

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

Institute of Geodesy, Brno University of Technology

Committee of Geodesy, Polish Academy of Sciences



PAN

Association of Students and PhD Students "Zenit-Nadir"



18th CZECH–POLISH WORKSHOP

ON RECENT GEODYNAMICS OF THE SUDETY MTS. AND ADJACENT AREAS

ABSTRACTS

Szklarska Poręba, Poland October 26–28, 2017 Organizing and Scientific Committee of the

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PROGRAMME OF THE 18 th CZECH–POLISH WORKSHOP

APPLICATION OF SATELLITE RADAR INTERFEROMETRY IN STUDIES OF HISTORICAL DEFORMATIONS IN POST MINING AREAS. CASE STUDIES FROM CZECH REPUBLIC AND POLAND

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ABSTRACT

Keywords: surface deformation, coal mine, satellite radar interferometry, Czech Republic, Poland

Secondary deformations are surface movements associated with effects of ceased underground mining activity. These are associated with delayed readjustment of rock mass resulting in subsidence, sudden destruction of underground, usually shallow, workings, which may result in discontinuous deformations, as well as elevation of ground surface in the response of rock mass to rising ground water levels following the end of mine water drainage. Analysis of secondary deformations of ground surface following the end of underground hard coal mining is the subject of this study. We have used satellite radar interferometry data and GIS to determine vertical (in satellite's line of sight, LOS) movements of the surface and analyse these movements in relation to location of mined coal fields and underground water table rise following end of mining. In the study two areas have been compared, Walbrzych in Poland and Ostrava in Czech Republic. The results have been presented on maps and graphs. The results of analyses based on the results of PSInSAR processing between June 1995 and June 2000 for the Walbrzych area indicate elevation up to + 25 mm in closed parts of coal fields and subsidence (up to -40 mm) in areas of continued mining. Results of PSInSAR analysis over Ostrava undermined areas indicate decaying subsidence after mine closures in the rate of up to -20 mm/year during 1995-1998 and up to -10 mm/year in 1998-2000. Residual subsidence in the rate of up to -3 mm/year has been identified at surroundings of closed Ostrava shafts from 2003-2010 data.

STOCHASTIC MODELS IN THE DORIS POSITION TIME SERIES: ESTIMATES FOR IDS CONTRIBUTION TO ITRF2014

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ABSTRACT

Keywords: ITRF2014, DORIS, time series, error analysis

This presentation focuses on the investigation of the deterministic and stochastic parts of the DORIS (Doppler Orbitography and Radiopositioning Integrated by Satellite) weekly time series aligned to the newest release of ITRF2014. A set of 90 stations was divided into three groups depending on when the data was collected at an individual station. To reliably describe the DORIS time series, we employed a mathematical model that included the long-term nonlinear signal, linear trend, seasonal oscillations (these three sum up to produce the Polynomial Trend Model) and a stochastic part, all being estimated with Maximum Likelihood Estimation (MLE). We proved that the values of the parameters delivered for DORIS data are strictly correlated with the time span of the observations, meaning that the most recent data are the most reliable ones. Not only did the seasonal amplitudes decrease over the years, but also, and most importantly, the noise level and its type changed significantly. We examined five different noise models to be applied to the stochastic part of the DORIS time series: a pure white noise (WN), a pure power-law noise (PL), a combination of white and power-law noise (WNPL), an autoregressive process of first order (AR(1)) and a Generalized Gauss Markov model (GGM). From our study it arises that the PL process may be chosen as the preferred one for most of the DORIS data. Moreover, the preferred noise model has changed through the years from AR(1) to pure PL with few stations characterized by a positive spectral index.

STATION COORDINATE DISPLACEMENTS DUE TO ATMOSPHERIC PRESSURE LOADING FROM SLR TRACKING OF MULTI-GNSS

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ABSTRACT

Keywords: SLR, Atmospheric pressure loading, multi-GNSS

Satellite Laser Ranging (SLR) is a precise satellite technique that provides range measurements to satellites that are equipped with retroreflectors. SLR provides a series of geodetic parameters i.e., station coordinates, range biases, multi-GNSS orbits, Earth rotation parameters, and geocenter coordinates, thanks to the precision of range measurements.

The International GNSS Service introduced Multi-GNSS Experiment (MGEX), due to the emerging of new navigation systems such as Galileo, BeiDou, QZSS, NavIC and continuous modernization of GPS and GLONASS. All new active GNSS satellites are equipped with retroreflectors for range measurements. As a result, SLR became an independent tool for deriving orbit products based on GNSS-derived data and a space linkage between two space geodetic techniques.

Atmospheric pressure loading (APL) deforms Earth's crust with the magnitude up to several millimeters, thus plays a crucial role in precise space geodesy, when the highest accuracy of station coordinates is requested. SLR observations are performed during almost cloudless conditions. Such weather conditions coincide with high atmospheric pressure that deforms the Earth's crust downwards, therefore most of the SLR observations are collected when the crust is deformed. This systematic offset is called the Blue-sky effect. The omission of APL corrections for SLR solutions may lead to an incorrect estimation of geodetic parameters including systematic errors.

In order to evaluate the impact of the lack of APL corrections in the solutions, we perform solutions with and without considering APL corrections. Unsurprisingly, the highest impact occurs for inland stations. The values of the Blue-sky effect reach up to 2.3 and 2.2 mm for Svetloe and Zelenchukskaya, respectively. The omission of APL corrections influences also estimated Earth rotation parameters by 8.1 and 21.0 µas for X and Y pole coordinates, respectively, geocenter coordinates by 0.4, 1.2 and 1.9 mm for X, Y and Z, respectively and multi-GNSS orbits with the amplitude of annual signal of 2.7 mm for the Z component.

APL corrections should be applied at the observation level, and not just in the post-processing, i.e., at the solution level, because loading corrections affect not only the station coordinates, but also other estimated parameters, such as Earth rotation parameters, global scale, and multi-GNSS orbits.

LANDSLIDE BARDO-JANOWIEC IN 2009–2017

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ABSTRACT

In July 1997 after heavy rains near the Village Janowiec in Bardo district a new landslide occurred. In next few years it was forgotten because mostresearchers and local people have not seen changes in shape of ground. From this point most opinion was that mass-movements stops.

In 2009 researchers from Wroclaw University of Environmental and Life Sciences started geodetic monitoring of this landslide. From year to year the control network was growing. On beginning authors used tachymetry, precise levelling, GNSS, airborne and terrestrial laser scanning, UAV photogrammetry technics. Most significant change occur in 2014 when one inclinometric and two piezometric columns has been installed. Which allow to connect surface and subsurface movement measurements.

In this research work authors show survey results from years 2009-2017 supporting by the geological data.

POLISH RESEARCH ON UNESCO WORLD HERITAGE PRE-COLUMBIAN ARCHAEOLOGICAL SITE "EL FUERTE DE SAMAIPATA"

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ABSTRACT

Keywords: Samaipata, terrestrial laser scanning, UNESCO, photogrammetry

El Fuerte de Samaipata is a pre-Columbian archaeological site located in Bolivia on the slopes of the Eastern Cordillera. Despite this strong dominance of the Inca character, the site is multicultural and its origins most probably date back to around 300 AD, when people began to carve in the abovementioned natural rock. Its current appearance is then a result of at least 1200 years of activities carried out by varied cultures developing in that area. It is quite certain that the rock served as *wak'a*, a sacred place, and its prestige among the local people was definitely one of the main – although by no means the only – reason why the Inca chose that spot for their administrative-ceremonial centre once these lands had been incorporated into the Tawantinsuyu (the Inca Empire) in the second half of the 15th century.Due to both its artistic and historical value, the site was entered into the UNESCO World Heritage list in 1998.

The site drew attention already in the Colonial period. A missionary named Diego de Alcaya stated at the end of the 16th century that it had been an important Inca administrative centre, and at the same time a fortress intended to protect the borderlands of the Empire from the assaults of the aggressive Chiriguanos from the Chaco area. The visit of a French naturalist, Alcide d' Orbigny in 1832 was another important event in the history of research of Samaipata. It was him, who made the first, sketchy as it was, diagram of the rock and the images that covered it. However, the real turning point came at the beginning of the 20th century with the works of a Swedish scholar Erland Nordenskjold, and an Austrian immigrant to Bolivia, Leo Pucher.The most important achievements include the study on the Samaipata pictures by Herman Trimborn and then the research – commenced in 1992 and continued until 2001 – of Proyecto de InvestigacionesArqueológicas de Samaipata (PIAS), managed by Albert Meyers. Ph.D., from the Bonn University. It was the research of this project that led to revealing of the Inca administrative-ceremonial centre.

