential techniques because this error is time and space uncorrelated. In order to minimize the influence of multipath, three categories of technologies and algorithms can be applied: antenna design, signal processing (or receiver design) and data processing. In this paper the method of multipath detection and mitigation based on data processing is presented. Because of the fact that the receiving of non-line-of-sight signals is closely connected with the place of observation, the direct models of terrain obstacles derived from on-point hemispherical images were applied.

RESEARCH ON RIVER TERRACES SEMI-AUTOMATIC DETECTION BASED ON DATA FROM AIRBORNE LASER SCANNING

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ABSTRACT

Shape of the land surface is not only a kind of trace of processes and phenomena which happened on the Earth's surface but also it has a significant impact on the phenomena observed and projected within a given area. Any kind of prediction of behavior would not be possible without prior knowledge of the phenomenon, it's characteristics as well as tests on the experimental model. The key data in the analysis modeling of this phenomenon or accompanying the process is a model of the form field. First attempts at modeling forms of field data from DEM (Digital Elevation Model) as well as their automatic detection has already been made. This task belongs to the interdisciplinary issues on the border of two science fields: geodesy and geomorphology. In this article attempts of modeling and semi-automatic detection of river terraces, ie. fragments of the old, split den valley, were made.

The study was based on classified data from the Airborne Laser Scanning from the area of Bug river. Method split-merge was used to scan for terraces on the declared area. The analyzed cloud of points was divided into voxel consisting of identical cuboids. In each voxel, based on the point clouds, a plain was generated. By analyzing individual surfaces slump, azimuth as well as the accuracy of the fit surface approximating a cloud of points and the distribution of residues, the aggregation of individual voxels was made.

NOVELTIES ON RECENT ACTIVITY AT THE DIENDORF–ČEBÍN TECTONIC ZONE

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ABSTRACT

Repeated GNSS measurements on points of the MORAVA network confirmed earlier assumptions about recent activity at the Diendorf–Čebín tectonic zone (DCTZ). Complex evaluation of geodetic measurements with geophysical and geomorphological data confirmed reasonable movement tendencies at marginal fault of the Boskovice Furrow and at the Waitzendorf and Diendorf faults too. It was confirmed also by newly appeared earthquakes in all area of the DCTZ. In the contribution latest results and findings about movement tendencies in the subject area are presented.

STEP DETECTION IN GNSS TIME SERIES FOR ESTIMATION OF VERTICAL CRUSTAL MOVEMENTS

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ABSTRACT

Networks of permanent GNSS stations give the opportunity to use its data in many applications. One of them is calculation of the speed of vertical crustal movements. Evaluation of height component of vectors between adjacent stations calculated in regular time grid can be used to accomplish this task if enough data is available. The requirement for a long time series is caused by high standard deviation of the height component relatively to the expected vertical velocity.

One of the main issues is that the GNSS stations are suffering from occasional GNSS receiver malfunctions. This is resulting in changes of the GNSS antennas or receivers, which is causing discontinuities and "steps" in the time series.

This paper presents an automated approach to estimate vertical crustal speed in the presence of "steps" in the GNSS data. It presents the algorithm description and the example of the results on the example data set.

INTRA-PLATE AND INTRA-MASSIF MOVEMENTS OF THE BOHEMIAN MASSIF

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ABSTRACT

The recent dynamics of the Bohemian Massif was revealed on the base of position data obtained from 15 years monitoring of GNSS/GPS signals on 129 stations. The calculated intra-plate site movements were analysed. It was found that the whole Massif moves northward approximately at the rate of 1 cm per year with counter-clockwise declination of 1.5 to 3 degrees relating to the Eurasian continental plate motion. After the elimination of the mean intra-plate motion trend, the intra-massif site movements were studied and correlated with known geological phenomena and historical and recent earthquake occurrences. Delineation of the Bohemian Massif into the blocks of similar dynamics and assessments of the movement types along main tectonic fault zones were accomplished.

AN EVALUATION OF MEASUREMENT NOISE AND MULTIPATH EFFECT FOR DIFFERENT GNSS SYSTEMS

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ABSTRACT

The rapid development of GNSS technology, including the emergence of new systems (Galileo, BDS) and modernisation of previously implemented (GPS, Glonass), gives users the opportunity for combined processing of satellite observations. However, the common use of measurements from different systems should be preceded by the detailed analysis of various intersystem effects. One of significant aspect of GNSS observations, which affects the results of positioning, are stochastic properties of pseudorange measurements for particular satellite constellations.

The presented work is focused on the analysis of code measurements noise and multipath effect detected in pseudorange observations. The study demonstrates the impact of both aforementioned factors observed in signals for four GNSS systems (GPS, Glonass, Galileo, BDS) and all available signals. The measurements from selected stations participated in multi-GNSS experiment (MGEX) were used in order to estimate the parameters describing properties of code observations.

STRUCTURAL AND MORPHOLOGICAL MARKERS FOR NEOTECTONIC DYNAMICS OF THE VISTULA RIVER SOURCE AREA

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ABSTRACT

The morphology of the Vistula River source area (Silesian Beskid, Outer Carpathian) is rebuilt by more than 170 landslides. Largest of these landslides are a complex or compound type with many morphological elements of the colluviums. High (up to 40 m) major scarps, a large number of minor scarps, trenches, large size blocks of rock and in some cases crevice-type caves are characteristic for them. Structural research of the joints and faults in outcrops and analysis of the Digital Elevation Model (DEM) show relationship between landslides development and structure of the basement. The problem has been particularly studied on slopes of the Cienków – Wisznia – Zielony Kopiec Ridge between Biała Wisełka and Malinka creeks valleys. Two large landslides complexes are situated on southern and southwestern slopes of this range. The Biała Wisełka Lanslide Complex (BWLC) covered central part and the Czarna Wisełka Landslide Complex (CWLC) developed in the western part of the range.

