Acta Geodyn. Geomater., Vol. 7, No. 1 (157), 99–111, 2010

GEONAS - GEODYNAMIC NETWORK OF PERMANENT GNSS STATIONS WITHIN THE CZECH REPUBLIC

Vladimír SCHENK *, Zdeňka SCHENKOVÁ, Milada CAJTHAMLOVÁ and Zdeněk FUČÍK

Institute of Rock Structure and Mechanics, Academy of Sciences of the Czech Republic, v.v.i.
V Holešovičkách 41, 182 09 Prague 8, Czech Republic
**Corresponding author's e-mail:* schenk@irsm.cas.cz

(*Received* January 2010*, accepted* March 2010)

ABSTRACT

To investigate the geodynamic pattern of the Bohemian Massif in Central Europe, the GEONAS network of permanent GNSS stations was established. It now consists of 18 stations, recorded both the NAVSTAR and GLONASS positional signals; they are located along the tectonic zones of the Massif in order to monitor any movement activities. Yet other stations are still planned to be built, and some recent stations are to be moved within these active areas to increase their local distribution density. The GNSS data are processed by the use of Bernese GPS software 5.0. The time series of station positions give fundamental information for both regional and local geodynamic studies. The GEONAS network covers an area of 400 by 220 km, and it allows the effects of dynamic processes going on inside the Earth's crust, as well as the upper lithosphere to be monitored. A few examples of geodynamic interpretations are presented here.

KEYWORDS: permanent GNSS stations, GEONAS network, IRS operational center, remote control, time series, geodynamics, the Bohemian Massif

1. INTRODUCTION

The Geodynamic Network of the Academy of Sciences (GEONAS) of the Czech Republic was established in order to make regular geophysical and geodetic observations for current geodynamic studies of the Bohemian Massif and adjacent Central European geological structures. The permanent GNSS stations have been set up, since 2001, by the Institute of Rock Structure and Mechanics, Acad. Sci. (IRSM) within the framework of the national Centre of Earth Dynamics Research activities. All stations register both NAVSTAR and GLONASS satellite signals. Some of these stations are located inside the regional geodynamic networks for epoch GPS measurements.

Five GEONAS stations: BISK, MARJ, POUS, SNEC, and VACO belong to the EUREF network of permanent stations (EPN). The current parameters of the individual stations and the registration of the time summaries of the GNSS signals are given on the Internet (http://geonas.irsm.cas.cz). The GNSS data of EPN EUREF stations, operated by the IRSM, are available at http://www.epncb.oma.be. For information about the availability of data from the other GEONAS stations it is necessary to contact V. Schenk (schenk@irsm.cas.cz).

There are additional GNSS permanent networks within Czech Republic territory, which differ from the GEONAS network by their direction. TopNET is a network of permanent GNSS stations operated by Geodis Brno Ltd. (http://www.geodis.cz/topnet). Construction began in 2005 as a support for field work of the Geodis group. Several GEONAS stations are incorporated into the TopNET system. The CZEPOS commercial Czech network (http://czepos.cuzk.cz) is administrated and operated by the Land Survey Office as a portion of the geodetic control within the Czech Republic. CZEPOS, established in 2004, provides its users with GPS corrected data for the precise determination of positions within the territory of the Czech Republic. In December of 2004 a network of eight GNSS permanent stations VESOG (http://pecny.asu.cas.cz/vesog) were built for research, experimental, and teaching purposes. These are operated by the Research Institute of Geodesy, Topography, and Cartography.

2. POSITIONS OF GEONAS STATIONS

The Bohemian Massif is a Precambrian cratonic terrane composed mostly of metamorphosed rocks intruded by a series of granitoids. During its existence, the Massif has been affected by several orogeneses that have formed its tectonic pattern. Recent crustal movements that exist within the Bohemian Massif depend on compression fields, originating from the Alpine orogene. Their existence has been detected by in-situ monitoring of stress tensors and by deformations within mines. The GEONAS

