19th Czech-Polish Workshop

ON RECENT GEODYNAMICS OF CENTRAL EUROPE

ABSTRACTS

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(Editors)

Hradec nad Moravicí, Czech Republic
October 25 - 27 th, 2018

ISBN 978-80-86433-70-7

Organizing Committee
of the 19th Czech-Polish Workshop

ON RECENT GEODYNAMICS OF CENTRAL EUROPE

Hradec nad Moravicí, Czech Republic
October 25 - 27 th, 2018

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SENSITIVITY OF THE GIA MODELS: A COMPARSION TO THE GPS DEFORMATIONS

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ABSTRACT

The vertical crustal deformations, as estimated from the Global Positioning System (GPS) observations, are affected by numerous phenomena of local and regional origin. The regional large-scale effects as the Glacial Isostatic Adjustment (GIA) are evident for stations situated in neighboring areas, while local phenomena as water withdrawal affect individual locations. Both of these are divided into elastic and poroelastic deformations. The GIA effect, clearly present for the Northern Europe and Northern America, arises from reaching the equilibrium shape after the last Glacial Age ice-load. Within this research we examine two global GIA models, i.e. ICE-5G and ICE-6G, and compare them with the GPS vertical rates for the area of Europe. The global GIA models differ in the ice-load history employed to construct them. Therefore, different model's sensitivity is met across Europe. We employ the Nevada Geodetic Laboratory (NGL) GPS vertical position time series and cross-compare them with the vertical rates as estimated from the GIA models. The GIA vertical rates exceeding 10 mm/yr affecting the northern part of Europe are easily detectable by the GPS observations. However, the GIA hinge line which divides Europe into two parts: the northern part with great positive rates and the southern part with close-to-zero-deformations is of great importance. For this area, the local phenomena may exceed the regional GIA effect and inhibit its detection, leading to false interpretations. Here, a sensitiveness of the GIA model plays a crucial role. Two ice-load histories employed in the ICE-5G and ICE-6G construction result in different vertical rates of the Earth's crust. Some of them are detectable by the GPS observations, while the others are covered by the local phenomena.

PROJECT EPOS-PL: TERRAIN DEFORMATION MONITORING USING REMOTE SENSING TECHNIQUES

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ABSTRACT

The main goal of the EPOS (*European Plate Observing System*) project is to improve the availability and quality of the multidisciplinary research and monitoring infrastructure related to solid Earth by integration of data and services on local, national and international, both European and global level. Another task of the project is also to foster the partnership with the industry in order to ascertain a permanent process of technology transfer between research units and industry in terms of geosciences. The establishment of the *Upper Silesian Geophysical Observation System* is one of the tasks in the framework of EPOS-PL. This task is realized by the consortium consisting of Institute of Geophysics PAS (leader), Central Mining Institute, Institute of Geodesy an Cartography, Military Academy of Technology, Wroclaw University of Environmental and Life Sciences (WUELS) and Polish Coal Group as an industrial partner. The Institute of Geodesy and Geoinformatics at WUELS is responsible for terrain deformation monitoring caused by underground mining exploitation. Since, the terrain subsidence in the area under investigation, namely Upper Silesian Coal Basin (USCB), can reach values from few millimetres to several meters, a set of measurement techniques with different characteristics and resources has to be used to cover the whole spectrum of possible terrain deformations. The main observation technique is SAR interferometry, applied in differential (DInSAR) and persistent scatters (PSI) variants. Data with six days revisiting time acquired by the radar sensor of the European Sentinel-1 satellite are used. The determined from the remote sensing technique deformations are validated by conventional levelling conducted in the area of investigation. The InSAR observations are used to determine small and initial deformations. To measure deformations with a greater amplitude (more

than 0.1 m) photogrammetric techniques are introduced. Besides the airborne laser scanning, low cost sensors mounted on a UAV (*Unmanned Aerial Vehicle*) platform are also involved in the current study. In particular, the UAV photogrammetry is based on a RGB camera and UAV laser scanning is based on Velodyne HDL-32 scanner. The terrain subsidence is determined as a differential model from point clouds as well as from digital terrain models. Moreover, four GNSS permanent stations have been deployed in the study area. In addition to the classical geodynamic purposes, the GNSS observations will serve as a scale determination for the results from the other mentioned techniques and to model tropospheric delay for decreasing it's effect in SAR products. In this work, detailed information about system and sensor configuration and also first results of the determined deformations including their validation will be given.