The BWLC developed along the ENE – WSW normal fault, which is parallel to regional scale fold axis. Upper part of the fault surface was a major scarp of the landslide. The minor scarp and trenches represent synthetic faults surfaces and tension cracks between slided blocks on the hanging wall of the fault. The major fault surface and the landslide are transformed by NW – SE trending, dextral oblique-slip faults also clearly visible as the displacement of the ridge. Furthermore, the CWLC was developed along NW – SE trending faults.

Development of the landslides complexes along analysed fault zones and displacement of the Cienków – Wisznia – Zielony Kopiec Ridge suggest neotectonic activity research area in extensional regime of deformation. The scale of mass movements shows the catastrophic processes related to post – orogenic uplift of the massif. High dynamics of these processes could be controlled by seismic activity of the region.

VALLEY EVOLUTION OF THE BIAŁA LĄDECKA RIVER – PRELIMINARY RESULTS FROM UPPER ADM MIDDLE PART OF THE BASIN

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ABSTRACT

Keywords: Biała Lądecka river, active tectonics, geophysical research, Góry Bialskie, Góry Złote Mts. (Rychlebské hory Mts.), Sudetic Marginal Fault, Bohemian Massif, Lower Silesia

Biała Lądecka (Biała Kłodzka) river is located in Lower Silesia (Poland) and its valley separates Góry Złote Mts. (Rychlebské hory Mts.) on the northeast from Góry Bialskie Mts. on the southwest. During last year we dealt with geomorphology research in Biała Lądecka river basin, which has a noticeably asymmetrical river basin, probably due to Quaternary tectonic activity of the Sudetic Marginal Fault. According to old research provided in this area by L. Finckh and G. Götzinger (1931), W. Walczak (1954) and A. Ivan (1966), Biała Lądecka river used to flow across the Góry Złote Mts. directly to Oderská nížina Lowland during Pliocene; currently it flows to Nysa Kłodzka Basin. Our research was focused on analysis of all available cartographic materials (geological and topographic maps), available literature and own detail geomorphological mapping of selected landforms. Spatial distribution of these landforms such as gullies, erosion trenches, dellens, alluvial plains, alluvial fans, springs, swamps, river terraces, could potentially indicate recent tectonic activity in the studied area. Moreover, stream network parameters (based on LIDAR data) such as changes in erosion intensity indicated in longitudinal profiles, slope gradient and Stream Length (SL) index (Hack 1973) for upper and middle river basin were analyzed. On selected localities ERT profiles were performed. Some preliminary results will be presented.

The results will also complete the research focused on tectonics in the adjacent areas, e.g. paleoseismologic studies on the SMF (Štěpančíková et al. 2010, 2011), monitoring using dilatometric gauges TM71 installed on the SMF (Stemberk et al. 2010), etc. Some of preliminary results will be presented.

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VALIDATION OF REGIONAL GEOID MODELS FOR POLAND: LOWER SILESIA CASE STUDY

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ABSTRACT

Nowadays, the high accuracy of the horizontal coordinates obtained from GNSS measurements is easily achievable. On the other hand, the precision of GNSS-derived heights is clearly lower comparing to the horizontal components. Nevertheless, state of the art measurements technique, field surveying equipment, data processing software and algorithms allow to achieve millimeter-level accuracy for ellipsoidal heights. In order to obtain the normal heights from GPS measurement, application of precise quasigeoid model is necessary. There are several available models covering the territorial of Poland, e.g. PL-geoid-2011; EGM2008; "leveling geoid 2001"; European Gravimetric Quasigeoid model EGG2008. In addition, a high-accuracy regional quasigeoid model for the Lower Silesia region was developed in 2015.

In this paper we investigate performance of the application of the current geoid models to the satellite leveling in precise test leveling network in the area of Lower Silesia in Poland. In this region, simultaneous precise geometric and satellite leveling measurements were carried out on over 1000 km of leveling lines and over 100 GNSS benchmarks. The results show that the current relative accuracy of the most accurate geoid models is better than 10 mm.

IMPACT OF TROPOSPHERE ESTIMATION METHODS ON PRECISE POINT POSITIONING TIME SERIES IN MOUNTAINOUS AREA

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ABSTRACT

Keywords: PPP, ZTD, MLE, noise analysis

We used GNSS data from 2008 till 2014 collected at 28 permanent EUPOS (European Position Determination System) stations, including 9 EPN sites, located in the Sudeten and Carpathians processed in PPP (Precise Point Positioning) mode using Bernese 5.2 GNSS software to investigate impact of troposphere to the GNSS-derived time series. At the processing stage, different troposphere mapping functions and gradient models were applied. Among others, we evaluated application of the newest: GMF (Global Mapping Function), VMF1 (Vienna Mapping Function) and different approaches to gradient modeling as well, along with the final IGS (International GNSS Service) orbits and clocks. The resulting time series of station positions (North, East and Up components) and respective velocity estimates were investigated. We focused on the different properties of the deterministic part of individual (4) solutions (amplitudes and phases of annual and semiannual oscillations as well as velocities of the permanent stations determined using Weighted Least Squares Estimation). Then we applied Maximum Likelihood Estimation (MLE) using a noise model being a combination of white and power-law to compare different properties of the stochastic parts of the considered time series. Finally, we investigated the GPS ZTDs (Zenith Total Delay) obtained from different processing strategies.