Table 1 Permanent stations of the GEONAS network and their characteristics

Station	Locality	Beginning of registration	Φ [º]	λ [º]	H [m]	Receiver	Antenna	Basement rock	Options
BEZD	Bezděkov nad Metují	Dec 16, 2005	50.50870277	16.22926031	537.728	Topcon GB-1000	TPSCR3_GGD CONE	sedimentary - marlstone	
BISK	Biskupská Kupa	Sep 6, 2001	50.25672330	17.42859875	950.867	Ashtech Z-18	ASH701946.2 SNOW	metamorphic - mica schist	meteo + webcam
CHOT	Chotěboř	Aug 10, 2006	49.71170820	15.67264081	607.445	Topcon GB-1000	TPSCR3_GGD CONE	metamorphic - gneiss	
KYNS	Kynšperk-Kolová	Dec 19, 2005	50.11282809	12.55601142	569.958	Topcon GB-1000	TPSCR3_GGD CONE	metamorphic - mica schist	
LITO	Litoměřice	Sep 1, 2006	50.54215782	14.14480306	244.695	Ashtech Z-18	ASH701946.2 SNOW	sedimentary - sandstone	
LUBY	Luby	Dec 21, 2005	50.24813459	12.40771465	587.868	Topcon GB-1000	TPSCR3_GGD CONE	metamorphic - phyllite	
MARJ	Mariánská	May 15, 2003	50.35688985	12.89347340	904.730	Topcon NET-G3	ASH701946.2 SNOW	igneous - granite	meteo + webcam
POUS	Poustka	Nov 12, 2003	50.13843445	12.29785666	572.177	Topcon GB-1000	TPSCR3_GGD CONE	igneous - granite	
PRAG	Praha-Holešovice	May 15, 2006	50.11810136	14.46361902	293.731	Topcon GB-1000	TPSCR3_GGD CONE	sedimentary – shale, silt	meteo + webcam
SECZ	Seč	Aug 11, 2006	49.84293455	15.64941357	581.978	Topcon GB-1000	TPSCR3_GGD CONE	igneous - granite	meteo + webcam
SLUK	Šluknov	Aug 17, 2006	50.99988785	14.46024839	424.157	Topcon GB-1000	TPSCR3_GGD CONE	igneous - granite	
SNEC	Sněžka	Aug 23, 2001 – Jun 10, 2009	50.73587968	15.73974170	1651.582	Topcon GB-1000	TPSCR3_GGD CONE	metamorphic - mica schist	meteo + webcam
SNE2	Sněžka	Oct 10, 2008	50.73574202	15.73987949	1648.715	Topcon GB-1000	TPSCR_G3 CONE	metamorphic - mica schist	
STAM	Staré Město	Aug 23, 2006	50.16232012	16.94776447	598.976	Topcon GB-1000	TPSCR3_GGD CONE	metamorphic - gneiss	meteo + webcam
TREB	Třebíč	May 14, 2008	49.20406499	15.87866901	528.786	Topcon NET-G3	TPSCR_G3 CONE	igneous - granite	
TEME	Temelín	Aug 17, 2006	49.17396461	14.37993066	562.789	Topcon GB-1000	TPSCR3_GGD CONE	metamorphic - gneiss	
UPIC	Úpice	Dec 21, 2005	50.50713162	16.01093213	468.089	Topcon GB-1000	TPSCR3_GGD CONE	sedimentary - sandstone	
VACO	Vacov	Oct 20, 2004	49.13378401	13.72417612	799.401	Ashtech Z-18	ASH701946.2 SNOW	igneous - granite	meteo + webcam
VIDN	Vidnava	Aug 22, 2006	50.37293401	17.18544542	287.546	Topcon GB-1000	TPSCR3_GGD CONE	sedimentary – loamy sands	

geodynamic network was established in 2001 to detect recent geodynamic motions ongoing within the geological structures of the Bohemian Massif, with respect to the positions of the main tectonic boundaries as well as the occurrence of earthquakes.

At present, the GEONAS network consists of eighteen permanent stations operated by the IRSM: BEZD, BISK, CHOT, KYNS, LITO, LUBY, MARJ, POUS, PRAG, SECZ, SLUK, SNE2, STAM, TEME, TREB, UPIC, VACO, and VIDN (Fig. 1). Table 1 gives the details for each individual station's: date for start of operation, geographical coordinates, types of receiver and antenna, as well as information of the basement rocks.

The first two stations, BISK and SNEC, were built in August and September 2001. Both stations are located inside the regional geodynamic networks for epoch GPS measurements, BISK inside the EAST SUDETEN network (Schenk et al., 2002a, 2002b, 2003) and SNEC inside the WEST SUDETEN network (Cacoń et al., 2004; Schenk et al., 2006), to ensure reliable evaluations of movements at these network sites. These two GEONAS stations are located in mountainous areas. The MARJ and POUS stations, set up in 2003, are close to the German GPS stations in Grünbach (GRNB), as well as Neustadt (NEUS), which all monitor the geodynamic motions along the seismoactive Mariánské Lázně fault zone. The fifth station, VACO, has operating since October 2004, and is located at the opposite sides of the shear zones of the Bavarian Pfahl, with respect to the EPN German Wettzel station (WTRZ). On April 24, 2005 all of these stations were included into the EPN network. Figure 2 shows the locations where these stations are placed.

The SNEC station was situated on Sněžka Mt. (1602 m). Its antenna was installed on the reinforced chimney of the *Česká poštovna* building (Czech post office) (Fig. 2a). When this building was removed from the summit of the mountain, a new station SNE2 began operated in June 2009. Its GPS measurements are performed upon an 8 meter high stone column, a basic Austria-Hungarian triangulation point, built in 1824. Several times GNSS measurements were performed on both of these points (SNEC and SNE2) to mutually link both of the GNSS data. Distance and angle measurements with a precise Leica TCA 2003 Total Station were carried out in order to verify and mutually link the relative positions of these two Czech points, and the point on the Polish summit of Sněžka Mt. (Cacoń et al., 2004).

