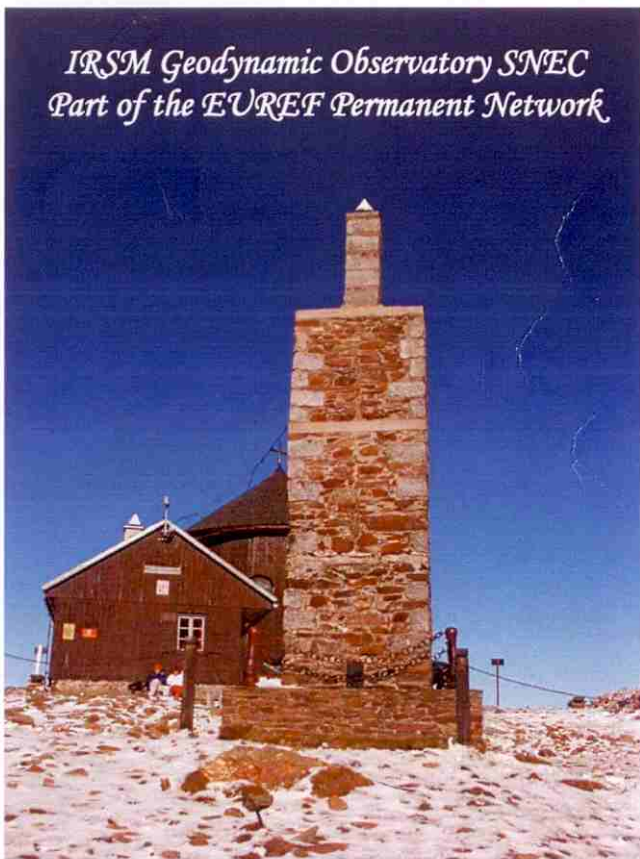


The 7<sup>th</sup> Czech-Polish Workshop  
ON RECENT GEODYNAMICS  
OF THE SUDETEN AND ADJACENT AREAS

# ABSTRACTS

*IRSM Geodynamic Observatory SNEC  
Part of the EUREF Permanent Network*



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*Facial*

## NEW POSSIBILITIES OF THE GRAVIMETRIC INVESTIGATIONS IN EAST SUDETEN AND FORE-SUDETIC BLOCK

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Results obtained from over ten years continuation of the non-tidal gravity changes investigations on the test fields in the Sudeten Mts. and Fore-Sudetic Block suggest a new approach and modernization of gravity works in this region. Observations of gravity changes using relative gravimeters pointed out some places with a mobility greater than other in a vicinity of the gps and classical observed stations. Warsaw University of Technology put in work at 2005 an absolute ballistic gravity meter FG – 5. The experiences reached and first results obtained at the Józefosław astro-geodetic observatory have directed authors to suggest an instalation of one more absolute gravity station in a vicinity of Prudnik (or Głuchołazy) town to support and complete results given by observations in Książ geophysical observatory. The next step ought to be to choose after inspection and install one another absolute gravity point on the Czech side, near a border in tectonical convenient place. The paper gives a short report from our investigations in Józefosław and some suggestions touching obtained possible accuracy of absolute gravity measurements outside laboratory. There will be given some remarks about modernization of the repeated gravity measurements pereformed with relative static gravity meters in area under investigation as well as a conception of a linkage of those two kinds of gravimetric works. The authors propose to take into account during the next period of geodynamical investigations only places and spans with distinct and clear gravity variations tendency and to connect them directly to the (two or three) absolute stations where ballistic gravity determinations ought to be repeated once at an observational season.

## ANALYSIS OF SELECTED FACTORS INFLUENCING DEFORMATIONS OF THE GROUND SURFACE – FIRST PHASE OF THE WALBRZYCH SATELLITE GPS MONITORING NETWORK PROJECT

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Underground coal mining in the Walbrzych area (SW Poland) lasted for several hundred years and finally ended at the turn of 20<sup>th</sup> and 21<sup>st</sup> century due to very difficult coal deposits conditions. The mining activity is responsible for large-scale deformations of the ground. The

processes of ground deformations are still active today and will remain so for many years to come. Consequently constant monitoring of ground state is essential to assess possible threats to the surface. A research project was proposed. It includes setting up of a satellite GPS survey network linked to the regional geodynamic network GEOSUD for ground monitoring of the Walbrzych area.

The paper presents the analyses of factors causing and influencing ground deformations, i.e. duration and intensity of mining, geology and groundwater conditions, natural movements of the ground in the contact zone of two major tectonic structures (the Fore-Sudetic Block and the Sudety Mts.). It also includes the results of analyses of benchmarks heights changes in selected precise levelling lines (1<sup>st</sup> order) passing through and nearby the studied area.