THE POSSIBILITIES OF THE APPLICATION OF GYROSCOPE INSTRUMENTS IN THE ASSESMENT OF THE ROCK MASS STABILITY

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ABSTRACT

The studies of the rock mass movements on considerable depths can be carried out based on the network of geodetic points, present in the mining excavations. Such a network is very unfavourable in a sense of geometry, because it is, in a large part, built of hanging polygonal series. Often the only way to raise the accuracy parameters of such a network is making the azimuth measurements on selected sides of the network with the use of gyrotheodolites. Applying the carried out gyroscopic observations in the levelling of the network gives base to select the regions, where the rock mass is not stable and the dislocation of stabilized there geodetic points occurred. In the article the stability of selected underground geodetic control line was assessed and basic rules of using gyroscopic instruments, the way of determining the accuracy of the measurement and the control of the correctness of their work were defined.

INVESTIGATION ON REFLECTION OF TECTONIC PATTERN IN SOME GNSS DATA

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ABSTRACT

Keywords: GNSS surveying, neotectonics, lineaments, horizontal displacements

The problem of tectonic movements of Sudety Mts. was dealt with by a number of many research activities. By years some progress was made in the investigation of neotectonic activity in the Sudetes area: in surveys methods, techniques or in approach to geological or geodetic data. Especially application of GPS/GNSS data pushes forward with the development of detection of neotectonic movements.

The GNSS data evaluated from on observation of ASG EUPOS stations in the Sudety Mts. and in adjacent areas were analyzed in the scope of disturbances in daily solutions that can be induced by tectonics stress. The horizontal displacements provide probably effects that – due to area size and duration of the process and their small size – can't be detected by classical surveys. The daily position changes derived from GNSS data demonstrate the long-term trends, which are affected by offsets of different nature. Finally, some determinants were found and they are discussed in the scope of tectonic setting. So, there are relations to orientations of tectonic lines presented in the paper.

However derived results are less than a limitation error, temporal distributions of coordinates are not random. The spatial-temporal evolution of horizontal displacements of the stations is determined by expressions of underlying geological structures.

A SHORT STUDY OF THE ORTHOMETRIC HEIGHS APPLICATION IN SOME LEVELING SURVEYS

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ABSTRACT

Gravitational effect induced by salt diapir in the area of Inowrocław evokes changes in plumb line directions. There were significant temporal changes of plumb line which were induced by removal of much rock salt by mining activity. Many geodetic methods or techniques, as gravimetric measurements, for studies on kinematics of Inowrocław salt diapir were applied. Among those the most important for detection of vertical movements seems to be precise leveling. The results were combined with GPS/GNSS observation for evaluation of plumb line deflection. Although results of this examination were discussed before, now (in these work) the authors study a problem of reliability of leveling measurements carried with respect to the changes of gravity. We analyze results of leveling adjustment in regards to combination of reference point's geometry, orientation of leveling traverses, gravimetric data and plumb line deflections. Calculation of the survey data with application of orthometric heights provided more reliable results. On the basis of obtained results the authors conclude that in a particular area of Inowrocław because of gravity anomaly and its spatial and temporal variability, leveling results expressed in physical/natural heights provide more reliable data. So, according to us in spite of country regulation on obligatory height system application, application of geoid as a reference surface in some scientific or engineering tasks is necessary.

CONCEPT OF AHRS ALGORITHM DESIGNED FOR PLATFORM INDEPENDENT IMU ATTITUDE ALIGNMENT

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ABSTRACT

Nowadays, along with the advancement of technology one can notice the rapid development of various types of navigation systems. So far the most popular satellite navigation, is now supported by positioning results calculated with use of other measurement system. The method and manner of integration will depend directly on the destination of system being developed. To increase the frequency of readings and improve the operation of outdoor navigation systems, one will support satellite navigation systems (GPS, GLONASS ect.) with inertial navigation. The most popular way of supporting the measurements is the use on inertial measurement unit (IMU). The band sensors implemented within systems of this type allows for position determination on the basis of readings carried out without the involvement of external signals. At the same time, due to the relatively high noise and the accumulation of errors, the MEMS-based inertial navigation cannot be used as a standalone navigation system. Such method of navigation consists of several steps. The first stage is the determination of initial orientation of inertial measurement unit, called INS alignment. During this process, on the basis of acceleration and the angular velocity readings, values of Euler angles (pitch, roll, yaw) are calculated allowing for unambiguous orientation of the sensor coordinate system relative to external coordinate system. The following study presents the concept of AHRS (Attitude and heading reference system) algorithm, allowing to define the Euler angles. The study were conducted with the use of readings from low-cost MEMS-based IMU unit and an ADIS 65134 unit. The results of the study were analyzed in order to determine the accuracy of determinations made by developed algorithm.

CERTAIN SURVEYING LIMITATIONS IN GNSS RTK POSITIONING

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ABSTRACT

Satellite positioning allows quick and accurate determination of the horizontal and vertical position of static and kinematic objects, and in particular control surveying points. There are well known in the literature various satellite positioning limitations to bear on the quality of survey, such as: precise satellite orbit determination, activity of the ionosphere, multipath and issues of receiver's initialization. In this paper, reference is made to certain restrictions on GNSS positioning occurring in engineering measurements. The authors analyzed the impact of the receiver's position determination on the location accuracy of intermediate terrain details. The size of the possible errors in the vertical point measurements to be fixed due to the impact of troposphere is also pointed. As a result of the study, in a GNSS horizontal position determination of measured points one observed errors at the centimeter, and even decimeter level. According to the authors, it gives certain limitations in the use of kinematic measurements of satellite technology in engineering practice. In addition, it seems reasonable to postulate these effects in the recommendations and technical standards.