The rapidly progressing erosion of the sandstone makes individual pieces of rock art increasingly less readable, and some of them are now unrecognizable. For that reason in 2016 Polish researchers headed by prof. Kościuk started realizing project 014/15/B/HS2/01108 funded by Polish National Science Centre.

The main aims of our project can be summarized as follows:

- A detailed documentation of the whole complex with the usage of modern surveying techniques allowing for the present state of object preservation to be archived, which is of a crucial importance due to a rapid degradation of the site.
- The analysis of range and speed of degradation (erosion) of the site and preparation of a risk map which will allow us to designate areas for immediate conservation intervention.
- Iconographic analysis of preserved petroglyphs which is becoming more and more difficult due to constant erosion (some presentations known previously, e.g. "an ostrich", are presently completely unrecognisable).
- To settle a relative chronology of particular elements/objects of the site a research problem incredibly essential because of analogous reasons.

GLOBAL GEODETIC PARAMETERS FROM SLR SOLUTIONS APPLYING HORIZONTAL GRADIENTS OF THE TROPOSPHERIC DELAY

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ABSTRACT

Keywords: Horizontal gradients, tropospheric delay, SLR, GNSS

Satellite Laser Ranging (SLR) has a considerable impact on the definition of the origin of the reference frame, the global scale, precise satellite orbit parameters and Earth gravity field coefficients. SLR is one out of four space geodetic techniques which are used to determine the International Terrestrial Reference Frame. Currently only in SLR solutions the horizontal gradients of the troposphere delay are neglected. This deficiency provides to a limitation of the present accuracy of SLR solutions.

SLR is only one optical space geodetic technique, therefore SLR needs appropriate handling of tropospheric horizontal gradients dedicated for optical (laser) wavelengths. We present first results of applying horizontal gradients derived from numerical weather models (NWM) based on data from the European Centre for medium Range Whether Forecast supported in specific locations by profiles from the National Centers for Environmental Prediction (NCEP) Global Forecast System.

First results show some systematic effects on the station coordinates which are related to differences in SLR residuals up to 3 mm for low elevation angles. We compare the estimated SLR station coordinates, geocenter coordinates, Earth rotation parameters and range biases from SLR solutions with and without applying horizon-tal gradients using observation to dedicated satellites LAser GEOdynamics Satelite (LAGEOS) 1 and 2. The data are reprocessed using a modified version of Bernese GNSS Software intended for SLR data processing with extended modelling of the troposphere delays. Applying the horizontal gradients of the troposphere delay in SLR solutions is essential in order to fulfil the requirements of the Global Geodetic Observing System (GGOS) asking for the station coordinate accuracy of 1 mm.

PRE- AND POST-CONSOLIDATED SEDIMENT DEFORMATIONS OCCURING AT THE BOUNDARY OF ZECHSTEIN AND LOWER BUNTSANDSTEIN DEPOSITS OF THE GRODZIEC SYNCLINE, NORTH-SUDETIC SYNCLINOIRUM, SUDETS

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ABSTRACT

Keywords: Grodziec syncline, pre- and post-consolidated sediment deformation, Buntsandstein, Zechstein, Sudetes

The study area is located in North-Sudetic Synclinorium in SE marginal part of European Zechstein basin, where KGHM PolskaMiedź S.A. holds a concession for documenting sediment-hosted copper deposit. During core logging one of the difficulties was to determine the boundary between Permian and Triassic sediments. A sandy-silty-argillaceous transitional succession is distinguished between Permian and Triassic deposits and is referred as a Top/Transitional Terrigeneous Series (PZt) (Wagner et al., 1978). A zone of pre- and post-consolidated sediment deformation was described within tempestitesheterolithes. It turned out to be significantly helpful horizon in determining boundary between both systems.

The zone of pre- and post-consolidated deformation structures has varied thickness from 2m in N and NE up to 14 m in SW of the study area. In principle, the original structure of the sediment is more or less susceptible to the destruction or complete obliteration. Sometimes it comes to rebuild of the sediment structure due to plasticizationor liquefaction. The predominant pre-consolidated sediment deformation structures occurring in the study area are: reversed density stratification('ba'),neptunian and clasticdykes, clastic diffusional cells, compacted desiccation (syneresis) cracks. If such structures form a correlation horizon on a larger area, they might be an indicator of seismic shocks - seismites (Moretti, van Loon, 2014). Seismic activity of the research area occurring at the turn of the Permian and Triassic may be also confirmed by the occurrence of compacted cracks in a soft sediment. Within these structures redeposited sediments filled with clastic or mineral material are visible. If they present penetrative character, they may indicate the synsedimentary tectonic activity of the study area. For post-consolidated deformations authors consider these phenomena, which are accompanied by the break of continuity of the sedimentary planes, relocation along newly created planes within the sediment or brittle failure (e.g. brecciation). These structures can be classified primarily as (micro)faults. There is no doubt that the horizon described at the boundary of the Permian and Triassic is correlated in the area ranging from a few kilometers to the south and a few tens of kilometers north of the border of the present structure of the Fore-Sudetic Block. The pre-consolidated sediment deformation structures have numerous features of seismites, however postconsolidated deformation structures raise more doubts about their origin and require more research.

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PRECISE ZTD ESTIMATION IN THE POSITIONING USING MAFA METHOD

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ABSTRACT

Keywords: GNSS, MAFA, ZTD, troposphere

In GNSS, the troposphere is one of the most important factor affecting the positioning precision. The influence of the tropospheric delay is estimated as the Zenith Total Delay (ZTD). The ZTD estimation is based on the implementation of the troposphere model into the positioning algorithm. Therefore, quality of the ZTD estimation means the accuracy of the position.

In this research, we tested the influence of the ZTD estimates on the accuracy of the rover position. For this purpose, the modified Hopfiled troposphere model was applied in the double difference positioning algorithm. Also, interpolated ZTD from 3 adjacent reference stations was applied for the comparison. Troposphere parameters on the reference stations were estimated precisely in the G-NUT/Tefnut software, with use of precise IGS products in the PPP mode. In the tests, self-made software were used. The Modified Ambiguity Function Approach (MAFA) method is the part of the software responsible for the precise positioning. Resulting position was compared to the station coordinates. Research was conducted on the stations in the Sudeten area. Three tested periods covered various weather conditions.

DETERMINATION OF THE GROUND SURFACE DEFORMATIONS ON THE SELECTED SECTION OF THE MIDDLE ODRA FAULT ZONE USING INSAR TECHNIQUE

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ABSTRACT

Keywords: Displacements, InSAR, Middle Odra Fault Zone

In the paper available SAR Images for research area have been analyzed in respect of their usefulness in determining the ground surface displacements using InSAR technique. The collection of analyzed materials includes data from satellites ERS1/2 (1996–2002), ENVISAT (2002–2009) and Sentinel1 (from 2014). Based on the selected data, the displacements occurring in the analyzed periods have been determined for the selected parts of the Middle Odra Faults Zone using PsInSAR and SBInSAR technigues.

TECTONIC CREEP MOVEMENTS IN THE SUDETY MTS, SW POLAND DETERMINED ON THE BASIS OF MEASUREMENTS INTERFERENCE CRACK GAUGES

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ABSTRACT

Keywords: crack gauges, 3-D monitoring, micro displacements, tectonic creep

Tectonic creep movement monitoring requires the use of specialized measuring instruments and high precision. For this purpose, crack gauges TM71 were designed in Czech Republic. They can be used to study the deformation of building structures. They are also suitable for measurement relative displacements in tectonic zones.

Institute of Geodesy and Geoinformatics, Wrocław University of Environmental and Life Sciences has started measurements of rock structure movements using crack gauges since 1972.

At present, Polish gauges network contains several instruments installed in the Sudety Mountains, SW Poland: Dobromierz, Złoty Stok, Janowice Wielkie, Wolany, Stołowe Mountains National Park, Bear Cave in Kletno, Nowy Waliszów. Interference gauges enable with high precision (sub-milimeter) determination of the spatial displacements of adjacent rock structures and their rotations. Data reading from the instruments are performed at monthly intervals and then processing in cooperation with Institute of Rock Structure and Mechanics Czech Academy of Sciences, in Prague. This paper presents the results of the latest research carried out in the interference gauges network in the Polish part of the Sudety Mts.