COSMIC RAYS AND SOLAR INFLUENCE ON SEISMICITY

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ABSTRACT

The solar activity affects all surface geosystems, including weather and climate indices, winds, rains, snow covers, mean sea level, river streamflows and other hydrological cycles. The Total Solar Irradiance (TSI) acts directly on Earth systems variations, while the solar wind affects the variations of geomagnetic field. The solar magnetic field and solar wind determine the properties of the heliosphere up to the heliopause. The variations of geomagnetic field and heliosphere have ability to modulate the charged particles of the cosmic rays. The recent models of ozone production by the cosmic rays in upper atmosphere and its influence on water content, which is the most powerful greenhouse gas, point out to significant effects on local and global temperature and climate processes. The variations of winds, air pressure, rains, snow covers, mean sea level and other hydrological cycles, produce small local and global crust and mantle deformations. These deformations may trigger earthquake and volcanic seismicity with synchronous periodicity of the cosmic rays and solar activity. The cosmic rays and solar influence on seismicity is investigated by comparing common cycles of cosmic rays, solar, and terrestrial data. The solar data consist of centennial time series of TSI, Wolf's Numbers and North-South solar asymmetry, where the Wolf's numbers represent solar wind variations and North-South solar asymmetry – solar magnetic field variations. The terrestrial data are represented by geomagnetic index AA since 1870, millennial data of the volcanic sulfate record in the GISP2 core, and short time series of earthquakes since 1968. Relatively good agreement exists between long-term variations of seismicity, cosmic rays, solar and geomagnetic indices.

UTILIZATION OF THE ARCHIVE GEOPHYSICAL DATA FOR GEODYNAMICAL STUDIES OF THE SUDETEN: EXAMPLE FROM NÍZKÝ JESENÍK MTS

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ABSTRACT

Geophysical data is used not only, in geological mapping, exploration of mineral resources, hydrogeology, but is also important for other branches such as environmental protection, civil engineering and archeology. That is why, within the project CzechGeo/EPOS (www.czechgeo.cz), geophysical data access is solved as a separate topic under the guidance of the Czech Geological Survey (hereinafter CGS). In accordance with the current needs of national and international activities (INSPIRE, EPOS, IAGA), an inventory of available data, its consolidation and harmonization according to national and international standards is conducted to securely and permanently store valuable data, which in many cases cannot be reinstated.

On the example from the Nízký Jeseník Mts is demonstrated possible utilization of Archive data for mapping and verification of the movement tendencies gained from GNSS networks – EPN, EASTERN SUDETEN and MORAVA.

Very valuable information is provided by geophysical data (seismic reflection profiles, etc.) for the interpretation of structural and tectonic conditions in the area of interest, especially in terms of monitoring the main fault systems and the character of the basement structures.

MICROMOVEMENTS IN THE POLISH PART OF THE SUDETY MTS BASED ON INTERFERENCE CRACK GAUGES READINGS

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ABSTRACT

Tectonic micromovement monitoring are based on the high precision measurement instruments. Crack gauges TM71 constructed by Košťák are most useful for measurement relative displacements in tectonic zones.

Scientists from Institute of Geodesy and Geoinformatics, Wrocław University of Environmental and Life Sciences have started rock structure movements monitoring in 70-ties of XX century. Precise levelling and crack gauges were used in the investigations.

Currently, our measurement network consists of several instruments. Crack gauges are installed on the surface, in caves, mining and dam corridors in the Polish part of the Sudety Mountains. There are fixed in Stołowe Mountains National Park, Dobromierz, Złoty Stok, Janowice Wielkie, Wolany, Nowy Waliszów, Bear Cave in Kletno. Each of the instrument allows to determine the relative rotations of rock structures and their 3D displacements. Direct photographic registration of all instrument indications is leading at monthly intervals. Measurement data are pre-processed and then analyzed and interpreted in cooperation with team from Institute of Rock Structure and Mechanics CAS in Prague. This paper presents the results of the last studies based on readings from crack gauges TM71 in the Polish part of the Sudety Mts.