The BISK station was placed on the 19.3 m stone high watchtower (Fig. 2b) built in 1898 upon the summit of Biskupská kupa Mt. (888 m). Its walls are about one meter thick. The antenna is located on a concrete block 40 x 40 x 60 cm on the walkway of this watchtower.

The MARJ station is in the IRSM building in Mariánská, which is part of the town of Jáchymov (Fig. 2c). The antenna is fixed upon a newly reinforced chimney which is no longer used. The POUS station (Fig. 2d) is situated on a prefabricated house in Poustka, which is a part of the town of Františkovy Lázně. The house was built more than twenty years ago, and so far no cracks or fissures have been detected. The antenna is placed on a concrete block 40 x 40 x 40 cm fixed upon the roof. A similar location for the antenna (on the roof of a prefabricated house) was chosen for the VACO station (Fig. 2e) in Vacov, near the town of Vimperk. The houses on which the MARJ, POST and VACO stations were built are on a granitic basement (Table 1).

Four other stations: BEZD, KYNS, LUBY, and UPIC (Table 1) started their operation in December 2005, with the aim to monitor the tectonic zones in the Bohemian Massif (Fig. 1). The LUBY and KYNS stations extended the number of stations in the West Bohemia earthquake swarm region (Fig. 1, zone A); and stations BEZD and UPIC follow the Hronov-Poříčí fault zone in NE Bohemia (Fig. 1, zone D). Eight stations: CHOT, LITO, PRAH, SECZ, SLUK, STAM, TEME, and VIDN (Table 1) were built in 2006. The CHOT and SECZ stations monitor the Železné hory fault (Fig. 1, zone C); stations LITO and SLUK detect movement trends connected with intersection of the Krušné hory fault system and the Elbe lineament (Fig. 1, zone B); and the STAM and VIDN stations monitor the regional movement trends around the Marginal Sudetic fault system (Fig. 1, zone E). The TEME station was established to better link the GPS measurements performed on the HIGHLANDS regional epoch network (Table 1; Fig. 1; Schenková et al., 2007, 2009; Kujal et al., 2009); and the TREB station was established in Třebíč for the same reason in 2008 (Table 1, Fig. 1). The PRAG station (Table 1; Fig. 1) was built in Prague on the roof of the IRSM building. These last three stations improve the balance of the network geometry of GEONAS.

In August 2006, a calibration base for testing the antennas was put into operation on the roof of the IRSM building in Prague (PRAH). The distance between the PRAG and PRAH pillars is 3.7 m.

3. STATION EQUIPMENTS AND CAPABILITIES

At present, the BISK, LITO, and VACO stations are equipped with the Ashtech Z-18 receivers; the BEZD, CHOT, KYNS, LUBY, POUS, PRAG, SECZ, SLUK, SNE2, STAM, TEME, UPIC and the VIDN stations equipped with Topcon GB-1000 receivers; and the MARJ and TREB stations equipped with the Topcon NET-G3 (Table 1).

The dual-frequency 18-channel Ashtech Z-18 receiver allows up to 18 visible American NAVSTAR and Russian GLONASS satellites to be acquired and tracked. The Topcon GB-1000 receiver has a display and interface for checking both satellite and receiver status. It also provides a Compact-Flash memory card slot and advanced communications support. The internal 100 MB memory allows the monitored of

Fig. 2 EPN stations of the GEONAS network; A - antenna.

the 1-second data to be stored for approximately the last 30 hours. It enables there to be continuous registration, even in the event of any PC main power failure.

A chip, featuring 40 universal channels, is capable of tracking L1 and/or L2 frequencies for both NAVSTAR and GLONASS satellite systems, i.e. it can register the data of 20 satellites on both the L1 and L2 frequencies. The Topcon NET-G3 receiver incorporates 72 universal channels capable of tracking all of the signals from all three satellite positioning systems (NAVSTAR - GLONASS - GALILEO).

The first GNSS permanent stations built were equipped with Ashtech Z-18 receivers and corresponding choke-ring ASH701946.2 snow dome antennas (Schenk et al., 2004a, 2004b, 2005; http://www.geonas.irsm.cas.cz). The permanent stations, built later in 2005 and 2006, are generally equipped with Topcon GB-1000 receivers and TPSCR3 GGD CONE snow dome antennas. At the POUS station, the Ashtech Z18 receiver was exchanged for a Topcon GB-1000 on August 31, 2005; the same change was made at the SNEC station on March 16, 2006. The newest station, TREB, has the Topcon NET-G3 receiver and the TPSCR G3 snow dome antenna. The exchange of the Ashtech Z-18 receiver for a Topcon NET-G3 receiver on the MARJ station was completed on December 9, 2009. The antenna has not been changed. The configurations and equipment of the GEONAS stations are shown in Figure 3.