THE IMPACT OF GEOPHYSICAL DEFORMATION OF THE EARTH'S CRUST ON CHANGES OF GNSS STATION COORDINATES IN THE SUDETY MTS. AND ADJACENT AREA

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ABSTRACT

<u>Keywords</u>: coordinate time series, geophysical fluid models, correlation coefficient, Sudety Mts.

The analysis of long enough GNSS coordinate time series may give us information about local or global deformations of the Earth's crust. The coordinate time series are including additional signals, another than the geodynamical signal which is interference on coordinates changes. This presentation is presenting the analysis of coordinate changes for selected GNSS stations in the Sudety Mts. and adjacent areas, referencing to deformation of Earth crust of geophysical loading models from BKG* center (APL - Atmospheric Pressure Loading, HYDRO - Hydrology, NTOL – Non-Tidal Ocean Loading). In this analysis, we are used coordinate time series data for stations of IGS (CODE Repro2013) and ASG-EUPOS network. The analysis was performed separately for North, East and Up component.

^{*} DFG Research Unit: Space-Time Reference Systems for Monitoring Global Change and for Precise Navigation in Space. Project 5: Consistent celestial and terrestrial reference frames by improved modeling and combination.

CONTINUATION OF INVESTIGATION OF THE PROBLEM OF HIGH ENERGY SEISMIC EVENTS IN THE MIDDLE-ODRA FAULTS ZONE BASED ON THE OBSERVATIONS OF THE SWIEBODZICE DEPRESSION KINEMATIC ACTIVITY

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ABSTRACT

<u>Keywords</u>: geodynamics, tectonic activity, mine surveying, tectonics of the Sudetic region, geodetic and geophysical measuring systems

The Geodynamic Laboratory of Space Research Centre in Ksiaz is located in the central part of geological unit called Swiebodzice Depression which is 50 km distant from the Fore-Sudetic Monocline. The kinematically active Swiebodzice Depression is completely aseismic which was proven by the nearby seismic stations. The reason of this situation is a constitution of the Swiebodzice Depression orogen which is separated by numerous faults permitting soft motions of blocks and defuse of stresses without seismic effects. Seismically active area is located in the Fore-Sudetic Monocline about 50 km distant from Ksiaz laboratory. The earthquakes which are discussed in the paper occurred in the Middle-Odra Fault Zone. Long lasting observations of the tectonic activity in Swiebodzice Depression are executed in Ksiaz laboratory with help of the horizontal pendulums and two water tube tiltmeters (WT). Our tiltmeters provide information of tectonic activity in aspect of tiltings of foundation as well as vertical movements. Intensity of these effects changes in time from low level to high level when it exceeds two times of tide amplitude. The variations of tectonic activity are described by four functions of tectonic activity (TAF) determined after tidal adjusting of the WT measurements. Variations of kinematic activity of massif associated with variations of tectonic stresses consist of two epochs compressions and extensions. During the epochs of compressions i.e. strong kinematic activity of massif large absolute values of TAF derivates are registered. On the contrary, in epochs of extensions tectonic forces are decreasing or vanishing and velocities of deformations of massif became close to zero which results in small values of TAF derivates. Therefore, close to zero derivates of TAFs indicate the epochs of extension. Long lasting observations confirmed that phases of extensions in the Swiebodzice Depression correspond in time with strong seismic events in Fore-Sudetic Monocline (Mag>=4).

This correlation suggests that both geological units are in large dimension field of tectonic pressure. The investigation provides us to conclusion that the special conditions must be fulfilled to earthquake happen. The most important condition are variations of signs of all derivatives of TAFs before earthquake in suitable time intervals as well as close to zero values of derivatives of TAFs.

Continuation of presented works aims for elaboration of forecast of seismic hazard in Fore-Sudetic Monocline.

IMPACT OF HIGHER-ORDER IONOSPHERE EFFECTS ON ESTIMATON OF PRECISE COORDINATES FROM GNSS DATA

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ABSTRACT

Keywords: GNSS data processing, Higher-order ionosphere effects

High precision Global Navigation Satellite Systems (GNSS) positioning and time transfer require correcting signal delays, in particular taking into account higherorder ionospheric (I2+) terms. We present a consolidated model to correct secondand third-order terms, as well as geometric bending and differential STEC bending effects in GNSS data. The model was implemented in new online service correcting observations in submitted RINEX files for I2+ effects. In order to investigate the impact of I2+ corrections on the processing results we performed GNSS data processing in two variants, with and without application of I2+ corrections. We selected three time periods, one week long each, representing different ionosphere conditions. We used GPS and GLONASS observations from global receivers and two regional networks, in Poland and Brazil. We estimated satellite orbits, and Earth rotation parameters, troposphere delay and its horizontal gradients, receiver positions using double-difference and Precise Point Positioning (PPP) techniques. The satellite clock corrections were estimated with PPP as well. The satellite-related products (orbits and clocks) were the ones capturing most part of the change after applying I2+ corrections, up to 2 cm for clock corrections, 1 cm for along- and cross-track components, and below 5 mm for radial component. Finally, we noticed I2+ corrections caused global systematic shift in coordinate domain up to 8 mm along Z-axis of ECEF coordinate system as well as the global scale change of 0.8 mm. I2+ corrections caused also systematic coordinate shifts that were time- and region-dependent, and reached up to -11 mm in the North component for Brazilian stations during active ionosphere conditions.

RECENT INDICATORS OF THE TECTONIC ACTIVITY IN THE VINCINITY OF THE KSIĄŻ CASTLE (ŚWIEBODZICE DEPRESSION, THE SUDETES) IN THE LIGHT OF GEODETIC MEASUREMENTS AND STRUCTURAL ANALYSIS

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ABSTRACT

<u>Keywords</u>: recent tectonic activity, brittle deformations, strike-slip tectonics, the Sudetes, Świebodzice Unit, Książ massif

Recent tectonic activity of the Książ area (Świebodzice Unit, Sudetes) was registered for the first time by the quartz horizontal pendullums installed in the Geodynamic Laboratory (GL) in the underground of the Książ Castle (Chojnicki,Blum, 1996). Observations carried out by the tiltmeters have been ongoing since 1974, which allowed to accumulate measurement material for a very long and uninterrupted period. The phenomenon of tectonic activity was confirmed after the launch of new devices - water-tube tiltmeters (WT) in 2002, whose indications confirmed the existence of irregular, strong signals related to the relative displacement of the rock blocks on which the Książ Castle was built (Kaczorowski, 2009). The signals recorded by WTs have two components: the inclination component and the component of the vertical movement of the foundation. Both effects are the result of horizontal shift movements, which are visible in the GL's underground corridors as surfaces of discontinuity (fault surfaces and reactivated joints). The effects of horizontal displacements in the vicinity of Ksiaż Castle are also visible as anomalies of the course of the Pełcznica river valley, which directly coincides with the major fault structures orientation occurring in this area (Kaczorowski, Wojewoda, 2011a, b; Wojewoda, 2016). The recent geodynamic activity of the Ksiaz Castle area also indicates the destruction of the elements of the castle complex in the form of cracks and gaps (Kasza et al., 2014). The analysis of instrumental indicators of motion, geodetic measurements and structural analyzes allowed to create model of the course of main discontinuities zones within Ksiaż massif.

Structural analysis has shown that the Książ and Chwaliszów Formation deposits which crop out in the Książ massif are strongly deformed. Bedding planes of the conglomerates and sandstones are W-E trending and are steeply inclined (65-90°) towards the N/NNW and S-SSE. It produces a visual effect of presence of fold structures in the study area (cf. Porębski, 1981). The investigated rocks are cut by joints of three main sets (j1, j2 and j3) and NW-SE and W-E dextral, and NE-SW sinistral faults. Numerous minor (secondary) fault related structures were documented. They involved mesostructural kinematic indicators associated with brittle and strike-slip tectonics. Slickensides, grooves, hackles, striated ridges, low-angle R (Riedel) shears, en echelon cracks and high-angle antithetic R' shears were measured and documented. Moreover, a numerous extensional, NE–SW trending extensional fractures associated with faults are filled by clay gouge, sometimes calcitised and impregnated by hematite mineralisation. Mineralisation is probably linked with the youngest stage of faulting.