DETECTION OF COMMON PERIODIC SIGNALS FOR GNSS STATIONS LOCATED CLOSE TO EACH OTHER

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ABSTRACT

Many global, regional and local factors influence the variability of GNSS coordinates, among others hydrological, atmospheric or oceanic changes. Correct interpretation of periodic components allows to extract signals related to geophysical phenomena and separate them from signals associated with the tectonics of a given area. The present research aims to present periodic analysis of stations located close to each other using the differentiation of time series of coordinates. FFT analyzes were performed both for the coordinates of individual stations and differential series. Residua differential series were subjected to FFT analysis and compared to the noise level to check if all periodic components from the input data were eliminated. The results of the analyzes will show whether at the GNSS stations located close to each other, the impact of geophysical phenomena is similar (it will be eliminated by differentiation), and whether there are other, site-dependent, periodic signals (not eliminated by differentiation) at the stations.

Keywords: *GNSS coordinate time series, periodic signals, FFT, noise analysis*

COINCIDENCES BETWEEN EPOCHS OF SEISMIC ACTIVITY OF CZECH MASSIF, FORESUDETIC MONOCLINE AND UPPER SILESIAN COAL BASIN AS CONFIRMATION OF THE THESIS OF EXISTENCE OF LARGE SCALE UNIFORM AND VARIABLE FIELD OF TECTONIC FORCES

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ABSTRACT

In the nearest surrounding of Ksiaz Geodynamic Laboratory there are three seismically active areas in Czech Massif, Foresudetic Monocline and Upper Silesian Coal Basin. Comparison of data events of seismic activity in Czech Massif, Foresudetic Monocline and Upper Silesian Coal Basin from the years 2010 to 2016 shows that seismic events occurred in these areas in the same time mostly. On account of large distances between seismic zones (few hundreds kilometers) and relatively small energy of seismic events effects the possibility of mutual induction of seismic activity between discussed areas were ignored. Seismic activity in mentioned zones took place in tens of hours wide time windows. Outside of these windows seismic activity almost vanishes especially in the case of strong events. To explain phenomenon of strong time dependences between epochs of activity of seismic zones it is necessary common relation which is fulfilled by uniform and variable field of tectonic forces.

Simultaneous increasing of seismic activity in distance zones indicates on great scale of this field and common variability presented by changes between extension and compression phases. The same tectonic field, which generates seismic events causes deformations of Ksiaz massif which are registered by water-tube tiltmeters in Ksiaz. These signals allowed to determination epochs of compressions and extensions on the basis of tectonic activity functions (TAF) and its derivatives. The epochs of extensions correspond in the time with seismic activity in areas of Czech Massif, Foresudetic Monocline

and Upper Silesian Basin, while during epochs of compressions seismic activity decreases almost to zero in all areas.

Keywords: *geodynamics, tectonic activity, tectonic activity of the Świebodzice Depression, seismic activity in Czech Massif, seismic activity in Foresudetic Monocline, seismic activity in Upper Silesian Coal Basin, geophysical measuring systems, mine surveying*

SENSING THE ENVIRONMENTAL LOADINGS BY THE GPS: A MULTIVARIATE ANALYSIS OF EUROPEAN PERMANENT STATIONS

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ABSTRACT

The Global Positioning System (GPS) observations constitute a great reference to recognize the geodynamic phenomena around the individual permanent station. As has been already proven, the GPS observations are influenced by the environmental loadings from atmosphere and hydrosphere. Part of them (tidal ocean loading) are subtracted during standard processing of satellite navigation data, but some of them (non-tidal effects) still remain in the position time series. Their direct removal brings an improvement in the root-mean-square (RMS) values of the GPS observations. However, as was proved before, the direct subtraction of the environmental effects causes also an unexpected artificial reduction in the time series power, in the frequency band between 4 and 80 cycles per year. In this analysis, we examine the sensitivity of the GPS position time series to the environmental loadings (non-tidal atmosphere, non-tidal ocean and continental hydrosphere). We use the International GNSS Service (IGS) position time series for selected European stations, which were included in the latest ITRF2014. We focus on the vertical changes, as they are mostly affected by the environmental effects. We found, that a direct subtraction of the loadings brings the 60% RMS reduction. Then, we employ wavelet decomposition to extract different frequency bands of the geophysical signals , cross-correlate the low- and high-frequency WD-derived details and found out that some of the stations are well-correlated of 0.4 with the loading models up to 15 day of period. Further, we employ different assumptions on the GPS time series deterministic model (trend-only, trend plus seasonal signals), adding the noise model in a form of a-pure-white-noise and a white plus flicker noise combination, which was found to be preferred for the GPS position time series, and perform a multivariate analysis to determine the scale factors between the GPS observations and loading models. We found that depending on the loading model, the scale factors may change from 0 to 3, which means that GPS senses the environmental loadings differently in different frequency bands. Accounting for the environmental loading models, leads to a

change of the GPS vertical velocities for the areas mostly impacted by the loading effects.