THE PROCESSING AND ANALYSIS OF MTI IMU SENSOR DATA IN INDOOR POSITIONING

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ABSTRACT

The conventional pedestrian dead reckoning (PDR) solutions measure the acceleration from accelerometers to take the step count and to estimate the step length and propagate the position with the heading from angular sensors such as magnetometers or gyroscopes. PDR has a large range of applications, such as emergency rescue workers, finding goods in a shopping mall, guiding blind pedestrians or even navigating firefighters in a burning house. However, these signals are sensitive to the alignment of sensor units, the inherent instrumental errors and disturbances from the ambient environment.

In presented inertial pedestrian navigation system, MTI/IMU was used successfully by strapping the IMU on foot/shoe. The PDR indoor positioning method has been implemented in a Kalman-based framework. The Extended Kalman Filter (EKF) is updated with velocity and angular rate measurements by the Zero-Velocity-Update (ZUPT) and Zero-Angular-Rate-Update (ZARU) separately. There is an advantage of the step detection combined with ZUPT and ZARU for calculating the actual position, distance travelled and estimating the IMU sensors' inherent accumulated error by EKF. Several tests with MTI/IMU device have been performed and analyzed in order to evaluate the performance of the proposed methods.

GEOPHYSICAL FLUIDS FROM DIFFERENT SOURCES, AND THEIR IMPACT ON EARTH'S ORIENTATION

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ABSTRACT

Recently we studied the effects of geophysical fluids and geomagnetic jerks in Earth's orientation in space. To this end, we used the American NCEP/NCAR model of the atmosphere and ECCO model of the oceans, and demonstrated that their influence alone cannot fully explain the observed variations of polar motion, length-of-day and celestial pole offsets. The agreement improved substantially when the modeled quasi-impulse effect of geomagnetic jerks was added. Now we concentrate on other available models of geophysical fluids, such as ERA and MERRA for the atmosphere, and OMCT for the oceans, and compare the results with the ones obtained with NCEP/NCAR and ECCO. We also test the hypothetic effect of geomagnetic jerks together with these alternative models and study how much the agreement with the observed Earth Orientation Parameters is improved.

GEODYNAMIC STUDIES IN THE PIENINY KLIPPEN BELT IN 2001–2015

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ABSTRACT

The Pieniny Klippen Belt (PKB), which is situated in Southern Poland, is one of the main fault zones on the boundary of the outer and inner Carpathians. The geodynamical investigations which have been carried out since 1960s indicate that PKB demonstrates neo-tectonic activity. In 1990s, the Dunajec river dam and the water reservoirs in Czorsztyn and Sromowce Wyżne have been built. This has created a new aspect in investigations related to the effect of tectonic movements on the dam. In 2001, after few years break, the investigations were revived. Current the measurements are performed annually, at the beginning of September and contain GNSS and gravimetric measurements. In this paper the results of horizontal displacement in the PKB area based on GNSS measurements as well as gravity changes obtained from relative and absolute measurements in 2001–2015 are presented and discussed.

LASER SCANNING TECHNOLOGIES FOR RIVER AREA REGISTRATION

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ABSTRACT

Laser scanning technologies are very popular and useful in acquiring a reliable and accurate data in relatively short time. Terrestrial Laser Scanning (TLS) applied in small areas enables to obtain high-resolution measurement of data with complex structures. Airborne Laser Scanning (ALS) is used to conduct rapid measurement of large area. However, the accuracy of the product derived from ALS is reduced, as well as a representation of vertical surfaces. Typically, these two technologies are used separately, but there are several possibilities, where they can effectively complement each other. For example, the river and its surroundings where the terrain has complex structures. It might be not easily accessible and therefore not all technologies can be take into consideration in data collection. In hydrological studies the relief determines the dynamics of the water cycle and processes which are related to it to a large extent. Ensuring the accuracy of the relief reconstruction (with striving to minimize the number of necessary data) requires a rapid method of measuring relief and rapid and reliable modeling algorithms.

In this article the analyses and fusion of TLS and ALS data are presented. It is conducted in order to measure complex structures within the river area. The task is taking into account differences in the density of points and scan directions. In addition, a proposal concerning the methodology of data processing is also developed.

GEODYNAMIC VERSUS ENVIRONMENTAL CAUSES OF FACIAL ARCHITECTURE STYLE – TWO EXAMPLES FROM PERMIAN AND CRETACEOUS SEDIMENTS (INTRASUDETIC BASIN)

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ABSTRACT

During the early Permian, on the area of the Intrasudetic Synclinorium, there existed periodic lakes. In periods of seasonal rainfalls the water suddenly invaded the vast and flat bottom of the dried-up lakes. Water flowing in such conditions made in lake sediments or dried-up lakes numerous incisions and highly meandering channels, whose migration led to formation of characteristic microcyclothems. These deposits outcrop nearby Hincyce on the Stenava River.

During the Triassic (Jurassic?) the area of the Sudetes was highly leveled due to a long-term denudation and then it had been flooded. The shallow reservoirs was alternately filled with water and dried up. Sporadically the water flowed through across the geodynamically elevated areas between the reservoirs (subbasins). One of such elevations markedly had influenced on former landscape and, moreover it still exists today and it separates the Nachod and Trutnov subbasins in the southern part, as well as the Police and Krzeszów subbasins in the northern part of the Intrasudetic Basin. Within the sedimentary succession of this elevation coexist quite different facially deposits, which point alternately aggradation and transportation conditions during the sedimentation.

PHYSICAL VERSUS GEOLOGICAL TIME

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ABSTRACT

Physical time is an *a priori* conventional dimension necessary for the understanding of the physical space-time. Units of measurement of physical time are contractual (SI) and relate to the phenomena and processes, whose values or speeds were assumed and are constant. **Geologic time is a stochastic concept and constitutes proof of existence of the physical time**, however it does not fill the entire scale of physical time. Methods for measuring geologic time are **absolute** (point) or **relative** (sequentional). The most accurate methods of measuring the absolute geological time are not more accurate than 1 year. Methods for measuring geological sequenced time are at the level of resolution of 0.5 day. Methods for measuring the relative time can reach a resolution of seconds. A comparison of the physical and geological times requires knowledge about how to measure them and what is ability to measure both.