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ARE THE TIME-VARYING SEASONAL SIGNALS DETECTABLE IN GPS POSITION TIME SERIES UNDER NORMAL NOISE LEVEL CONDITIONS?

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ABSTRACT

Keywords: GPS, least squares estimation, wavelet decomposition, singular spectrum analysis, Kalman filter, Chebyshev polynomials

Global Positioning System (GPS) coordinate time series contain annual and semi-annual periods that are routinely modelled by two periodic signals with constant amplitude and phase-lag. However, the amplitude and phase-lag of the seasonal signals vary slightly over time. Various methods have been proposed to model these variations such as Wavelet Decomposition (WD), writing the amplitude of the seasonal signal as a polynomial that is a function of time (CP), Singular Spectrum Analysis (SSA) and using a Kalman Filter (KF). Using synthetic time series, we investigate the ability of each method to capture the time-varying seasonal signal in time series with different noise levels. Estimating a varying seasonal signal always results in lower noise amplitudes and lower spectral indices compared to estimating a constant seasonal signal. The accuracy by which the varying seasonal signal can be estimated depends on the ratio of the variations in the seasonal signal to the noise level. For most GPS time series, this ratio is between 0.05 and 0.1. Therefore, the most accurate estimates of the variations are given by the SSA and KF methods. WD and CP have trouble in separating the seasonal signal from the noise for high noise levels. For real GPS data, SSA and KF can model 49-84% and 77-90% of the variance of the true varying seasonal signal, respectively.

AN ATTEMPT TO VERIFICATIONS OF THE HYPOTHESIS ON GRAVITATIONAL COLLAPSE FOR THE MAIN MOUNTAIN RANGES OF EUROPE ON THE BASE OF EPN PRODUCTS

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ABSTRACT

<u>Keywords</u>: EUREF Permanent Network, European mountain ranges, gravitational collapse

Preliminary interpretation of results of appointing contemporary, horizontal surface deformations of the area of the Sudeten mountains and the adjacent areas, based on long-term GPS observations, is showing the extension on highlands of the Sudeten mountains and the compression on foothill areas. Such regime of horizontal deformations is matching the hypothesis of gravitational collapse, published in 2001 (Rey, Vanderhaege and Teyssier, "Gravitational collapse of the continental crust: definition, regimes and modes", Tectonophysics, vol. 342, 435-449).

Authors made an attempt to check, whether it is possible to detect the similar regime of horizontal surface deformations also for main mountain ranges of Europe: of the Alps, the Pyrenees and the Carpathians. At this target selected products of the EPN service were used: ETRF velocities of permanent GNSS stations located in cross sections perpendicular to the most important mountain ranges of Europe. Two cross sections were analyzed for the Alps and by one cross sections for the Pyrenees and the Carpathians. For every cross section values of the linear deformation were calculated along the lines between next stations (stretching or hugging). Unfortunately insufficient density of the EPN stations in these areas didn't let to the explicit and truly credible confirmation or rejecting the established hypothesis.

THE EFFECT OF TEMPERATURE ON THE CHANGE IN THE HEIGHT DIFFERENCE BETWEEN SELECTED POLISH GNSS STATIONS

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ABSTRACT

Keywords: temperature, vertical crustal movements, change of height coordinate

In the last years air temperature increasing gradual. It also changes depending on the area: metropolitan, rural. The temperature changes directly affects the expansion of materials of which are made geodetic control network and support infrastructure. This may be influenced on the daily change in the amount determined for permanent GNSS stations. The main aim of the article is to examine the relationship between height changes and temperature changes. Daily difference in height between the selected stations Polish ASG EUPOS and the temperature in the vicinity of the stabilization of these stations data were used. Three year period was taken to the analysis. The results give a view on the article thesis.

EVIDENCE OF THE PLEISTOCENE GLACIOTECTONIC DEFORMATIONS IN THE WESTERN SUDETES – NEW STRUCTURAL AND SEDIMENTOLOGICAL DATA FROM THE CZAPLE II GRAVEL PIT

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ABSTRACT

Keywords: glaciotectonic deformations, Middle Polish Glaciation, Western Sudetes

We present the preliminary results of structural and sedimentological studies carried out in outcrops of the Quaternary (Late Pleistocene) deposits near the village of Czaple (Lower Silesia, Western Sudetes). In the active gravel pit ("Czaple II") crop out fluvial/glaciofluvial sands and gravels assigned to the Middle Polish (Saalian II) Pleistocene Glaciation (Milewicz, 1961). Sandy gravel deposits are covered by glacial tills in the northern part of the quarry. Within these deposits we recognized and documented a numerous mesoscale glaciotectonic deformation structures which have not been described in this part of the Sudety Mts. These structures are an effect of sediments deformations both in pro-glacial as well as in a sub-glacial setting and comprise among others asymmetrical folds, overthrusts, steeply inclined reverse faults, normal faults and conjugate sets of fractures. Based on the orientation of secondary kinematic structures associated with fault and fracture planes (slickensides, hackles, grooves, R shears) the south and south-westerly directed the ice-sheet horizontal pressure is postulated. This direction coincides with other scientific data from the Sudety Mts. (cf. Jahn 1981; Wójcik 1985; Urbański et al. 2011), indicating that the ice-sheet advanced from north, north-east and north-west.

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THE USE OF UAV FOR CONSTRUCTION OF DIGITAL SURFACE MODELS OF LANDSLIDES - EXAMPLE OF THE CZERWONY WĄWÓZ LANDSLIDE (WESTERN SUDETES)

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ABSTRACT

Keywords: mass movements, landslides, UAV, photogrammetry

The paper presents the use of data from non-metric cameras (SLR) for the construction of numerical model of terrain in landslide-affected areas using Structure form motion technology (Jozkow, Toth, 2014). A multi-helical platform consisting of a hexakopter equipped with a Pixhawk autopilot and a triaxial stabilizer was used to carry out research. Test works were carried out on a landslide in Wleń (Western Sudetes, Izerskie Foothills). This reactivated landslide occured on 16th July, 2016, after heavy rainfalls in Lower Silesia and covered the area of ca. 880 m² above the renovated pension "Leśny Dwór" in Wleń town (Kowalski, 2016; 2017). The main scarp of the landslide is up to 4 m high, shows an inclination of 45-80° and is built of a strongly deformed, Middle-Upper Permian (Zechstein) sandstones, mudstones, limestones and claystones which built the marginal part of the Wleń Graben - NW-SE elongated, tectonic sub-unit within the Northsudetic Synclinorium. Morphologically diversified colluvium comprises well-developed minor scarps, colluvial swells, benches and steps which pass downward to landslide toes. The landslide was a consequence of undercutting a steep slopes of the Bóbr River Valley by human activities and overloading of the slope surface by blocks and walking paths in the vicinity of the pension. Mass movements destroyed already-built infrastructure and led to significant material damages.

The internal accuracy (IQC) and the consistency of the photogrammetric data obtained from the unmanned aerial vehicle (UAV) using images from non-metric camera were investigated (Wajs, 2016). The results show that the execution of the appropriate sequence of images together with appropriately spaced photocells (GCPs) allow to produce the final product with the required decimal accuracy. Further analyzes concerned the Digital Surface Model (DSM) developed in Agisoft PhotoScan Professional software. As a reference data there were used a collection of points from the ISOK project. The results show that the final product developed based on small format non-metric camera is characterized by relatively high accuracy and is a very good tool for monitoring of mass movements affected areas.