In the final part, the satellite GPS survey network for ground monitoring is described and its proposed tasks are given. These take into consideration geological conditions and analyses of repeated geodetic surveys and location of survey and control points within and outside the Walbrzych area.

## **NEW ASTRO-GEODETTIC GEOID IN POLAND**

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In 2002 Polish State Committee for Scientific Research assigned the project of high-precision geoid determination on the territory of Poland. The researches concerned with the astrometric determinations were a joint venture of the Institute of Geodesy and Geodetic Astronomy WUT and the Department of Theoretical Geodesy SUT. Totally 22 new astro-points were designed to densify the existing observation network. The aim is to use them for simultaneous adjustment for astro-geodetic geoid determination. This paper shows details concerned with the astronomical observations performed with the transportable circumzenithal instrument, evaluation of reliability of astronomical positioning and the results of the astro-geodetic leveling adjustment.

## **GPS TIME SERIES FROM PERMANENT AND EPOCH OBSERVATION IN REGIONAL AND LOCAL GEODYNAMIC INVESTIGATIONS**

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The future of the global and local geodynamic research belongs to the permanent monitoring. The conception of the use of semipermanent GPS observations in geodynamic research on the area of Sudeten is presented in the paper. This conception bases on spatial modeling of the

disturbing phenomena in the coordinate time series of (semi)permanent stations. The local intraplate movements and their correlations with major tectonic structures of Europe are determined on the base of coordinate time series of these stations. The problem of integration of epoch, semipermanent and permanent (EPN/IGS) observations for local geodynamic monitoring is also investigated.

## **PRELIMINARY RESULTS OF ANALYSIS OF VECTOR SOLUTION TIME SERIES FOR ASG-PL PERMANENT NETWORK.**

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Currently in the South of Poland are operating 9 following permanent GPS stations: WROC (Wrocław), KATO (Katowice), ZYWI (Zywiec), WODZ (Wodzisław Śląski), TARG (Tarnowskie Góry), KLOB (Kłobuck), LELO (Lelów), KRAW (Krakow), SACZ (Nowy Sącz), (status October 2005). These stations are included in the so called Active Geodetic Network (ASG-PL), which operate continuously delivering observations to the Data Center in Katowice ([www.asg-pl.pl](http://www.asg-pl.pl)). The network cover entire area of Upper Silesian Coal Basin in Poland and forms precise reference frame for geodetic and geodynamic applications. The operations of the above stations also stimulate research on increasing accuracy, reliability and efficiency of positioning with use of GPS permanent stations. The relative coordinate time series created on the base of GPS observations from ASG-PL network are discussed. In the first step the general characteristic of short-periodic variations in overlapping time series of GPS-derived vector components as well as research of their mathematical modelling is considered. Presented approach enables the estimation of differential tropospheric delay for any GPS vector located on the area enclosed by permanent GPS stations. It also allows any unmodelled effects in GPS vector solutions to be mitigated that cannot be predicted with use of empirical models. The reliability analysis of estimation of accuracy of GPS solutions with commercial software obtained on the basis of the numerical experiments are given. The research has been supported by the University of Mining and Metallurgy in Kraków in frame of the project No.11.11.150.478.

## **ANALYSIS OF STABILITY OF PERMANENT GPS STATIONS KRAW, KATO AND ZYWI**

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GPS permanent stations KRAW, KATO and ZYWI are part of the so called Active Geodetic Network which cover entire area of Upper Silesian Coal Basin (USCB) in Poland and forms

precise reference frame for geodetic and geodynamic applications. Moreover the above stations belong to EUREF Permanent Network. The stations, as datum points, play important role in precise positioning and geoid determination in area of USCB. The study of the stability of these points is one of the main components in precise monitoring of ground deformation in mine areas. The analysis of stability of permanent GPS stations KRAW, KATO and ZYWI are based on the coordinate time series obtained from the EUREF weekly solutions. The relative coordinate time series of weekly solutions for the vectors KRAW - KATO, KRAW - ZYWI, KATO - ZYWI and KRAW-GANP are presented. It is noteworthy that station GANP is located on Slovak Tatra Side. We assume that the study of behaviour of vector KRAW - GANP may be interesting from geodynamical point of view. The consistency, linearity, seasonal variations and jumps in the relative coordinate time series are discussed. The research has been supported by the University of Mining and Metallurgy in Kraków in frame of the project No.11.11.150.478.

## **ANALYSIS OF VERTICAL GROUND MOVEMENTS IN THE MIDDLE Odra FAULT SYSTEM ZONE NEAR WROCLAW**

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The paper concerns the results of determined relative changes of benchmarks heights in precise levelling lines of the 1<sup>st</sup> order for the 1956 - 2000 period. The leveling lines pass through the Wrocław agglomeration and traverse the Middle Odra Fault System zone and local fault zones i.e. Sobotka Fault and Trzebnica Fault.