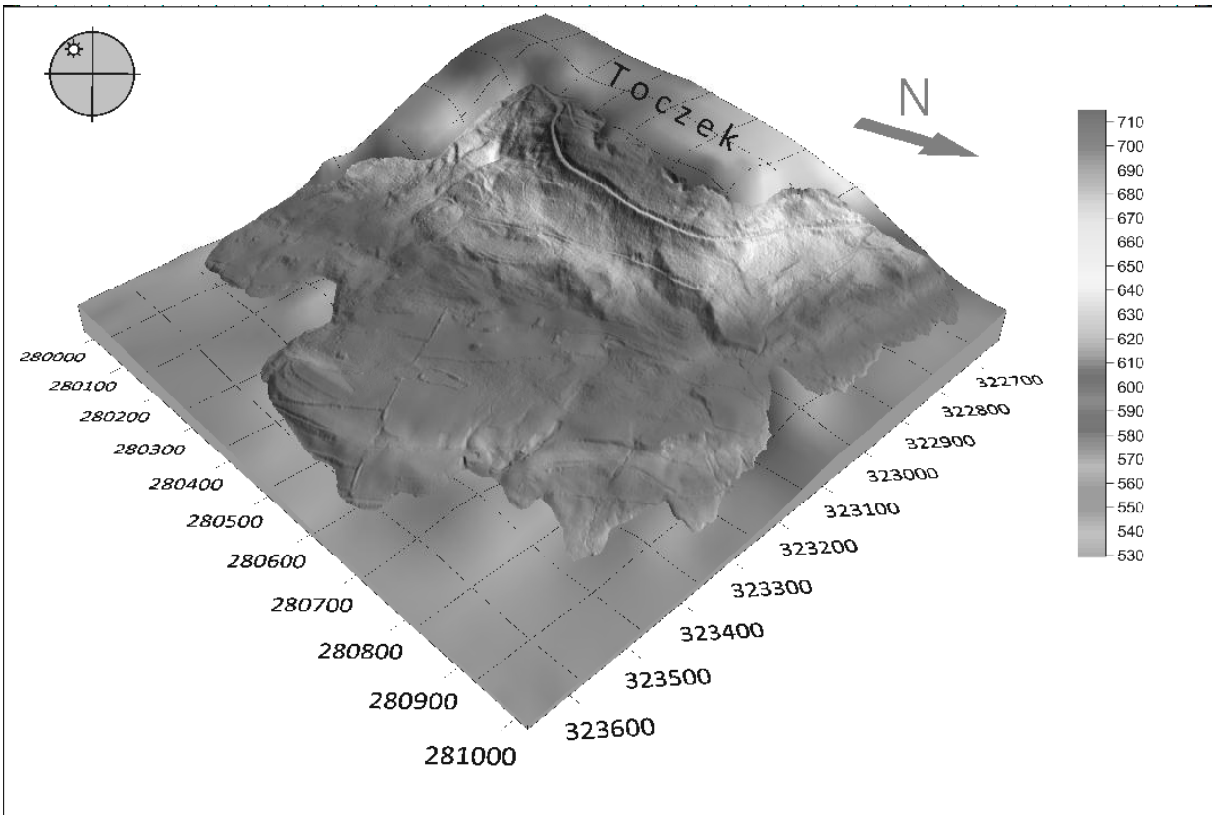

Fig. 1. 3-D model of the Toczek hill lanslide

Table 1. Total volume and thickness analysis of the Toczek landslide interpolated by chosen methods available in Surfer (Golden Software) and Move (midland Valley)

Interpolation method	*Total volume of the landslide colluvial fill [m^3]*	*Maximal thickness of the landslide colluvial fill [m]*
kriging	23 028 717	70,02
minimum curvature	23 440 356	69,88
natural neighbor	23 334 430	69,86
triangulation with linear interpolation	23 354 849	69,87
GeoCellular Volumes (Move)	23 089 477	–
TetraVolumes (Move)	23 028 463	–

References

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Różycka, M., Michniewicz, A., Migoń, P., Kasprzak, M., 2015. Identification and morphometric properties of landslides in the Bystrzyckie Mountains (Sudetes, SW Poland) based on data derived from airborne LiDAR. Geomorphometry for Geosciences, 1: 247–250.

ANALYSIS OF GNSS OBSERVATIONS IN LOCAL AND REGIONAL SCALES FOR SUPPORTING GEODYNAMICAL INTERPRETATION OF STRONG NON-TIDAL SIGNALS OBSERVED BY TILTING INSTRUMENTS IN KSIĄŻ GEODYNAMIC LABORATORY

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ABSTRACT

Permanent registration of tilting effects was launched in Książ Geodynamic Laboratory (LGK) since 1975. In addition to pure tidal signal in optical registration, episodic, non-periodic strong titling effects was observed causing dysfunctions of the horizontal pendulums for few days. At that time we couldn't observe the whole amplitude and time interval of such phenomena. Situation changed in 2003 after the launch of a new instrument – water-tube tiltmeters (WT), few orders more precise and based on different observing technique, sensitive also to vertical movements of the foundation along the instrument. In 2006 a new system of automatic registration of horizontal pendulums titling signals was applied, which allows to observe signals with larger amplitudes. Studies of registered signals on two different type of instruments as well as geological data: shift of geological formations and horizontal stretch of Pełcznica riverbed allowed us to conclude that their sources are geodynamic phenomena. In cooperation with geologists faults inside and outside the Książ Massif were recognized, measured and mapped. Because the main driving force of tectonic events are horizontal crustal movements, for further analysis it was necessary to extend the instrumentation of measurement techniques allowing the registration of the horizontal component in the closer and further environment of the LGK. For this purposes two GPS permanent stations were installed: in November 2010 station KSIA and in May 2013 station KSI1. The first station was established directly above the corridors of the laboratory for determination of the stations velocity vector and its comparison with the velocity vectors of the neighboring permanent GNSS stations and to compute infinitesimal strain rate between GNSS stations. Station KSI1 was established 400 m from KSIA station on the opposite wing of the 'main fault' for determination the relative motions of the wings of this fault. The results and first analysis from reprocessing data from WT and GPS stations covering the period from 2010 to the mid-2015 are presented.