Each receiver is connected to a personal computer to store the monitored data (Mantlík et al., 2005b). The data are stored in combined RINEX files, containing registered signals from NAVSTAR as well as GLONASS satellites.

The Z-18 receiver has no internal memory. The communication between this receiver and the station computer is provided using the original Ashtech Geodetic Base Station Software (GBSS). All receiver and registration parameters can be set-up directly from the GBSS. The receivers are set according to the EPN rules for data registration with a 5° elevation mask, and the recording interval is set to 1 second (except for the LITO station which is set at 5 seconds).

To protect the receivers and the PCs against power failures, the stations are equipped with 230/12V power source/charges and lead/acid 12V/225Ah stand-by batteries (Kottnauer et al., 2003) which can power the station equipment independently for at least 24 hours. Under normal conditions, the main 230V AC is converted to 12V DC by a switching power source/charger. In the case of a primary power failure it is then automatically taken-over by the 12V/225 Ah battery.

Furthermore, the BISK, MARJ, PRAG, SECZ, SNE2/SNEC, STAM and VACO stations are equipped with webcams, which monitor the snow coverage on the antennas in real-time, along with the meteorological sensors by ANEMO Ltd. that register the temperature, relative humidity, and air pressure (Grácová et al., 2007; Mantlík et al., 2009).

These can measure the air temperature within the range of -30 ºC to 70 ºC, with accuracy of 0.2 ºC; relative humidity in the range of 0 – 100 %, with an accuracy of 1 %; atmospheric pressure in the range of 800 - 1200 hPa, with accuracy of 5 hPa; in addition, the wind direction and velocity can be measured in real-time. Temperature, moisture, and pressure are registered and stored in the RINEX-Meteo format in 30second intervals for later GNSS data processing.

After storage on the PC's internal hard disk, the data are automatically transferred to the IRS operational centre in the IRSM, using an Internet connection. The BISK station is connected via wireless internet; all other stations by means of GPRS technology (Fig. 4). Data transfers were tested for several months (Schenk et al., 2004b).

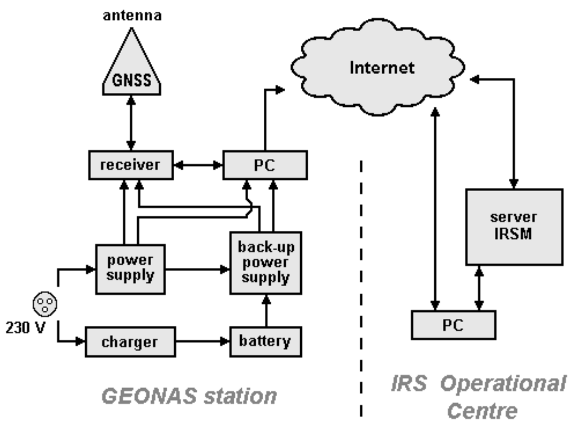

Fig. 4 Connection schematic of the station, with the IRSM server IRS and control PC.

4. DATA PROCESSING IN THE IRS OPERATIONAL CENTRE

Data delivery from the stations to the IRS center is provided by the RSYNC protocol (Linux RSYNC command) (Mantlík et al., 2005, 2007). Every 4 minutes a new RSYNC session automatically starts at the IRS server, in order to synchronize the recorded data with the station directories. The RSYNC protocol operates in a manner so that only newly monitored data are transmitted from each station, and provides automatic compression of the transmitted data. This approach provides a very effective use of the connection capacity, so that hourly RINEX data are available at the IRS centre within 1 - 2 minutes after each full hour, even if a slow GPRS connection is used.

When the hourly data are delivered to the IRS data center, a routine check is performed using standard TEQC procedure (Estey and Meertens, 1999). In the case of any problem, incorrect data are invalidated and a new synchronization with the given station is performed. Data files that have correctly passed all tests are stored according to the IRS center rules and registered in the IRS database. Finally, hourly data of the BISK, MARJ, POUS, SNEC, and VACO are submitted to the EPN data centers of BKG in Frankfurt am Main, and OLG in Graz; and can be publicly accessed as so-called near-real-time data.

An automatic merging procedure combines the final daily data of these five stations and submits them to the EPN data center after all 24 hourly data files are in place in the IRS data centre. Usually, this procedure takes place after 1:00 UT and the data are publicly available about 5 - 30 minutes later, depending on the procedure at the corresponding EPN data centre.

Data flow monitoring and data quality mapping are available at the IRS operational center. The operator has full on-line overview of both the data transmission and processing procedures using a user-friendly web interface. Thanks to this any transmission problems, as well as any data quality problems at any permanent station can immediately be revealed. The operator can see this web interface easily on the Internet (http://geonas.irsm.cas.cz) and take any necessary action to return it to normal operation (Figs. 5a,b). The data files are stored in RINEX v. 2.