VERTICAL CRUSTAL MOVEMENTS OF THE SOUTHERN BALTIC COAST USING TIDE GAUGE AND GNSS OBSERVATIONS

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ABSTRACT

In this study the vertical crustal movements of the southern Baltic coast determined on the basis of two independent methods, namely tide gauge and GNSS observations. Mean sea level change trends determined from 5 tide gauge stations along the Polish coastal zone. The vertical crustal movements at nearby GNSS stations were also designated. We have used the tide gauge water level data from the Permanent Service for Mean Sea Level (PSMSL) and from the Institute of Meteorology and Water Management National Research Institute, Poland. We also used the time series for ELBL, KAM1, KOSZ and REDZ stations (ASG-EUPOS) and the data from other stations developed with the PPP technique. The statistical approach methods were used for analysis. The obtained results make a view of the vertical crustal movements of the Polish coast. Based on statistical testing, it is identified that there is a difference in the trends increase in all analyzed stations.

GEOLOGY OF BRUNOVISTULICUM

Oldřich Krejčí, František Hubatka

ABSTRACT

The deepest structural level and simultaneously the foreland of the Outer Western Carpathians in the eastern part of the Czech Republic consist of the Bruno-Vistulian promontory of the Fenosarmatian Platform. The crystalline fundament with autochthonous lithostratigraphic units (Paleozoic – Neogene) of the region may be divided on the basis of geological and geophysical data into several tectonic blocks with different geological history and regional extent.

During the Hercynian orogeny, when complicated, mainly nappe geological structure, was formed, comprising clastic rocks of the Cambrian and Lower Devonian age, Devonian and Lower Carboniferous limestone and dolomite, Lower Carboniferous flysch and partially coal-bearing Upper Carboniferous, was the Cadomian Bruno-Vistulian block locally strongly affected by brittle thrust and nappe tectonic.

During the Tertiary Alpine orogeny, the Western Carpathians Flysch Belt was overthrust over the SE margin of the Bruno-Vistulian block and have buried the most of the autochthonous lithostratigraphic units to depths. The platform fundament, reworked and consolidated during the Hercynian orogeny, with stacked Mesozoic, Paleogene and Neogene sediments, was during the Alpine orogeny affected by brittle thrusting and strike-slip tectonic movements. However, the extent of the movements has not been properly clarified yet. If these young movements have been identified only in the older Hercynian geological units or in the crystalline fundament, there is a lack of unambiguous evidence about their time classification and thus speculative results may easily presented. That is a reason why in our work is presented only an enumeration of these tectonic features, which have been evidenced by the field survey, drilling works or by geophysical investigations (mainly reflection seismic survey and paleomagnetic measurements).

The proposed Hercynian and Alpine geodynamic reconstruction and dating of the thrust and nappe movements within the originally Cadomian consolidated Bruno-Vistulicum block is based on new regional geological and geophysical data and field structural observations.

The degree of consolidation during the Cadomian orogeny controlled the subsidence of the transverse basement blocks during Paleozoic

sedimentation. During the Hercynian orogeny was locally created entirely new alochthonous nappe structure with Paleozoic sediments, which was identified e.g. by Radim Kettner, who based his work on the results of geological mapping, facial analysis, and at the first place on tectonic observations (e.g. contact area between Brno Massif and Moravian Karst or Silurian sediments outcrops near Stínava village within the Carboniferous flysch).

According to new paleomagnetic measurements (the Moravian Gate depression, Hevlín) and 3D reflection seismic survey (Dolní Dunajovice region), sedimentary cover and deeper fundament were affected also by left lateral strike-slip movements, which were connected with the last phases of the Outer Western Carpathians nappe system formation.