The values of relative vertical displacements of benchmarks reach several centimeters. The maximum value of 10 cm occurred on the Wrocław - Zabkowice levelling line that cuts the Sobotka Fault and the Middle Odra Fault System.

The aim of analyses concerns determining relative changes of benchmarks heights and estimating exogenic and endogenic factors influencing vertical movements of the ground.

## **SEISMIC EVENTS RECENTLY RECORDED IN THE WESTERN CARPATHIANS, POLAND.**

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On November 30, 2004, an earthquake of magnitude  $M=4.3$ , intensity  $I=7$  in the EMS scale occurred in the Western Carpathians, within the Orava-Nowy Targ Basin, where the Pieniny Klippen Belt crosses Poland almost latitudinally. Earthquakes have been recorded there since

## CONTEMPORARY KINEMATICS OF THE MAIN TECTONIC STRUCTURES OF POLISH SUDETEN AND FORE-SUDETIC BLOCK – NEW RESULTS OF THE GPS MEASUREMENTS

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The major tectonic structure of the Lower Silesia Region is connected with the Sudetic Marginal Fault (SMF), which past and contemporary activity has been pointed by many authors. Yearly repeated satellite GPS measurements were carried out since 1996 year on the sites of the GEOSUD Network, covering Sudeten and Fore-Sudetic Block. The analysis of the results of these measurements for the period 1996–2002 limited only to the horizontal movement, published in 2003 year, showed that tectonic activity of the SMF zone is still going on. Preliminary results of the study indicated NE-SW probable compression of the main fault zone and local, left-lateral horizontal movements of the individual segments of the fault. Extension of analysed period by including GPS measuring campaigns 2003 and 2004 has resulted in more accurate and more reliable picture of velocity vectors, particularly for NW part of the GEOSUD Network. Detailed analyses have shown lesser values of the relative movements than previously estimated, but general character of the deformations has been unchanged.

## IMPACT OF SUMATRA 2004 EARTHQUAKE ON GEODYNAMIC STATION GOPE

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The aim of this contribution is a detection of geodynamic effects at a very distant geodynamic station GOPE in the middle of Europe. Strong earthquake, followed by strong indirect effect (tsunami), was analyzed from the records of tidal gravimeter Ascania No. 228 with respect to free oscillations of the Earth (spheroidal component), by spectral analysis. This analysis detects significant vertical component of GOPE position in relatively long time interval (several hours) after the beginning of the earthquake. To verify the geodynamic tendencies of the GOPE station movements the GPS observations were analyzed at the same time interval. We had data with 1s sampling interval at our disposal. For the analysis we used PPP (Precise Point Positioning) method which produces absolute values of coordinates in the ITRF2000 system. Possible correlations between the results of both ways have been searched.

south foreground (from Dzianisz to Jordanów). The profiles cut across geological structures which are different in age and have different tectonic deformation styles and show different neotectonic tendency.

In the summer of 2004 and 2005 gravity surveys were conducted, providing data for first analysis. In both 2004 and 2005 the measurements were taken using three different gravity meters: one LaCosta&Romberg G-986 and two Scintrex CG-3. Unfortunately both times one of the gravity meters Scintrex CG-3 broke, which resulted in obtaining only one profile per year (2004 – profile DD, 2005 profile KO) from this type of device.

For both survey series the errors of conducting of the gravity value between the stations were calculated. The values of the errors show that the measurements were taken with approximately the same precision.

The analysis of periodic gravity changes were made separately (if possible) for each of the gravity meters and for the average value which was determined from all gravity surveys.

The character of the profiles DD and KO show that the change of the gravity value between stations in 2004 and 2005 are quite different.

The absolute values of the gravity changes with time for DD profile are generally smaller than for KO profile. The DD profile shows that the gravity value changes between the stations and the average changes have the same sign. Most of these changes are not greater than 0.01 mGal.

Generally profile KO shows greater amplitude changes. Some parts of the KO profile, opposite to the DD profile, have different signs of changes of the gravity.

There might be two reasons which could explain the results for KO profile. The existence of the different directions in the gravity changes could be explained by bad weather conditions during gravity survey. Bigger amplitude changes could be explained the same way but they also could be caused by double tectonic tremor which was observed in 2004 and 2005 with its epicenter near Czarny Dunajec.

There is a third series of gravity measurements planned for 2006. This future work might confirm already observed trends.

## **ANALYSIS OF LEVELLING BENCHMARKS HEIGHT CHANGES ON KARKONOSZE MTS. GRANITE BLOCK AND ADJACENT AREAS**

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W referacie przedstawione zostaną analizy wysokości punktów pomiarowych uzyskanych z aktualnych obserwacji niwelacyjnych sieci państwowych w odniesieniu do pomiarów z lat 60. oraz 80. XX wieku.