Registered RINEX data at a sampling rate of 1s are post-processed off-line at daily intervals using Bernese GPS software version 5.0 (Dach et al., 2007; Beutler et al., 2007). The positions of the GNSS antennas and their RMS are evaluated for each GPS day (0 - 24 h UT) by the RNX2SNX standard double difference procedure. The precise satellite orbits, the Earth orientation parameters, clock corrections, and global ionospheric model, etc. are taken from the CODE European regional center in Bern, which offers products for both the NAVSTAR and GLONASS satellite systems. The daily data processing of the 32 permanent stations are included [18 - GEONAS network + 6 - TopNET network + 8 EPN network (GOPE, TUBO, BOR1, POTS, DRES, WROC, WTZR, and PENC)]. The stability framework is created by four EPN stations: WTRZ, GRAZ, POTS, and BOR1. Near Real Time (NRT) processing has a latency of 48 -72 hours. An example of a time series of one of the GEONAS stations is given in Figure 6.

The time series are cleaned of outliers, and additionally, for example, the jumps in the station positions caused by antenna changes are corrected. The position time series reveals inconsistencies for those stations located in the mountains, especially for the SNEC station. Therefore, these stations were equipped with web cameras and meteorological sensors (Table 1). The cameras capture the GNSS antennas at 5 minute intervals. The photos allow the snow coverage (thickness, form, and snow consistency) on the GNSS snow dome antenna to be evaluated, and inconsistencies in the time series to be partly corrected (Grácová et al., 2007; Mantlík et al., 2009). A strongly contingent position shift has been observed chiefly at the SNEC station. Site disturbance effects caused by snow coverage of the GNSS antennas have also been observed at other European stations (e.g. Angermann et al., 2003).

5. GNSS DATA APPLICATIONS IN REGIONAL AND LOCAL GEODYNAMIC STUDIES

Final processing of GNSS data from the GEONAS stations gives the station positions in their geographical coordinates; in their north (N), east (E) and altitude (Up/Down) components. Annual station movement velocities are determined from station time series, in units of mm/yr. Since the GEONAS network is located in Central Europe, the absolute movement vectors of all stations must move in agreement with the general Euroasian lithospheric plate movements (to the NE).

All the same, the regional geodynamic studies analyze the relative movements among and between individual stations. For this reason, one station is adopted as the reference station, and then its coordinates are subtracted from the positions of other stations in the region under study. By this method, all of movements obtained display the relative movements of the station, with respect to the reference station. As to our choices of the reference stations, we applied a gradual iteration among all investigated vectors in order to obtain an optimal balance of those relative movements that could withstand a modern-day look at the tectonics of the Bohemian Massif. It is evident that there are yet additional mutual movements among the individual structures of the Massif. The orientations of horizontal movements in the Bohemian Massif illustrate the influence of Alpine pressure upon the Massif. The Alps push the structural units toward the north; and simultaneously they also exert upon them a slight east-west extension (Schenk et al., 2009c; Schenková et al., 2009). From the vertical movements, it follows, that the central part of the Bohemian Massif exerts uplift against its marginal portions. An all-inclusive explanation of these mobile trends is impossible to determine without an understanding of the regional movements among the individual and fundamental structural units of the Bohemian Massif.

The geodynamic pattern of the West Bohemia region, based on permanent GNSS movements (Schenk et al., 2009a, 2009b) will be presented in detail. This region is characterized by occurrences of earthquake swarms. The analysis of detected movements in the West Bohemia region was directed toward an evaluation of movement velocities of structures in the region. The time series of absolute horizontal and vertical site components of five permanent GEONAS stations (MARJ, KYNS, LUBY, POUS, and VACO), plus one EPN station (WTRZ), were included in the analysis and are given in Figure 7a. Corrections on the antenna exchange (POUS station), on the snow cover of the antenna (MARJ station), and on the elimination of outliers