SEISMIC PHENOMENA IN THE LIGHT OF HIGH-RATE GPS PRECISE POINT POSITIONING RESULTS

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ABSTRACT

The instability of GPS permanent stations during three earthquakes has been investigated with the use of Precise Point Positioning (PPP) technique and the seismological data. The study examines the ability of high-rate GPS observations to reflect the ground motion retrieved by the strong motion instruments considered to be more reliable and precise. The kinematic PPP approach in RTKLib software was used, supported by the CODE precise orbit and clock products to calculate positions from 5 hour long GPS phase datasets. The goal of this article is to show the sensitivity of GPS PPP kinematic high-rate positioning with position domain filtering using band-pass Butterworth filter on small samples of position time-series. We used data for 2015 7.8 Mw Gorkha earthquake in Nepal and two (6.1 and 6.6 Mw) 2016 earthquake events in Appenines, Italy. North, East and Up results from accelerographs have been used as a reference to the comparison with the results from GPS observations. We have demonstrated, that in all analyzed earthquake and station cases the displacements were the most similar by the means of time-series correlation measured with Pearson coefficient. Application of Butterworth band-pass filtering of GPS and seismological data increased their agreement by 1% to 72%, resulting with correlations within the range 0.34 to 0.99. Comparison of peak ground displacements (PGD) revealed that for Italian events GPS-SM absolute value of average difference is 6 mm with GPS-SM distances smaller than 2.14 km. In all analyzed earthquakes the agreement between GPSgrams and seismograms in terms of the first P-arrival polarity was checked and it was found that it is consistent in all cases. This confirms the GNSS technique capability for determining fault plane solution.

A FORWARD MODELING OF THE GRAVITY GRADIENTS FROM GOCE SATELLITE MISSION

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ABSTRACT

We discuss the determination of gravity gradients from the orbital ceiling to the depth of the Mohorovičić discontinuity (Moho) for Central Europe. Components of the Eötvös tensor were derived from "Heterogeneous gravity data combination for Earth interior and geophysical exploration research" project ("GOCE+"). We used gridded data with a resolution of 0.2° per 0.2°. Gravity gradients to Moho boundary depths were modelled forward in to 255 km orbital height. We calculated gradient sensitivity using a 3D lithospheric model divided into: topography/bathymetry, sediments and location of the Moho boundary. To define tesseroids as mathematical model we need to set two parameters of the lithosphere: density and depth for each layer separately. Altitudes for topography/bathymetry were derived from ETOPO1 model, sediments depths from EuCRUST-07 model, and Moho boundary from Grad and Tiira (2009) seismic map. For high latitudes, we noted the largest changes for the gradients towards the poles, with particular values of 689.07 mE (milli-eotvos) and 1138.19 mE for V_{XX} and V_{ZZ} gradients, respectively. We obtained extreme values for the location of the deep and shallow areas of the crust (Alps, North-Eastern Poland and areas of seas) equal to -3 E and +1.5 E, respectively. Most of the gradients showed strong correlation with anomalies of crustal density of -2.5 E for V_{ZZ} and +1.5 E for V_{YY} in the extreme cases. We have shown that changes in lithosphere density and depth by 50 kg/m^3 and 10 km entail changes in gradient values by 15% for density and 10% for depths.

GEOMORPHOLOGICAL ANALYSIS OF THE EASTERN BOHEMIAN MASSIF: SPATIAL CORRELATION OF UBIQUITOUS SUBPARALLEL TOPOGRAPHIC LINEAR SYSTEMS WITH RESPECTIVE GEOLOGICAL, GEOPHYSICAL AND RECENT GEODETIC DATA

Pavel Roštínský, Lubomil Pospíšil, Otakar Švábenský, Eva Nováková, Martin Kašing

ABSTRACT

New full-area geomorphological analysis of the Eastern part of the Bohemian Massif, the most complex segment of this Central European Variscan domain with more older Cadomian elements and overlying younger cover units located in the foreland of the Cenozoic Alpine-Carpathian junction region, was carried out primarily based on recent real LiDAR elevation data visualized in GIS. The ubiquitous occurrence of subparallel topographic linear systems of various scale (a few hundreds of kilometres to meters scale) and of geographical direction were detected there, frequently with en echelon geometry and regardless of bedrock lithology. The geomorphological lineaments are mostly of composite character integrating diverse landscape features: hillslopes, river valleys or boundaries between individual topographic blocks. Especially, a tight fitting of regional fluvial system the linear scheme of basement is evident. That is why a passive adjustment of recent surface processes to older structural features has unequivocally been the dominant evolutionary mechanism of the outlined landscape pattern. However, in a few specific cases a development of lineament arrangement involving non-negligible active tectonic component could not yet be excluded including existing related pull-apart residual settings of recent sediments or more tens kilometres long linear suites of stream offsets, mainly in some sedimentary areas. Cross-checking with other data types such as geological (confirmed faults, associated young sedimentary sites), geophysical (regional fields, nearby earthquake events) or geodetic (significant horizontal movements indicated by Global Navigation Satellite Systems or vertical movements detected by repeated precise leveling) is inevitable to select the best places for eventual verification of active kinematics. A number of linear structures not yet present in geological maps were highlighted.