Analizy dotyczyć będą obszaru karkonoskiego bloku granitowego (głównie Kotliny Jeleniogórskiej) oraz terenów przyległych: rejonu Gór Izerskich, rejonu Pogórza Izerskiego, Gór Kaczawskich, Pogórza Kaczawskiego oraz Rudaw Janowickich.

## PRELIMINARY WEST SUDETEN SITE MOVEMENTS DETERMINED BY THE GAMIT/GLOBK AND BERNESE GPS SOFTWARE

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Since 2001 the Institute of Rock Structure and Mechanics AS CR has performed annual GPS epoch measurements on 11 sites of the West Sudeten geodynamic network. The 48-hour epoch site data were linked to 5 permanent EUREF station observations (SNEC, GOPE, BOR1, GRAZ and WTZR) to obtain well-defined frame for the site movement assessments. Identical input data were applied to two independent computations of the precise site locations carried out both by GAMIT/GLOBK, version 10.2, and by BERNESE GPS software, version 4.2. The main purpose of the computations was to detect differences between the GAMIT/GLOBK software package, adapted more for geodynamic studies, and the BERNESE software, adapted more for geodetic tasks. It can be concluded that both techniques give satisfactory results. They will be presented and discussed in the form of preliminary movement velocity maps of the investigated region.

## APPLICATION OF SAR INTERFEROMETRY TO RESEARCH INTO LANDSLIDES

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Landslides occurrence depends on a wide variety of processes. Erosion as well as earthquakes disrupts balance of geological structures. Intense rain can trigger off severe flooding and mass movements. Landslides as a result of natural processes are common in the Polish Flish Carpathians, where geology (occurrence of alternating sandstones and shales) gives favorable conditions to mass movements.

It is statistically affirmed that majority of landslides had formed in the spring when snow melt. However intense rain can be mass movements reason what occurred repeatedly. Torrential and long-lasting rains characterized summer in 1997 and caused 20 000 landslides in the Carpathians. Landslides hazard is still current issue. Movement of some of landslides is almost imperceptible – slow but continual – however intense rain may lead to catastrophe. The price of mass movements may be humans life as well as millions loss connected with destruction of infrastructure and settlements. Methods usually used to research into mass movements in the Carpathians are insufficient cause of large number of landslides. Remote sensing make possible to get in one imagery large surface of study area. Images from Synthetic Aperture Radar (SAR) are used into landslides research. InSAR or PS InSAR techniques can be used to carry out image interpretation. Those methods give opportunity to monitoring of mass movement hazard and determine of landslides boundaries. This knowledge can be very useful for local government to protect people and infrastructure.



## GPS - GEOPHYSICS- GIS - THE WAY TO MICRO-STRUCTURAL ANALYSIS

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Accurate time series of (possibly) permanent GPS stations are required to infer a local velocity and an associated strain rate field. Exhaustive analyses and interpretations of the time variable data make serious problem. The expert team of the Institute of Geodesy (IG) has concentrated efforts not only in supplying of the GPS data from TUBO permanent GPS station, but also in collection of the complex geo-database to be possible structural and tectonic analyses of selected and required territories. The contribution is aimed not only to present example of complex interpretation of the acquired horizontal movement tendencies surrounding of Muráň - Malcov tectonic zone, but also of risks combined with construction and contents of prepared Geo-Database.

### RELIABILITY OF THE GPS DATA FOR GEODYNAMIC STUDIES

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Satellite geodesy methods, mainly the global position system technologies (GPS), are broadly applied in geodynamic studies. The problem joined to a reliability of site movement assessments is discussed in details on the regional EAST SUDETEN network (the Bohemian Massif, Central Europe). Statistical tests of site positions determined by the BERNESE software, their linear approximations for site movement velocities and an establishment of probabilistic thresholds for reliability these data for regional geodynamic studies are delivered. The thresholds define necessary observation periods for annual GPS epoch measurements performed on regional networks for geodynamic studies. The BERNESE software v. 4.2., module ADDNEQ, and other linear approximations of the Least Square, the M-estimation and the Least Median of Square methods were applied to GPS data of eight annual epoch solutions (1997-2004) on the EAST SUDETEN geodynamic network, to obtain reliable approximations of time series of network site positions and to exclude and/or mitigate outlier effects. Statistical analyses of site velocity movements allowed three probability thresholds for site movements to be defined: (a) acceptable, (b) reasonable and (c) reliable movements. It was found that the acceptable / reasonable site horizontal movements can be obtained for the north component in 4 or 5 annual epochs and for the east component in 3 or 4 annual epochs, respectively. The probabilistic thresholds defining reliable site movements brought further important recommendation for the GPS practice. It is evident, if any GPS measurements are planned on regional networks aimed to geodynamic studies then it should be taken into account a fact that whole period of these planned measurements would not be less than six years. This conclusion is imperative for many recent project proposals planned for geodynamic and any geodetic interpretations.



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