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SEISMOTECTONIC DEFORMATION STRUCTURES FROM THE ZECHSTEIN HETEROLITHIC DEPOSITS OF THE WLEŃ TROUGH (NORTH SUDETIC SYNCLINORIUM) – EVIDENCE OF PERMIAN SEISMICITY IN THE NORTHERN SUDETES

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ABSTRACT

Keywords: seismotectonic deformation structures, Zechstein, Pzt, North Sudetic Synclinorium, Wleń Trough

In the Zechstein (Middle/Upper Permian) heterolithic deposits – predominantly sanstones, mudstones and siltstones intercalated by dolomitic limestones - which crop out in the vicinity of the Wleń town (Western Sudetes, Czerwony Wąwóz locality), a numerous deformation structures of supposedly seismotectonic origin were recognized. They occur in the close vicinity of the north-eastern margin of the Wleń Trough - NW-SE elongated, fault-bounded tectonic sub-unit within the North Sudetic Synclinorium. Unfortunately, Permian sedimentary rocks in the study area are not well exposed and collected rock samples have been only found in isolated blocks scattered within recent landslide colluvium (Kowalski, 2016), thus only a precise cartographic works allows determinig vertical profile of the sedimentary succession. Extremely wide and diversified range of deformation structures comprising among others synsedimentary listric and normal faults, clastic dikes, diffusional cells, small collapse structures, brecciated mud clasts or boudined layers of limestones and others features which occur in the topmost part of the Zechstein profile near the Permian-Triassic (Buntsandstein) boundary. Most of these structures are linked with liquefaction and fluidisation of fine-grained sediments probably due to seismic shocks. It is worth mentioning that symilar, pre-lithification structures were recently described by Durkowski et al. (2017) from the area of the so-called Grodziec Syncline - tectonic sub-unit located also within the North Sudetic Synclinorium (the northern part). Results of our investigations confirm the thesis about regional extension of synsedimentary deformation structures near the Permian-Triassic boundary (Durkowski et al. 2017) and may support the opinion about their seismic origin.

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SEISMIC SIGNAL IN PRECISE POINT POSITIONING POST-FIT PHASE RESIDUALS

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ABSTRACT

Keywords: GNSS seismology

GNSS observations are widely used to analyze large scale natural earthquakes. In smaller events it is more efficient to combine the GNSS and seismic observations, as these two methods are complementary. Among the differences between them, the integration of seismogeodetic data allows to observe dynamic and static coseismic displacements. Integration of seismogeodetic data leads to the concept of seismogeodesy, especially GNSS seismology.

Within the "EPOS – European Plate Observing System" project it is expected to apply the GNSS technique in analysis of displacements caused by natural and anthropogenic earthquakes, especially mining-induced seismicity.

In the presentation there are discussed first results of GNSS time series analysis in comparison to seismic observations. The observing data was calculated with the Precise Point Positioning method, which is commonly used in coseismic GNSS data calculations, as there is no need to have reference stations, which might be displaced by the earthquake.

The calculations were performed for the vertical component of phase residuals. By analysing the obtained results, similarity to the seismograms was found. The results of the analysis will be shown on the examples of the earthquakes of magnitude 5.0 to 7.8.

MASS MOVEMENTS OF THE PLATEAU SZCZELINIEC WIELKI

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ABSTRACT

Keywords: rock blocks, height measurement, vertical displacement, earthquakes

Mass movements the rock blocks of Szczeliniec Wielki caused by different endo- and exogenous processes. These processes started in Upper Chalk formation and their intensification was in Tertiary. The result of recent geodesy measurement suggests that activity these processes continue to now although there is much less intensification. The occurrence of recent horizontal and vertical mass movements of the Earth's crust it gets confirmation in geodynamic research. These research are implemented for a few research polygons which are located on the Sudety Mts. (among others in the area of Stołowe Mts.). In this area occurred recent and historical earthquakes.

In this study, we have presented results of period measurements, mostly vertical component for observation points which are located on the mass plateau of the Szczeliniec Wielki. The base of elaboration are results obtained in the 2017 year. These results are presented in references to geodynamic research from 1972 to now.

MULTI-CONSTELLATION HIGH-RATE GNSS SIGNAL PROCESSING ALGORITHMS AND APPLICATIONS: SELECTED ACTIVITIES AT UWM

Jacek Paziewski, <u>RadosławBaryla</u>, Rafał Sieradzki, Paweł Wielgosz

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ABSTRACT

Keywords: GNSSantenna oscillations, precise GNSS positioning, RTK, PPP

In this contribution we present recent activities at Institute of Geodesy University of Warmia and Mazury in Olsztyn in software and algorithm development for multi-constellation high-rate GNSS signal processing. The developed algorithms were practically applied for performance assessment of small-scale high-rate dynamic displacement detection. In the experiment the GNSS antenna oscillations were determined using three selected approaches: RTK, PPP and direct signals processing. Two former methods are generally well-recognized as a source of accurate information on position whereas the last one is the innovative method for dynamic displacements determination taking advantage of GNSS phase signals processing. The method is based on the developed functional model with parametrized epoch-wise topocentric relative coordinates derived from filtered GNSS observations. Moreover since nowadays regular PPP positioning may not offer such high-precision coordinate estimates, novel processing strategy was developed and applied for millimeter level precision displacements determination based on absolute GNSS positioning. All methods were implemented in the in-house developed software allowing for high-rate precise GNSS positioning and signal processing. The investigations were also aimed at comparative analysis of developed methods including analysis of the impact of combined GPS+BDS processing and dependence of relative methods results on baseline length. As a dataset in the experiment served the phase and pseudorange observations collected with 50 Hz rate during field test. The displacements at rover station were triggered in horizontal plane using designed and constructed device, which ensured a periodic motion of GNSS antenna with amplitude ~3 cm and frequency of ~4.5 Hz. The research has shown that the standard deviation of the displacements residuals obtained as the difference between benchmark solution and selected scenarios were in the range of 1.1 - 3.4 mm. At the same time the differences between mean amplitude of the oscillations derived from established scenarios did not exceed 1.3 mm. Finally, the study has shown than all techniques were capable to provide reliable and in a good agreement results with precision of the determined dynamic displacements at the millimeter level.

ACTIVE TECTONICS IN THE MORAVIAN REGION DETERMINED ON BASE OF MORPHOLOGICAL, GEOPHYSICAL AND GEODETIC DATA

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ABSTRACT

Keywords: GNSS, Geophysics, Moravia, faults, seismicity

An important contribution to the discussion and interpretation of recently active faults and zones are the results of permanent and epoch GNSS measurements on the Sneznik, Highlands and Morava networks. The main focus was on the active areas and tectonic zones, where the recent velocities reached 1mm/year and more. Such phenomena were detected at the Diendorf–Čebín tectonic zone, the marginal Sudetic fault, the Železné hory – Tišnov tectonic zone or the Nectava-Konice fault. An overview of each tectonic system and its detailed study has brought more information about recent activity in the Moravian region.

SOME DYNAMIC FEATURES OF EARTHQUAKE SWARM PROCESSES OBSERVED IN WESTERN BOHEMIA

Vladimír Schenkand Zdenka Schenková

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ABSTRACT

Keywords: geodynamics, GPS movements, earthquake focal mechanisms, West Bohemia

In West Bohemia during October 2008 an earthquake swarm of round 25,000 shocks with a maximum event of ML \sim 3.7–3.8 occurred at depths of 7–11 km. Since in 2007 annual GPS campaigns were launched in the area and thus the surface movements appeared within the pre-, co-, and post-seismic phases could be evaluated. In our presentation these surface movements are compared with movements originated on faults during the co-seismic phase estimated from focal mechanisms of more than hundred strong events of this 2008 earthquake swarm. The character of these movements allows stress field changes between pre- and co-seismic phases to be indicated.

DETERMINATION OF GLOBAL GEODETIC PARAMETERS USING SLR OBSERVATIONS TO MULTI-GNSS

<u>Krzysztof Sośnica</u>, Grzegorz Bury, Radosław Zajdel, Kamil Kaźmierski, Mateusz Drożdżewski, Jan Kapłon, Tomasz Hadaś

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ABSTRACT

Keywords: multi-GNSS, SLR, Earth rotation parameters, station coordinates

All satellites of new GNSS systems, such as Galileo, BeiDou, GLONASS, QZSS and NAVIC, are equipped with laser retro-reflectors dedicated to SLR tracking. Between 2014 and 2017, the International Laser Ranging Service (ILRS) performed three intensive SLR tracking campaigns devoted to all GNSS satellites, four Galileo, and one GLONASS campaign. As a result, the number of tracked GNSS satellites and the number of SLR observations have dramatically increased allowing for determining GNSS orbits, SLR station coordinates, geocenter coordinates, and Earth rotation parameters. This paper provides results from the GNSS intensive tracking campaigns and shows the contribution of SLR tracking of multi-GNSS constellation to improved SLR-derived reference frame and scientific products.