INTRAPLATE STRUCTURE MOVEMENTS IN CENTRAL EUROPE AN OVERVIEW OF SOME PUBLISHED OBSERVATIONS

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ABSTRACT

Presentation of published intraplate movements observed for geological structures in the central European area allows a pattern of common movement trends to be obtained. The movements discussed in this overview had been taken from originally independent sources and because of their individual data processing they could not be linked together in absolute values. Therefore they show only their mutually relative trends. It can be concluded that the intraplate movement pattern displays a rather slow northward movements of the central European structures regarding to post Alpine orogenics having slight anticlockwise rotations reflecting a movement of the Adriatic subplate.

SOME SEISMIC EVENTS RELATED TO GEODYNAMIC CAUSES IN THE LUBIN-GŁOGÓW COPPER DISTRICT (POLAND)

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ABSTRACT

Many analyzes devoted to high-energy rock mass tremors occurring in mining area of the Lubin-Głogów Copper District (Poland) were carried out basing on geological and mining conditions, seismic activity, focal mechanism or local stress field. They were carried out with relevance mostly to the safety of underground works as development in nearby urban areas. Results of investigations provided some data to determine the degree of seismic hazard. But in the author's opinion they still left a question about the role of the geological and tectonic background as so called "a complex event" i.e. interaction of two stress fields: tectonic and mining induced (lower seismic energy of tremors). The problem should be investigated in regional scale, so geodetic methods should be applied as within geodynamics studies in tectonic active areas. In modern geodesy the main topics are devoted to geodynamics: deformations caused by plate or intraplate tectonics, tides etc. They are main source of deformations in regional scale that can be missed in limited area observations.

The author examined these geodynamical aspects of terrain surface deformations in area of the study, so GNSS data evaluated from on observation of permanent stations were analyzed. Strong relations between high energy seismic events and mentioned deformations caused by geodynamical effects are discussed and illustrated by a number of examples.

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

REDUCED LATENCY NRT GNSS PROCESSING FOR STATION STABILITY MONITORING AND GEOPHYSICAL PROCESSES RETRIEVAL

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ABSTRACT

The EPOS project is The European Plate Observing System which integrate the existing and newly created research infrastructures to facilitate use the multidisciplinary data and products in the field of Earth sciences in Europe. One of the tasks in EPOS project is creation the service which will by monitoring GNSS station positions in Real- Time and Near Real- Time processing.

The Near Real- Time GNSS processing uses the most current data- with a latency of maximum of one day and perform multiple tasks after data collection. Currently, NRT standard processing is based on one hour processing. The availability of real-time clocks and orbits in ultra-rapid files available on IGS FTP servers allows to further improve accuracy and reduce latency of solution. The NRT solution may be used for monitoring of coordinates and NRT models of water vapor distribution in the troposphere. In this paper we show the results of processing with 15 minutes calculations interval with comparison to one hour process outcomes and daily solution based on rapid orbits. The test will cover coordinates and troposphere delay estimates, we will also review the computing power requirements with respect to increasing number of stations. The research was carried out on around 30 GNSS stations located in the area of Poland and neighboring countries. The expected outcome is getting a similar results in 15 minutes and hourly processing with respect to daily processing.

NEW GFZ EFFECTIVE ANGULAR MOMENTUM EXCITATION FUNCTIONS AND THEIR IMPACT ON EARTH ORIENTATION

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ABSTRACT

Recently GFZ in Potsdam started producing their new series of Effective Angular Momentum Excitation Functions (EAM). As a novelty, they are given in 3-hour resolution and they contain the influence of the atmosphere, dynamic ocean, terrestrial hydrosphere, and barystatic sea-level changes. In addition to this, IERS recently started to publish their new series of C04 solution for Earth Orientation Parameters (EOP), based on new combination of all observations and ITRF2014 terrestrial frame. We use the GFZ data to numerically integrate Brzeziński's broad-band Liouville equations and compare the results with IERS C04 solution for polar motion and celestial pole offsets. Alternatively, we also add a possible influence of unevenly distributed Geomagnetic jerks (GMJ). In the process of integration we look for best-fitting parameters (period *P*, *Q*-factor) of both free motions – Chandler wobble in case of polar motion, Free Core Nutation (FCN) in case of celestial pole offsets. It is demonstrated that the fit between integrated and observed values is much better when compared with our previous solutions, based on older models of geophysical excitations, especially in case of polar motion. The fit is significantly improved, in all cases studied, when GMJ quasi-impulse effect is included.