Programme of the 16th Czech–Polish Workshop

ON RECENT GEODYNAMICS OF THE SUDETY MTS. AND ADJACENT AREAS

Srebrna Góra, 5-7 November 2015

Thursday, November 5, 2015	
11:00–13:00	**Registration**
13:00–14:00	**Lunch**
14:00–14:15	**Opening Session** Chairmen: Vladimír Schenk, Bernard Kontny
14:15–15:45	**Session I** Chairmen: Władysław Góral, Jan Vondrák
14:15–14:30	Vladimír Schenk, Richard Pichl, Zdenka Schenková, Bernard Kontny INTRA-PLATE AND INTRA-MASSIF MOVEMENTS OF THE BOHEMIAN MASSIF
14:30–14:45	Paweł Aleksandrowski, Janusz Badura, Szymon Ostrowski, Agnieszka Bochnacka, Marcin Lasocki, Magdalena Pańczyk, Bogusław Przybylski, Olga Rosowiecka, Katarzyna Sobień FIRST RESULTS OF THE POLISH GEOLOGICAL SURVEY'S PROJECT "RECENT FAULTS AND GEOTHERMAL WATERS IN THE SUDETES AND THEIR FORELAND IN THE LIGHT OF STRUCTURAL, GEOCHRONOLOGICAL AND THERMOMETRIC INVESTIGATIONS"
14:45–15:00	Jurand Wojewoda PHYSICAL *VERSUS* GEOLOGICAL TIME
15:00–15:15	Jurand Wojewoda GEODYNAMIC *VERSUS* ENVIRONMENTAL CAUSES OF FACIAL ARCHITECTURE STYLE – TWO EXAMPLES FROM PERMIAN AND CRETACEOUS SEDIMENTS (INTRASUDETIC BASIN)
15:15–15:30	Aleksander Kowalski ŁĄCZNA ANTICLINE (INTRASUDETIC SYNCLINORIUM) – A NEW STRUCTURAL AND GEODYNAMIC INTERPRETATION
15:30–15:45	Marcin Dąbrowski, Janusz Badura, Paweł Aleksandrowski ROCK FAILURE DUE TO TOPOGRAPHIC STRESS IN THE SUDETES MTS: A THREE-DIMENSIONAL NUMERICAL MODEL
15:45–16:15	**Coffee break**
16:15–17:45	**Session II** Chairmen: Paweł Aleksandrowski, Zdenka Schenková
16:15–16:30	Otakar Švábenský, Lubomil Pospíšil, Josef Weigel NOVELTIES ON RECENT ACTIVITY AT THE DIENDORF–ČEBÍN TECTONIC ZONE

16:30–16:45	Ewa Andrasik, Tomasz Olszak, Marcin Barlik, Piotr Spadarzewski CORRELATION BETWEEN OBSERVED GRAVITY CHANGES AND TIME SERIES DERIVED FROM SATELLITE GRAVIMETRY IN SUDETEN REGION
16:45–17:00	Marek Kaczorowski, Zbigniew Szczerbowski, Damian Kasza, Ryszard Zdunek, Mieczysław Jóźwik, Roman Wronowski TECTONIC ACTIVITY OF ŚWIEBODZICE DEPRESSION AND THEIR PROBABLY CONNECTIONS IN TIME-DOMAIN WITH STRONG AND DEEP SEISMIC EVENTS IN LUBIN COPPER MINING REGION
17:00–17:15	Damian Kasza, Marek Kaczorowski, Ryszard Zdunek, Roman Wronowski CHANGE OF THE CHARACTERISTICS OF THE TECTONIC EVENTS EFFECTS RECORDED BY INSTRUMENTS OF THE GEODYNAMIC LABORATORY IN KSIAZ (CENTRAL SUDETES, SW POLAND) IN THE CONTEXT OF IMPACT ON THE ARCHITECTURE OF THE KSIAZ CASTLE
17:15–17:30	Roman Gotowała, Aleksander Kowalski, Artur Sobczyk, Jurand Wojewoda STRUCTURALLY CONTROLLED LANDSLIDE (TOCZEK MT., INTRASUDETIC SHEAR ZONE)
17:30–17:45	Rafał Sikora STRUCTURAL AND MORPHOLOGICAL MARKERS FOR NEOTECTONIC ACTIVITY OF THE VISTULA RIVER SOURCE AREA
17:45–18:15	**Coffee break**
18:15–19:30	**Session III** Chairmen: Marek Kaczorowski, Josef Weigel
18:15–18:30	Zbigniew Szczerbowski, Olgierd Jamroz, Maciej Walicki A SHORT STUDY OF THE ORTHOMETRIC HEIGHS APPLICATION IN SOME LEVELING SURVEYS
18:30–18:45	Zbigniew Szczerbowski INVESTIGATION ON REFLECTION OF TECTONIC PATTERN IN SOME GNSS DATA
18:45–19:00	Janusz Walo, Dominik Próchniewicz, Tomasz Olszak, Andrzej Pachuta, Ewa Andrasik, Ryszard Szpunar GEODYNAMIC STUDIES IN THE PIENINY KLIPPEN BELT IN 2001–2015
19:00–19:15	Ryszard Zdunek, Marek Kaczorowski, Roman Wronowski, Damian Kasza, Zbigniew Szczerbowski ANALYSIS OF GNSS OBSERVATIONS IN LOCAL AND REGIONAL SCALES FOR SUPPORTING GEODYNAMICAL INTERPRETATION OF STRONG NON-TIDAL SIGNALS OBSERVED BY TILTING INSTRUMENTS IN KSIAZ GEODYNAMIC LABORATORY
19:15–19:30	INTRODUCTION TO FIELD SESSION
20:00–23:00	**Grill dinner**