We present a solution strategy with estimating satellite orbits, SLR station coordinates, geocenter coordinates, and Earth rotation parameters using SLR observations to 2 geodetic LAGEOS satellites and 55 GNSS satellites: 1 GPS, 31 GLONASS, 18 Galileo, 3 BeiDou IGSO, 1 BeiDou MEO, and 1 QZSS satellite for the period 2014.0-2017.5. We compare the SLR station coordinate repeatability and Earth rotation parameters derived from a combined 'SLR to GNSS+LAGEOS' solution to the classical LAGEOS-only solution. We found that the repeatability of SLR station coordinates improves by 6.9, 6.4, and 15.7%, for the North, East, and Up component, respectively, when adding SLR observations to GNSS. Due to a large number of GNSS observations, the number of weekly solutions for some SLR stations, e.g., Arkhyz, Komsomolsk, Altay, Brasilia, Wettzell, is larger up to 41% in the LAGEOS+GNSS solution as compared to LAGEOS-only solution. The RMS of differences of the length-of-day parameter w.r.t. IERS-C04-14 series is reduced from 132 µs to 43 µs when adding SLR observations to multi-GNSS. Finally, we show the comparison of the multi-GNSS orbits derived using SLR-only results to the MGEX products provided by the Center for Orbit Determination in Europe (CODE).

DATA FROM GEODETIC STRUCTURAL MONITORING SYSTEM PROCESSING

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ABSTRACT

Keywords: geodetic monitoring system, monitoring data, data processing

Geodetic monitoring systems are a solution allowing for continuous and direct monitoring. Using such solutions saves time, money and increases the safety of observed object and its surroundings. It is more and more common, that to the traditional surveying methods, non geodetic sensors are included, geotechnical sensors as well. Such solutions, called structural geodetic monitoring systems, gives more accurate and detailed data of the observed objects.

The author will present the Leica GeoMos monitoring system installed on Geo-Info-Hydro, one of the buildings of Wrocław University of Environmental and Life Sciences. The system consists of a several sensors, a computer station and software (Analyzer and Monitor). The configuration of the system, the measurement solutions used and the characteristics of the data obtained from the measurements will be discussed. The methods of data processing from the system will also be presented. The author will present his own approach to the processing of observations obtained from the monitoring system. The versatility of the methods allows them to be used in processing data from any geodetic monitoring system.

IN DETECTION OF RECENT TECTONIC ACTIVITY OF THE POLISH CARPATHIANS WITH THE USE OF GNSS DATA

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ABSTRACT

Keywords: GNSS surveying, neotectonics, horizontal and vertical displacements, tectonic stress

Geological studies on recent tectonic activity of the Polish Carpathians provide rates of vertical movements ranging from -1 to +2 mm/yr. However horizontal rates are not documented as far but with the use of various geological methods (geomorphic, borehole breakout measurements) some models of tectonic stress were evaluated. Geological data concern process in geological time and usually don't prove the continued relevance of tectonic processes. In order to accomplish the tasks of studies on recent tectonic activity various geodetic methods need to be extensively applied. Although geodetic measurements are still insufficient in the area of the Polish Carpathians, permanent GNSS station working there provide some trends in changes of their positions. Several years of permanent observations within ASG EUPOS gives reason to analyze displacement vectors for the area of the Polish Carpathians and adjacent area in the aspect of tectonic activity of that area. The author discuss results of the changes and stress evaluated by geodetic methods, which are identified in some examples with movements caused by tectonic stress. Finally the author relates evaluated deformations to tectonic stress documented by geological methods.

COMPARISON OF REAL TIME SATELLITE CLOCK SSR STREAMS FOR GNSS POSITIONING

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ABSTRACT

Keywords: SSR stream, IGS, EUREF, Satellite clock corrections

International GNSS Service (IGS) as well as EUREF permanent GNSS network provides access to real time satellite orbit and clock corrections which can be used in replacement for ultra – rapid IGS products. These streams can be used for reduction of positioning errors in SPP (Single Point Positioning) or PPP (Precise Point Positioning). Theoretically, the values sent by both institutions should be similar because they concern the same errors and quantities. Practically both streams affect the positioning results in different way. The aim of presented study was to test the accuracy of clock corrections send from both streams. To perform these task data collected in real time were compared with final clock corrections presented by IGS service. Finally the impact of clock SSR errors on positioning results was shown.

THE RESEARCH OF INTERRELATION BETWEEN SEISMIC ACTIVITY AND MODERN VERTICAL MOVEMENTS OF THE EUROPEAN PERMANENT GNSS-STATIONS

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ABSTRACT

Keywords: crust movements, vertical velocities

Based on experimental research and having applied the "integral index of velocity altitude displacement" and the criteria for generalized seismicity close functional link between two different physical parameters: seismic and vertical crust displacements in Europe have been set. According to the seismic data of GNSS-stations for the period since 2000 till 2011 on the territory of Europe close correlation between seismic velocity and vertical crust movements and mathematical correlation between the generalized parameters of the velocity and altitude displacement of the seismic territory have been learned. The results of the research can be applied for predicting places of altitude displacement at the European continent foundations and for conducting models of vertical crust movements.

PRECISE LOCAL QUASIGEOID MODELLING USING GNSS/LEVELLING AND GRAVITY DATA

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ABSTRACT

Keywords: local quasigeoid modelling; interpolation methods; local gravity potential model

The study compared four approaches of a local quasigeoid modelling using GNSS/levellingheight anomalies. The two approaches usedonly a dense network of points with known GNSS/levellingheight anomalies and the EGM2008 model. They were based on the interpolation of residual values of height anomalies($\zeta_r = \zeta_{GNSS/lev} - \zeta_{GM}$) by applying function of minimal curvature and least squares collocation (LSC) method. Two following approaches used additional data in the form of surface gravity data and digitalelevation model. One of these approaches was based on the classical Molodensky method combined with the LSC. The second approach utilized the method of gravity datainversion (GGI). In the researches the authors used a local network of points with precisely defined GNSS/levellingheight anomalies located in the South-Western part of Poland. At maximum Grade Compression Ratio(about 1 point per 30 km^2) of GNSS/ levelling data, comparable results were obtained for all tested methods. The differences between the GNSS/levelling data points and the reduced accuracy of the used global geopotential model.

20 YEARS OF THE BRNO GPS SEMINARS AND THE 25TH ANNIVERSARY OF THE BRNO–WROCLAW COOPERATION

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ABSTRACT

Keywords: GPS, Snežník network

In 1992 the Local Geodynamic "Sněžník" Network was established in Králický Sněžník Massif, in cooperation of Institute of Geodesy Brno Technical University (now Brno University of Technology) and Department of Geodesy and Photogrammetry AU Wroclaw (now Institute of Geodesy and Geoinformatics, Wroclaw University of Environmental and Life Sciences). The network spreads out on both sides of the state frontier in Králický Sněžník Mt. area. Main purpose was the upper lithosphere movement monitoring, but the network is serving also for experimental testing of various geodetic measuring technologies (GNSS, gravimetry, EDM, precise leveling, geodetic astronomy). At this point the long-term cooperation of both universities began not only in the Sudeten area, but also in other activities. Since 1994 it is also exploited in Czech part for field practices of the BUT students.

Twenty years ago, in 1997, regular seminars on the issue of GPS and satellite technology were also started at Brno University of Technology. The article reminds you of some moments of this long-standing collaboration.

GRAVITY-INDUCED FRACTURES ('EPIGENETIC FRACTURES') FROM THE RADKÓW BLUFF (STOŁOWE MOUNTAINS) – STRUCTURAL EVIDENCE OF THE PROGRESSIVE SANDSTONE SCARP RETREAT

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ABSTRACT

Keywords: epigenetic fractures, scarp retreat, Stołowe Mountains

The so-called "epigenetic fractures" described from the Stołowe Mountains area (Wojewoda, 2012) represent specific type of the gravity-induced, non-tectonic brittle deformations that occur only locally. These features comprise non-planar extensional fractures and faults which are associated with gravitionally overloading of the single rocky forms (e.g. lower parts of rock cliffs, columns, rock mushrooms and other similar). We present the preeliminary results of a structural analysis carried out in outcrops of the Radków Bluff ("Próg Radkowa") between the Stroczy Zakręt and the Psi Potok valley (Figs. 1 & 2), where differently oriented sets of fractures and faults (efon Fig. 3) were documented. However, orientation of these features is indirectly linked with the regional joint system (cf. diagrams on Fig. 3), their spatial orientation and distribution is determined mainly by the shape of individual rock forms. A numerous kinematic indicators observed on fault and fracture planes were documented in outcrops and within loosely scattered sandstone boulders below the main escarpment. This evidenced that assemblages of epigenetic fractures constiute privileged zones of sandstone scarp degradation.