In case of polar motion, the best fit is obtained when only atmospheric and oceanic excitations are considered in combination with GMJ; our preferred values for Chandler wobble parameters are P=433.99±0.02d, Q=63.1±0.4. Correlation between integrated and observed polar motion is as high as 0.994. For celestial pole offsets, the best fit is also obtained for atmospheric, oceanic and GMJ excitations, the parameters of FCN being P=429.53±0.04d, Q=21600±200 and correlation 0.671.

MONITORING OF SURFACE DEFORMATION IN OLSZTYN WITH SENTINEL-1A /B DATA

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ABSTRACT

Monitoring changes in the Earth's surface is determined , inter alia, by the availability of data from the Sentinel-1 satellite mission and products developed on the basis of it. The use of the Synthetic Aperture Radar (SAR) interferometry, allows the detection of even small deformations of the surface. while the analysis of the time series of SAR images makes it possible to estimate the size of displacements by reducing the sources of errors.

Spatial and temporal data analysis presented in this article enabled obtaining information on the location of land deformation in Olsztyn. In order to estimate the size and variability of the studied area, algorithms and statistical methods were used. The analysis of SAR imaging was included in the article in the form of an estimated deformation maps.

Keywords: *time series, surface deformation, satellite interferometry, Sentinel-1*

RELATIONS BETWEEN DISTRIBUTION OF EXTENSION AND COMPRESSIONS PHASES OF ŚWIEBODZICE DEPRESSION MASSIF REGISTERED BY WATER-TUBE TILTMETERS WITH SOUTHERN FAULT WINGS MOVEMENTS OBSERVED ON GPS VECTOR

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ABSTRACT

The results of studies of observational data from water-tube tiltmeters, conducted at the Geodynamic Laboratory in Książ since 2003 indicate the occurrence of strong, non-periodic tectonic effects with an amplitude at least an order of magnitude larger than tidal effects. The recorded signals are the resultant of two movements: tilting of foundation and relative vertical movements of large rock blocks occurring on fault surfaces that cross two mutually perpendicular tubes of the instruments. This superposition is called the Tectonic Activity Function (TAF). Topographical, geomorphological and geological analysis of the Książ massif and its environment allowed the thesis that the direct cause of tectonic activity recorded by water-tube tiltmeters are the mutual displacement of the southern fault wings, which are monitored by analysis of the vector between the KSIA and KSI1 GPS stations, located on the opposite wings of this fault. Obtained results of GPS observations for the KSIA-KSI1 vector from the period 2013-2016 seem to confirm this thesis. Mutual horizontal displacements of both wings of the southern fault are currently at around 0.2 mm / year. In addition, the analysis of the residuals after the removal of the linear trend and the annual expression from the time series of the vector components shows the occurrence of long periods of similar trends in the mutual displacement of both fault wings. They were compared with periods of occurrence in the crystalline geological structures of this region of the compression and extension phases, determined from the analysis of the tectonic

activity functions and their derivatives, as well as the seismic events registered by seismometers during the investigated period of time.

Keywords: *geodynamics, recent tectonic activity, tectonic faults, geophysical measuring systems, GPS/GNSS technique, station velocity vector, time series analysis.*

CONTEMPORARY GEODYNAMIC ACTIVITY OF THE ROCK MASS SURFACE IN THE SZCZECIN AREA

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ABSTRACT

Characteristics of urban and industrial infrastructure in the Szczecin area and its impact on changes in the rock mass surface were made. These changes led to deformation of engineering structures in the area of oder islands. INSAR studies have shown the occurrence of vertical upward and downward movements occurring on the oder islands. The geological structure of the near-surface layer of the Earth's crust within them was analyzed. The deformation was caused by excessive load on weak bearing organic soils. An analysis of changes in the height of benchmarks on 1st and 2nd class lines based on archival materials concerning measurements in several campaigns was carried out. Only a detailed recognition of the geological structure in connection with the analysis of changes in benchmarks height on lines of 1st and 2nd class and 3rd and 4th class will enable a comprehensive monitoring of the further course of the deformation process within the objects. These analyses are the basis for reliable monitoring of deformation of existing and future objects within the islands. Then it will be possible to analyse the causes of deformations and not only their effects. In this way, the threats to new construction projects on islands will also be shown.