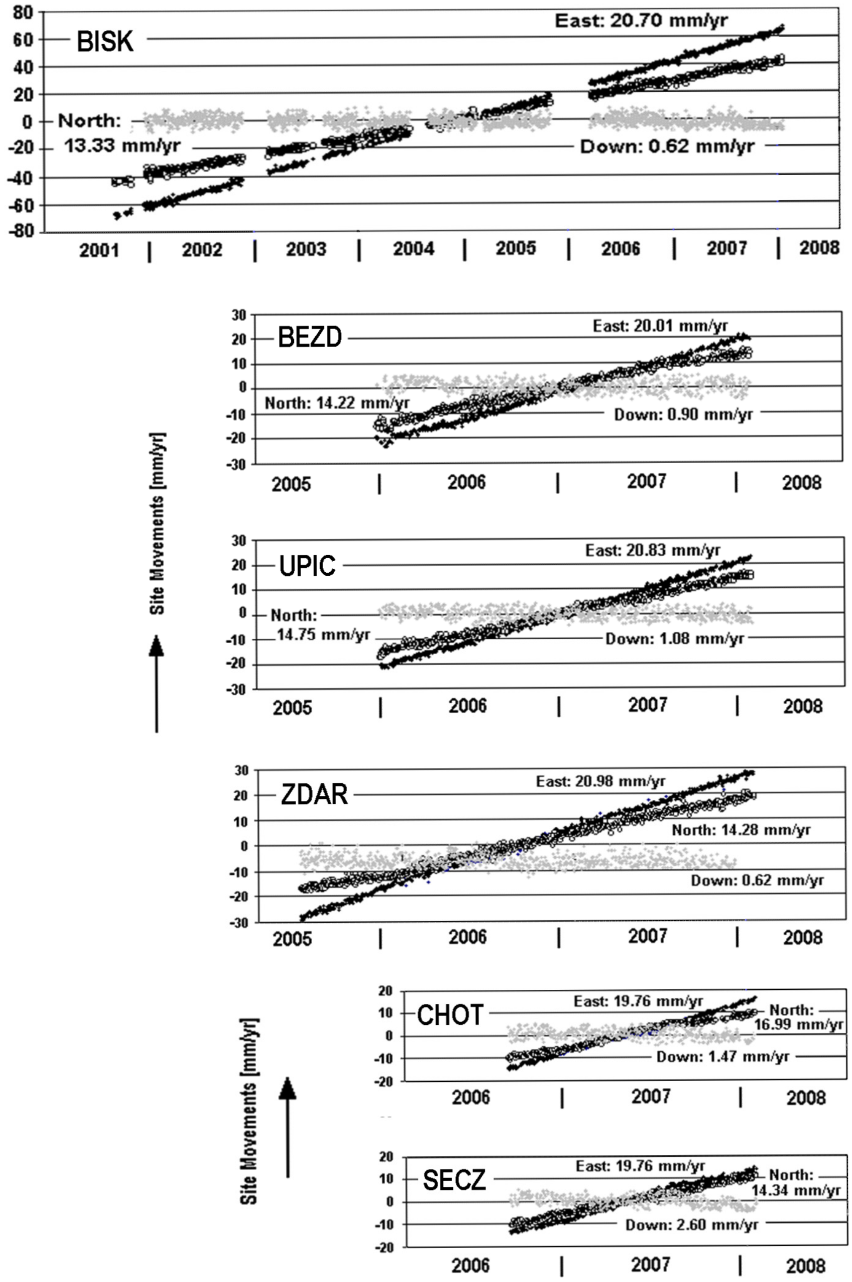

Fig. 6 Time series of six permanent stations of the GEONAS network, for all three components: horizontal (North, East) and vertical (Up/Down) movements.

were performed. The corrected time series of the absolute horizontal and vertical site components were fit by regression lines, using the Least Squares methods, in order to determine the north, east, and vertical site velocities. Figure 7a shows that the reliability of movement velocities for individual GNSS permanent stations is sufficient for geodynamic studies.

The size and direction of the horizontal and vertical components of the relative site velocities, determined from measurements on six GNSS permanent stations, are given in Figure 7b. The vertical movements reveal the subsidence of the Cheb Basin and the crystalline rocks of the Smrčiny Mts.; taking into consideration the surrounding units of the Bohemian Massif. In order to assess the on-going horizontal movements along the two main tectonic directions in the area under investigation (the Mariánské Lázně fault (MLF) zone and the Krušné hory Mts), directions were projected onto the