Friday, November 6, 2015	
07:00–08:00	**Breakfast**
08:00–14:00	**FIELD SESSION** – Książ Castle, Szczawno Zdrój
14:30–15:30	**Lunch**
15:30–17:00	**Session IV** Chairmen: Andrzej Borkowski, Otakar Švábenský
15:30–15:45	Y. Chapanov, Cyril Ron, Jan Vondrák ACCURACY AND SENSITIVITY OF A METHOD OF IMPULSE DETECTION, EVALUATED BY SIMULATED TIME SERIES
15:45–16:00	Kamil Kowalczyk, Jacek Rapiński VERIFICATION OF THE ALGORITHM TO IDENTIFY DISCONTINUITIES IN TIME SERIES DATA ON THE EXAMPLE OF GNSS DATA
16:00–16:15	Janusz Bogusz, Anna Kłos, Jean-Paul Boy TIME DOMAIN CROSS-CORRELATION ANALYSIS FOR INVESTIGATION OF ATMOSPHERIC AND HYDROSPHERIC SIGNALS IN GPS TIME SERIES
16:15–16:30	Anna Kłos, Janusz Bogusz ACCELERATION OF GNSS STATIONS IN NOISE ANALYSIS
16:30–16:45	Maciej Gruszczyński, Janusz Bogusz, Anna Kłos ORTHOGONAL TRANSFORMATION IN EXTRACTING OF COMMON MODE ERRORS FROM CONTINUOUS GPS NETWORKS
16:45–17:00	Marta Gruszczyńska, Janusz Bogusz, Anna Kłos APPLICATION OF SINGULAR SPECTRUM ANALYSIS FOR DETERMINATION OF THE GPS TIME SERIES SEASONAL COMPONENTS
17:00–17:30	**Coffee break**
17:30–18:45	**Session V** Chairmen: Cyril Ron, Zbigniew Szczerbowski
17:30–17:45	Władysław Góral, Bogdan Skorupa FIRST INTEGRALS IN THEORY OF MOTION OF GNSS SATELLITE BASED ON THE GPTFC
17:45–18:00	Renata Pelc-Mieczkowska, Dariusz Tomaszewski, Michał Bednarczyk MULTIPATH DETECTION AND MITIGATION METHOD WITH DIRECT (ON POINT) MODELS OF TERRAIN OBSTACLES
18:00–18:15	Ján Hefty, Ľubomíra Gerhátová, Peter Špánik USING GNSS REMOTE SENSING FOR COMPLEX REPRESENTATION OF STATION ENVIRONMENT

18:15–18:30	Katarzyna Stępniak, Anna Kłos, Janusz Bogusz IMPACT OF TROPOSPHERE ESTIMATION METHODS ON PRECISE POINT POSITIONING TIME SERIES IN MOUNTAINOUS AREA
18:30–18:45	Adrian Kaczmarek, Bernard Kontny ANALYSIS OF THE IMPACT OF METEOROLOGICAL FACTORS ON THE TIME SERIES OF GNSS COORDINATES
18:45–19:30	**POSTER SESSION** Friday, 6 November 2015 Chairmen: Sławomir Cellmer, Ľubomíra Gerhátová
Jan Blachowski, Piotr Grzempowski, Wojciech Milczarek MODELLING OF SURFACE DEFORMATIONS ON TERRAINS UNDER THE INFLUENCE OF MINING	
Monika Biryło, Katarzyna Pająk, Jolanta Nastula THE YANGTZE DAM IFLUENCE ON A LOCAL AND REGIONAL GEODYNAMICAL FLUCTUATIONS	
Sławomir Cellmer, Krzysztof Nowel, Dawid Kwaśniak THE PRECISE POSITIONING IN GEODYNAMIC RESEARCH USING THE MODIFIED AMBIGUITY FUNCTION APPROACH	
Piotr Gołuch, Kazimierz Ćmielewski, Janusz Kuchmister APPLICATIONS OF LEICA DNA03 DIGITAL LEVEL TO THE PRECISE VERTICAL AND HORIZONTAL MEASUREMENTS OF INANIMATE NATURE OBJECTS	
Piotr Gołuch, Kazimierz Ćmielewski, Janusz Kuchmister PRECISE MEASUREMENTS OF ROCK BLOCKS MOVEMENTS WITH THE USE OF LEICA NOVA MS50 MULTISTATION AND AUTOREFLECTION METHOD	
Aleksander Kowalski GEODYNAMICALLY ACTIVE FAULT-RELATED LANDSLIDE ON THE DROGOSZ HILL (INTRASUDETIC SYNCLINORIUM)	
Anna Krypiak-Gregorczyk, Jan Kapłon, Paweł Wielgosz, Krzysztof Sośnica, Tomasz Hadaś, Dawid Kwaśniak PROCESSING OF REGIONAL NETWORKS WITH SINGLE-FREQUENCY GPS DATA SUPPORTED WITH HIGH-RESOLUTION REGIONAL IONOSPHERE MODEL	
Michał Lupa, Andrzej Leśniak NEW PROSPECTS FOR AUTOMATED GEOLOGICAL MAPPING WITH SENTINEL-2 MULTISPECTRAL INSTRUMENT	
Krzysztof Mąkolski ,Stefan Cacoń, Blahoslav Košťák, Mirosław Kaczałek, Wojciech Sowa, Magdalena Bachorska, Kinga Gancarek THE STUDY OF MASS MOVEMENT OF ROCK BLOCKS ON STOŁOWE MOUNTAINS AREA	