Fig. 1. Rocky wall of the Radków Bluff fractured at the foot (point 1, Fig. 3)



Fig. 2. Rocky wall of the Radków Bluff fractured at the foot (point 3, Fig. 3)



Fig. 3. Blockdiagram of the Radków Bluff between the Stroczy Zakręt and the Psi Potok valley (generated from LiDAR 1x1 m data). Sites of structural measurements are marked

References:

Wojewoda, J., 2012. Joints in Cretaceous sandstones of the Góry Stołowe Mountains: tectonic and non-tectonic. [In:] 13th Czech – Polish Workshop On Recent Geodynamics of the Sudety Mts. and Adjacent Areas, November 20 – 22, Wrocław-Pawłowice, Poland, p. 57-58.

AUTOMATED GEODETIC SYSTEM FOR MONITORING OF ENGINEERING CONSTRUCTIONS DEFORMATION

<u>Oleksandr Zayats</u>, Kornyliy Tretiak, Olga Smirnova, Sergiy Periy, Volodymyr Glotov, Ihor Savchyn, Ihor Sidorov, Mykhaylo Navodych

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ABSTRACT

Keywords: geodetic monitoring, automation, engineering objects, deformation processes, destructive processes monitoring

Theoretical and practical aspects of automated geodetic monitoring system realization are considered. The special hardware and software was developed to collect, analyze and process results of geodetic measurements originating from various surveying devices, sensors and transducers (electronic total stations, digital levels, inclinometers, meteosensors and other). Collection and processing of information is implemented on the basis of a personal computer (PC) or mini PC (raspberry PI 3), to which all the aforementioned devices are connected. The information exchange between devices and PC is provided throughout wire and radio channels. Processing of observation may perform in real time. Automated geodetic monitoring system can operate in two modes: permanent geodetic monitoring and mobile monitoring mode.

The system is able to carry on automated collection and recording in real-time data coming from geodetic equipment and geotechnical sensors; to store information concerning geometric parameters, deformations spatial and temporal changes of great engineering structures with aim of preventing of destructive processes and man-made disasters. The application fields of the system are: energetics (objects of hydropower, nuclear power generation, fuel and energy complexes); transport industry (objects of road and railroad infrastructure); constructions. Proposed automated geodetic monitoring system costs 3-4 times less than foreign analogues; allows achieving accuracy at level 2 mm (horizontal) and 3 mm (vertical) on the territory of 2 sq. km; is able to make "real time" coordinate determination.

COMPARISON OF CHANGES OF THE KSIA-KSI1 GPS VECTOR WITH TECTONIC ACTIVITY FUNCTIONS OF ŚWIEBODZICE DEPRESSION MASSIF OBTAINED FROM WATER-TUBE TILTMETERS IN KSIĄŻ GEODYNAMIC LABORATORY

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ABSTRACT

<u>Keywords</u>: geodetic and geophysical measuring systems, GNSS systems, station velocity, geodynamics, Sudeten tectonic activity

Observations collected in Geodynamical Laboratory in Książ from the tilting instruments: since 1975 from horizontal pendulums (HP) and since 2003 also from water-tube tiltmeters (WT) include strong, non-periodic geophysical signals: tilt (on both types of instruments), and on WT also vertical movements of the ground. These signals have a tectonic nature. The main driving force of kinematic activity of the Świebodzice Depression are horizontal crustal movements. For monitoring this type of movements, a GPS vector was set up in May 2013. Two permanent stations: KSIA and KSI1 were established on the opposite wings of the geologically recognized one of the major faults in the immediate vicinity of LG. Because of its location and its unique role in shaping the present land morphology, this fault was called 'the main southern fault'. It has been assumed that the movements on the 'main southern fault' generate tectonic activity (secondary displacement) on faults within the Książ rock mass. The most likely cause of the tilting effects and vertical movements of rock blocks within the Książ rock mass are the friction forces created by the difference in travel speeds between the wings of the 'southern fault'. Thus, the kinematic activity of the 'southern fault' translates into the complex movements of the block masses of the Książ massif. The complex system of faults gives a great freedom of movement of rock blocks and without the shock of unloading of tectonic stresses in Świebodzice Depression (no seismic activity). These dependences indicate the importance of studying the mutual movement of the wings of the fault for the interpretation of the tectonic signals observed in LG and the determination of expected time-amplitude relationships between observations from LG instruments and GNSS technique. Rock blocks separated by faults in combination with the measuring system of the laboratory are a natural detector of regional tectonic activity allowing the determination of the

tectonic activity function of the Książ rock mass and it's derivative. The results of nearly 4 years of monitoring of KSIA-KSI1 GPS vector and some comparisons with the results obtained from water-tube tiltmeters observations covering time period of 2013-2016 will be discussed in the context of the tectonics movements of the 'main southern fault' and the rock blocks movements in LG.

Programme of the 18th Czech–Polish Workshop

ON RECENT GEODYNAMICS OF THE SUDETY MTS. AND ADJACENT AREAS

Szklarska Poręba, October 26-28, 2017

Thursday, October 26, 2017 11:00 – 13:00 Registration 13:00 - 14:00 Lunch 14:00 – 15:10 **Opening Session** Chairman: Bernard Kontny, Vladimír Schenk, Otakar Švábenský Session I Chairmen: Bernard Kontny, Zdenka Schenková Lubomil Pospíšil, Pavel Roštínský, Otakar Švábenský ACTIVE TECTONICS IN THE MORAVIAN REGION DETERMINED ON BASE OF MORPHOLOGICAL, GEOPHYSICAL AND GEODETIC DATA Marek Kaczorowski, Damian Kasza, Ryszard Zdunek, Roman Wronowski, Zbigniew Szczerbowski CONTINUATION OF INVESTIGATION OF THE PROBLEM OF HIGH ENERGY SEISMIC EVENTS IN THE MIDDLE - ODRA FAULTS ZONE BASED ON THE OBSERVATIONS OF THE SWIEBODZICE DEPRESSION KINEMATIC ACTIVITY Vladimír Schenk, Zdenka Schenková SOME DYNAMIC FEATURES OF EARTHQUAKE SWARM PROCESSES **OBSERVED IN WESTERN BOHEMIA** Krzysztof Mąkolski, Mirosław Kaczałek, Wojciech Sowa, Adrian Kaczmarek MASS MOVEMENTS OF THE PLATEAU SZCZELINIEC WIELKI DISCUSSION 15:10 – 15:25 Coffee break

15:25 – 16:50 Session II Chairman: Vladimír Schenk, Marek Trojanowicz

Damian Kasza, Aleksander Kowalski, Jurand Wojewoda, Marek Kaczorowski RECENT INDICATORS OF THE TECTONIC ACTIVITY IN THE VINCINITY OF THE KSIĄŻ CASTLE (ŚWIEBODZICE DEPRESSION, THE SUDETES) IN THE LIGHT OF GEODETIC MEASUREMENTS AND STRUCTURAL ANALYSIS Ryszard Zdunek, Marek Kaczorowski, Roman Wronowski, Damian Kasza, Zbigniew Szczerbowski COMPARISON OF CHANGES OF THE KSIA-KSI1 GPS VECTOR WITH TECTONIC ACTIVITY FUNCTIONS OF ŚWIEBODZICE DEPRESSION MASSIF OBTAINED FROM WATER-TUBE TILTMETERS IN KSIĄŻ GEODYNAMIC LABORATORY

Adrian Kaczmarek, Bernard Kontny THE IMPACT OF GEOPHYSICAL DEFORMATION OF THE EARTH'S CRUST ON CHANGES OF GNSS STATION COORDINATES IN THE SUDETY MTS. AND ADJACENT AREA

Kornyliy Tretyak, Volodymyr Romaniuk

THE RESEARCH OF INTERRELATION BETWEEN SEISMIC ACTIVITY AND MODERN VERTICAL MOVEMENTS OF THE EUROPEAN PERMANENT GNSS-STATIONS

Bernard Kontny, Adrian Kaczmarek

AN ATTEMPT TO VERIFICATIONS OF THE HYPOTHESIS ON GRAVITATIONAL COLLAPSE FOR THEMAIN MOUNTAIN RANGES OF EUROPE ON THE BASE OF EPN PRODUCTS