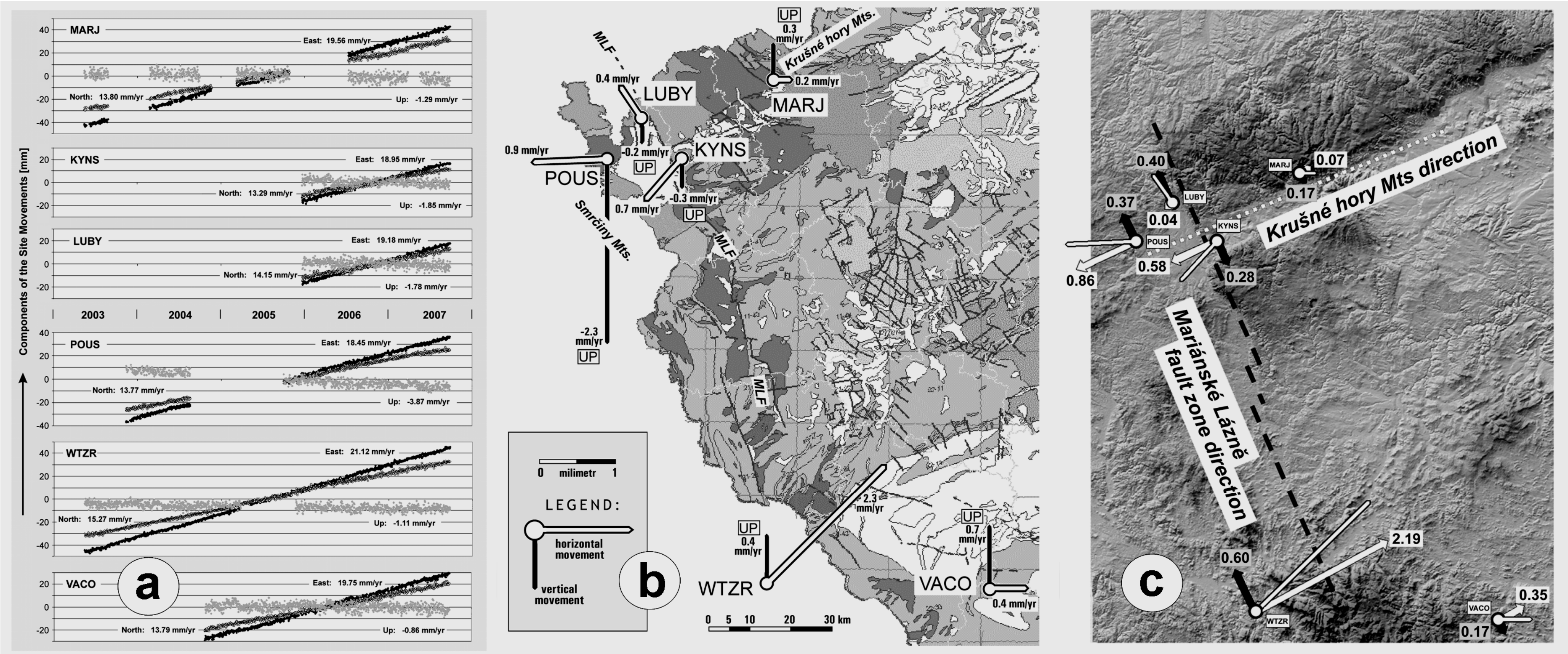

Fig. 7 Example of the geodynamic interpretation of GNSS data of the GEONAS stations located in West Bohemia (Schenk et al., 2009a): **a** - time series of six stations (KYNS, LUBY, MARJ, POUS, VACO, WTZR), **b** - interpreted horizontal and vertical GNSS movements, **c** - evaluated horizontal movements along the Mariánské Lázně and Krušné hory Mts fault zones.

velocity components, corresponding to these directions (Fig. 7c). The movement components of all six stations along the MLF zone display a dextral character. Movement components in the direction of the Krušné hory Mts. represent a horizontal extension in the Cheb basin, as well as the Smrčiny Mts. area; whereas they have a compressional character in the area of the Šumava Mts. These mobile trends described correlate with the geological and geophysical materials in the investigated region.

The analysis of the movement trends completed for West Bohemia displayed points toward the importance of geodynamic studies carried-out on the local scale. Subsequently, their mutual consecutive linkage will allow the creation of a regional geodynamic model of the Bohemian Massif to be compiled.

6. CONCLUSION AND OUTLOOK

The eighteen permanent GNSS stations of the GEONAS network record high-quality data, from the NAVSTAR and GLONASS systems, at well-chosen and well-built sites. They provide a precise reference frame for epoch GPS measurements and geodynamic studies. Two stations are already prepared to record GALILEO satellite signals. The data registered by five stations are available at the EPN data centers BKG and OLG usually within 1 - 2 minutes past every hour, after their registration. Information about all the registered data is available on-line at http://geonas.irsm.cas.cz. In the coming years, after the regional movement fields of the geological units of the Bohemian Massif are defined, and the local movement particularities detected, it is planned to move some stations to those regions precisely with the noted particularities.

The meteorological sensors and webcams are planned to be installed on those other stations situated at mountain sites. In 2010, two new permanent stations of the GEONAS network are planned to be installed in Habartov (HABA) near the town of Sokolov, and in Vonšov-Skalná (VONS) in West Bohemia. They will monitor time changes of surface deformations in the epicenter area of the seismoactive Nový Kostel zone. Further advancement of the network will be enjoined with the reconfiguration of some its stations, with respect to those zones already detected as having tectonic mobility.

ACKNOWLEDGMENTS

The establishment and the operation of the permanent GNSS stations could not have been realized without the considerable financial support from the Ministry of Education, Youth and Sports of the Czech Republic (Projects LN 00A005, LC 506, and 1P05ME781). The authors wish to express their thanks to Geodis, Ltd. for covering the financial aspects of the GPS data transmission from numerous GEONAS stations to the IRS operational center. This work corresponds to the Institute Research Plan A VOZ30460519.

REFERENCES

Angerman, D., Meisel, B., Krügel, M., Tesmer, V., Miller, R. and Drewes, H.: 2003, Analysis of site position time series derived from space solutions. AGU Fall Meeting, San Francisco, 8-12 December, 2003, G52C – 0052.

Beutler, G., Bock, H., Dach, R., Fridez, P., Gäde, A., Hugentobler, U., Jäggi, A., Mendl, M., Mervart, L., Prange, L., Schaer, S., Springer, T. Uschl, C. and Walser, P.: 2007, User manual of the Bernese GPS Software Version 5.0, Bern.