GEOLOGY OF THE CULM FACIES OF THE NÍZKÝ JESENÍK HIGHLANDS

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ABSTRACT

Time and space setting, geological history within European Variscides:

Culmian facies of the Nízký Jeseník Highlands was developed in the foreland of the Variscan orogen. This part of outer zones of Rhenohercynicum was sometimes called as Sudeticum (Dvořák 1973). Diagnostic vertical sequence of limestone-chert-flysch within the Devonian–Carboniferous basins started by Devonian rift- and extension-related sediments and volcanites of Moravia. The basin margins were covered with calciclastic and lime-mud limestone facies, where as the remnant ocean basins were filled by diastrophic (orogenic) sediments of the Culmian flysch and flysch-related facies. These basin-fills comprise up to 5–7 km of clastic sediments, but these thicknesses are undoubtedly increased by stacking and folding of these rocks. The Culmian facies sediments were sub-conformably overlain by coal-bearing coastal plain deposits of early Late Carboniferous age (Kumpera – Martinec 1995).

Basin characteristics, provenance and changes of the basin fill:

Within the frame of the Moravian-Silesian Palaeozoic outcrop area (approximate triangle between Brno in the S, Zlaté Hory in the N and Ostrava in the E) the Culmian of the Nízký Jeseník represents its northern part. Both northern (Nízký Jeseník) and southern (Drahany) parts of the basin are subdivided into western and eastern basins. The „Culmian basin“ as a whole was supplied from S – SW and the coarse materiál was distributed via an inferred axial turbidite system generally in NW direction. The most important change of source in the latest Visean (Mississippian) was recorded by a progressive influx of HP and HT metamorphic detritus, especially gneisses and granulites (Hartley – Otava 2001). The change reflects unroofing of the HT HP moldanubian metamorphic nappes (Schulmann – Gayer 2000).

Tectonic and thermal history of the basin:

Generally the iniciation of the Culm Basin was coeval with emplacement of Moldanubian high grade metamorphic nappes. The deformation of Culmian facies basin fill was moreless synchroneous with its deposition. Study of thermal maturity of Culmian sediments shows saw-tooth profiles which reflect tectonic stacking and thrusting. The maximum pre-thrusting burial was according to models 6–9 km in the West and 1,5–2 km in the East (now under the Carpathian Nappes). This was actually the thickness of eroded rocks transported to newly opened basins during the Late Palaeozoic, Cretaceous and Paleogene (Franců – Otava 2014).

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BALTIC SEA LEVEL CHANGES FROM SATELLITE ALTIMETRY DATA BASED ON THE OPTD METHOD

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ABSTRACT

The paper presents a methodology of the investigation of the Baltic sea level changes based on the Optimum Dataset (OptD) optimalization method. The OptD method was used to identify characteristic points from the analyzed satellite altimetry dataset. For detailed theoretical and empirical tests, the sea level anomaly was used.

The time series were created from the dataset after introducing OptD method, in the period from January, 1993 to December, 2017. The time series were subjected the statistical approach.

The results present that, depending on the latitude and longitude, the trends in sea level variations are different.

ABSTRACTS

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19th Czech-Polish Workshop

ON RECENT GEODYNAMICS OF CENTRAL EUROPE

Lubomil Pospíšil and Alena Berková
(Editors)

Vydal

ECON publishing, s.r.o.
Pod Nemocnicí 590/23, 625 00 Brno
e-mail: econ@atlas.cz
tel.: 602 755 541
www.econ.cz

v roce 2018 jako svoji 81. publikaci v systému ISBN.

Vydání první.

Redakce: prof. Ing. Otakar Švábenský, CSc., doc. Ing. Lubomil Pospíšil, CSc.
Grafické zpracování: doc. Ing. Lubomil Pospíšil, CSc., Ing. Alena Berková

Tisk: FAST VUT

ISBN: 978-80-86433-70-7