DISCUSSION

16:50 – 17:05 Coffee break

17:05 – 18:15 Session III

Chairman: Krzysztof Sośnica, Lubomil Pospisil

Marek Trojanowicz, Edward Osada, Krzysztof Karsznia PRECISE LOCAL QUASIGEOID MODELLING USING GNSS/LEVELLING AND GRAVITY DATA

Zbigniew Szczerbowski

IN DETECTION OF RECENT TECTONIC ACTIVITY OF THE POLISH CARPATHIANS WITH THE USE OF GNSS DATA

Grzempowski Piotr, Badura Janusz, Milczarek Wojciech, Blachowski Jan DETERMINATION OF THE GROUND SURFACE DEFORMATIONS ON THE SELECTED SECTION OF THE MIDDLE ODRA FAULT ZONE USING INSAR TECHNIQUE

Olgierd Jamroz

TECTONIC CREEP MOVEMENTS IN THE SUDETY MTS, SW POLAND DETERMINED ON THE BASIS OF MEASUREMENTS INTERFERENCE CRACK GAUGES

DISCUSSION

19:30 – 23:00 Grill dinner

Friday, October 27, 2017	
8:00 - 9:00	Breakfast
9:00 - 14:00	Field session Julia – Crystal Factory and Karkonosze National Park
14:00 - 15:00	Lunch
15:00 - 16:10	Session IV Chairman: Josef Weigel, Jurand Wojewoda
Jan Blachows	ci, Eva Jirankova, Milan Lazecky, Wojciech Milczarek
APPLIC	ATION OF SATELLITE RADAR INTERFEROMETRY IN STUDIES
OF HIST	ORICAL DEFORMATIONS IN POST MINING AREAS. CASE
STUDIE	S FROM CZECH REPUBLIC AND POLAND
Iwona Kudłac	ik, Jan Kapłon
SEISMIC	C SIGNAL IN PRECISE POINT POSITIONING POST-FIT PHASE
RESIDU	ALS
Jacek Paziews	ki, Radosław Baryła, Rafał Sieradzki, Paweł Wielgosz
MULTI-C	CONSTELLATION HIGH-RATE GNSS SIGNAL PROCESSING
ALGORI	THMS AND APPLICATIONS: SELECTED ACTIVITIES AT UWM
Paweł Gołaszo	ewski, Dawid Kwaśniak
PRECISI	E ZTD ESTIMATION IN THE POSITIONING USING MAFA METHOD
	DISCUSSION
16:10 – 16:25	Coffee break
16:25 – 17:35 Session IV Chairman: Andrzej Borkowski, Otakar Švábenský	
Janusz Bogusz	z, Anna Kłos, Guilhem Moreaux
STOCHA	ASTIC MODELS IN THE DORIS POSITION TIME SERIES:
ESTIMA	TES FOR IDS CONTRIBUTION TO ITRF2014
Mateusz Droż	dżewski, Krzysztof Sośnica
HORIZO	NTAL GRADIENTS FOR SLR
Jan Kapłon, K	rzysztof Sośnica, Tomasz Hadaś, Kamil Kaźmierski, Anna Krypiak-
Gregorcz	yk, Paweł Wielgosz
IMPACT	OF HIGHER-ORDER IONOSPHERE EFFECTS ON ESTIMATON
OF PREC	CISE COORDINATES FROM GNSS DATA
Anna Kłos, M	achiel S. Bos, Janusz Bogusz
ARE TH	E TIME-VARYING SEASONAL SIGNALS DETECTABLE IN GPS
POSITIC	IN TIME SERIES UNDER NORMAL NOISE LEVEL CONDITIONS?
17:35 - 17:50	Coffee break
OF PREC	achiel S. Bos, Janusz Bogusz
Anna Kłos, M	E TIME-VARYING SEASONAL SIGNALS DETECTABLE IN GPS
ARE TH	IN TIME SERIES UNDER NORMAL NOISE LEVEL CONDITIONS?
POSITIC	DISCUSSION
17:35 – 17:50	Coffee break

17:50 – 19:15 Session V Chairman: Jarosław Bosy, Kornyliy Tretiak

Jurand Wojewoda, Aleksander Kowalski GRAVITY-INDUCED FRACTURES ('EPIGENETIC FRACTURES') FROM THE RADKÓW BLUFF (STOŁOWE MOUNTAINS) – STRUCTURAL EVIDENCE OF THE PROGRESSIVE SANDSTONE SCARP RETREAT

Kamil Kowalczyk

THE EFFECT OF TEMPERATURE ON THE CHANGE IN THE HEIGHT DIFFERENCE BETWEEN SELECTED POLISH GNSS STATIONS

Krzysztof Sośnica, Grzegorz Bury, Radosław Zajdel, Kamil Kaźmierski, Mateusz Drożdżewski, Jan Kapłon, Tomasz Hadaś DETERMINATION OF GLOBAL GEODETIC PARAMETERS USING SLR OBSERVATIONS TO MULTI-GNSS

Dariusz Tomaszewski, Jacek Rapiński COMPARISON OF REAL TIME SATELLITE CLOCK SSR STREAMS FOR GNSS POSITIONING

Grzegorz Bury, Krzysztof Sośnica STATION COORDINATE DISPLACEMENTS DUE TO ATMOSPHERIC PRESSURE LOADING FROM SLR TRACKING OF MULTI-GNSS

DISCUSSION

20:00 – 23:00 Gala Dinner

Saturday, October 28, 2017

8:00 – 9:00 Breakfast

9:00 – 10:10 Session VI Chairman: Janusz Bogusz, Zbigniew Szczerbowski

Karol Durkowski, Dominik Sokalski, Jurand Wojewoda, Anna Durkowska PRE- AND POST—CONSOLIDATED SEDIMENT DEFORMATIONS OCCURING AT THE BOUNDARY OF ZECHSTEIN AND LOWER BUNTSANDSTEIN DEPOSITS OF THE GRODZIEC SYNCLINE, NORTH-SUDETIC SYNCLINOIRUM, SUDETS

Aleksander Kowalski, Jarosław Wajs, Damian Kasza THE USE OF UAV FOR CONSTRUCTION OF DIGITAL SURFACE MODELS OF LANDSLIDES - EXAMPLE OF THE CZERWONY WĄWÓZ LANDSLIDE (WESTERN SUDETES)

Oleksandr Zayats, Kornyliy Tretiak, Olga Smirnova, Sergiy Periy, Volodymyr Glotov, Ihor Savchyn, Ihor Sidorov, Mykhaylo Navodych AUTOMATED GEODETIC SYSTEM FOR MONITORING OF ENGINEERING CONSTRUCTIONS DEFORMATION

Wojciech Sowa DATA FROM GEODETIC STRUCTURAL MONITORING SYSTEM PROCESSING

DISCUSSION

10:10 – 10:25 Coffee break

10:25 – 11:35 Session VII Chairman: Radosław Baryła, Olgierd Jamroz

Aleksander Kowalski, Jurand Wojewoda, Paweł Raczyński SEISMOTECTONIC DEFORMATION STRUCTURES FROM THE ZECHSTEIN HETEROLITHIC DEPOSITS OF THE WLEŃ TROUGH (NORTH SUDETIC SYNCLINORIUM) – EVIDENCE OF PERMIAN SEISMICITY IN THE NORTHERN SUDETES

Aleksander Kowalski, Małgorzata Magda Makoś, Mateusz Pitura, Adam Kozłowski EVIDENCE OF THE PLEISTOCENE GLACIOTECTONIC DEFOR-MATIONS IN THE WESTERN SUDETES – NEW STRUCTURAL AND SEDIMENTOLOGICAL DATA FROM THE CZAPLE II GRAVEL PIT

Bartłomiej Ćmielewski, Jacek Kościuk POLISH RESEARCH ON UNESCO WORLD HERITAGE PRE-COLUMBIAN ARCHAEOLOGICAL SITE "EL FUERTE DE SAMAIPATA"

Bartłomiej Ćmielewski, Bernard Kontny LANDSLIDE BARDO-JANOWIEC in 2009-2017

Josef Weigel

20 YEARS OF THE BRNO GPS SEMINARS AND THE 25TH ANNIVERSARY OF THE BRNO-WROCLAW COOPERATION

DISCUSSION

11:35 – 12:00 Final Discussion and Closing Ceremony Chairman: Bernard Kontny, Vladimir Schenk

12:00 – 13:00 Lunch