Krzysztof Mąkolski, Piotr Grzempowski, Beata Gońda RESEARCH OF BENCHMARK HEIGHTS CHANGES ON THE WROCŁAW AREA
Krzysztof Mąkolski, Mirosław Kaczałek, Anna Libront THE STUDY OF VERTICAL DISPLACEMENT OF THE BEAR CAVE ROCK MASS SURROUNDINGS IN THE AREA OF "ŚNIEŻNIK KŁODZKI"
Krzysztof Mąkolski, Wojciech Sowa, Grzegorz Bury, Aleksander Łotecki ANALYSE OF GEODYNAMIC RESEARCH RESULTS BASED ON GNSS MEASUREMENTS OF "STOŁOWE MTS" NETWORK
Katarzyna Mirek SENTINEL-1 SAR INTERFEROMETRY FOR SUBSIDENCE MONITORING ON MINING AREAS, USCB CASE STUDY
Jacek Paziewski, Paweł Wielgosz COMBINED BDS + GPS PRECISE RELATIVE POSITIONING
Rafał Sieradzki, Jacek Paziewski AN EVALUATION OF MEASUREMENT NOISE AND MULTIPATH EFFECT FOR DIFFERENT GNSS SYSTEMS
Jakub Stemberk, Petr Tábořík, Petra Štěpančíková VALLEY EVOLUTION OF THE BIALA LĄDECKA RIVER – PRELIMINARY RESULTS FROM UPPER ADM MIDDLE PART OF THE BASIN
Katarzyna Stępniak, Paweł Gołaszewski, Radosław Baryła, Jacek Paziewski, Paweł Wielgosz, Grzegorz Kurpiński, Edward Osada VALIDATION OF REGIONAL GEOID MODELS FOR POLAND: LOWER SILESIA CASE STUDY
Marcin Uradziński, Adam Doskocz CERTAIN SURVEYING LIMITATIONS IN GNSS RTK POSITIONING
Marcin Uradziński, Hang Guo THE PROCESSING AND ANALYSIS OF MTI IMU SENSOR DATA IN INDOOR POSITIONING
Jan Vondrák, Cyril Ron GEOPHYSICAL FLUIDS FROM DIFFERENT SOURCES, AND THEIR IMPACT ON EARTH'S ORIENTATION
Beata Wieczorek, Katarzyna Pająk, Anna Sobieraj, Dariusz Tomaszewski LASER SCANNING TECHNOLOGIES FOR RIVER AREA REGISTRATION
20:00–23:00 Gala Dinner

Saturday, November 7, 2015	
08:00–09:00	**Breakfast**
09:00–10:15	**Session VI** Chairmen: Janusz Bogusz, Lubomil Pospíšil
09:00–09:15	Stefan Cacoń, Dawid Strączkowski RECENT VERTICAL MOVEMENTS OF GEOLOGICAL STRUCTURES ALONG A SUDETEN MARGINAL FAULT
09:15–09:30	Kamila Pawłuszek, Andrzej Borkowski LANDSLIDE SUSCEPTIBILITY MAPPING USING STATISTICAL METHOD WEIGHT OF EVIDENCE
09:30–09:45	Magdalena Pieniak RESEARCH ON RIVER TERRACES DETECTION
09:45–10:00	Jacek Rapiński, Kamil Kowalczyk STEP DETECTION IN GNSS TIME SERIES FOR ESTIMATION OF VERTICAL CRUSTAL MOVEMENTS
10:00–10:15	Dariusz Tomaszewski, Renta Pelc-Mieczkowska CONCEPT OF AHRS ALGORITHM DESIGNED FOR PLATFORM INDEPENDENT IMU ATTITUDE ALIGNMENT
10:15–10:45	**Coffee break**
10:45–11:45	**Session VII** Chairmen: Stefan Cacoń, Vladimír Schenk
10:45–11:00	Piotr Grzempowski, Janusz Badura, Wojciech Milczarek RESEARCH OF THE VERTICAL GROUND SURFACE DISPLACEMENTS USING INSAR TECHNIQUE ON THE SOUTH-EASTERN PART OF THE CENTRAL EUROPEAN SUBSIDENCE ZONE
11:00–11:15	Anna Szafarczyk, Rafał Gawałkiewicz THE POSSIBILITIES OF THE APPLICATION OF GYROSCOPE INSTRUMENTS IN THE ASSESSMENT OF THE ROCK MASS STABILITY
11:15–11:30	Daria Filipiak-Kowszyk, Artur Janowski,Waldemar Kamiński, Karolina Makowska, Jakub Szulwic, Krzysztof Wilde THE GEODETIC MONITORING OF THE FOREST OPERA IN SOPOT – A PRACTICAL SOLUTION OF THE PROBLEM IN 3D SPACE
11:30–11:45	Rafał Gawałkiewicz, Anna Szafarczyk DETERMINATION OF CHANGES IN THE CHARACTERISTICS IN SELECTED CRACOW'S MOUNDS ON THE BASIS OF GEODETIC SPOT-MONITORING RESULTS
11:45–12:15	**Final Discussion and Closing Ceremony** Chairmen: Vladimír Schenk, Bernard Kontny, Stefan Cacoń
12:15–12:45	**Lunch**
12:45–15:00	**Visit to Srebrna Góra Stronghold**