Cacoń, S., Schenk, V., Makolski, K., Kaplon, J., Schenková, Z. and Kottnauer, P.: 2004, Analysis of mutual positions of geodetic observation points situated on the Sniežka mountain based on GPS and total station. Acta Geodyn. Geomater., 1, No. 3(135), 69–73.

Dach, R., Hugentobler, U., Fridez, P. and Mendl, M.: 2007, Bernese GPS Software Version 5.0, User manual. Astronomical Institute, University of Bern. Produced in Digital Print by Stampfli Publications ASG, Bern.

Estey, L. M. and Meertens, C. M.: 1999, TEQC: The multi-purpose toolkit for GPS/GLONASS data. GPS Solutions, 3, No. 1, 42–49.

Grácová, M., Mantlík, F., Schenk, V. and Schenková, Z.: 2007, Data processing of GNSS observation of the GEONAS network – Effects of extreme meteorological conditions. Acta Geodyn. Geomater., 4, No. 4 (148), 153–161.

Kottnauer, P., Rucký, A., Schenk, V. and Schenková, Z.: 2003, Note to remote control of GPS observatory using GSM modem. Acta Montana, Ser. A, No. 24(131), 163-165.

Kujal, R., Schenk, V. and Schenková, Z.: 2009, Gravity measurements in the region of the geodynamic network HIGHLANDS (the Bohemian Massif). Acta Geodyn. Geomater., 6, No. 2 (154), 155–161.

Mantlík, F., Kottnauer, P., Schenk, V. and Schenková, Z.: 2005a, Transmission of continuously recorded data from remote GPS permanent stations to IRSM control unit. Acta Geodyn. Geomater., 2, 2, No. 3 (139), 69–73.

Mantlík, F., Schenk, V., Grácová, M., Schenková, Z. and Fučík, Z.: 2007, Processing of GPS signals of permanent observatories of the geodynamic network GEONAS and estimation of recent movements among individual observatories (in Czech). Sborník referátů jubilejního 10. semináře s mezinárodní účastí "Aplikace družicových měření v geodézii". FAST VUT v Brně, ECON Brno, 87–91.

Mantlík, F., Schenk, V., Schenková, Z. and Grácová, M.: 2009, The influence of snow coverage on GPS antennas of the mountain EPN stations. EUREF Publication No. 17, Mitteilungen des Bundesamtes für Kartographie and Geodäsie, 42, Frankfurt am Main, 131–132.

Mantlík, F., Schenk, V., Schenková, Z., Kottnauer, P., Grácová, M. and Fučík, Z.: 2005b, GEONAS – The GEOdynamic Network of the Academy of Sciences of the Czech Republic: Permanent GNSS observations and routine data processing in the IRS operational centre. EUREF Publication No. 14, Mitteilungen des Bundesamtes für Kartographie and Geodäsie, 35, Frankfurt am Main, 140–142.

Schenk, V., Cacoń, S., Bosy, J., Kontny, B., Kottnauer, P. and Schenková, Z.: 2002a, GPS geodynamic network EAST SUDETEN – Five annual campaigns (1997-2001), data processing and results. Acta Montana, Ser. A, No. 20(124), 41–44.
Schenk, V., Kottnauer, P. and Schenková, Z.: 2004a, Permanent GPS observatories operated by the IRSM Acad. Sci. (in Czech). Sborník Semináře s mezinárodní účastí "Současný stav a vývoj bodových polí". FAST VUT v Brně, ECON Brno, 55–59.
Schenk, V., Kottnauer, P., Schenková, Z. and Mantlík, F.: 2004b, Czech permanent GPS observatories for geodynamic investigations of the Bohemian Massif operated by the IRSM, Prague. Acta Geodyn. Geomater., 1, No. 3 (135), 111–114.
Schenk, V., Kottnauer, P., Schenková, Z., Rucký, A., Pšenička, J. and Řehák, J., jr.: 2002b, New permanent GPS observatories Sněžka (SNEZ) and Biskupská kupa (BISK). Acta Montana, Ser. A, No. 20 (124), 41–44.
Schenk, V., Mantlík, F., Kottnauer, P., and Schenková, Z.: 2005, Permanent GPS observatories of the Institute of Rock Structure and Mechanics, Acad. Sci. and their use for needs of routine practice (in Czech). Sborník Semináře s mezinárodní účastí "Vývoj metod a technologií GPS v geodézii". FAST VUT v Brně, ECON Brno, 95–99.
Schenk, V., Schenková, Z., Cacoń, S., Kontny, B., Bosy, J., Kottnauer, P.: 2003, To geodynamic interpretations of GPS data monitored on the East Sudeten network. Acta Montana, Ser. A, No. 24(131), 87–97.
Schenk, V., Schenková, Z. and Grácová, M., Kottnauer, P.: 2006, Preliminary site movements in the GPS WEST SUDETEN network. Acta Geodyn. Geomater., 3, No. 3(143), 45–51.
Schenk, V., Schenková, Z. and Jechumtálová, Z.: 2009a, Geodynamic pattern of the West Bohemia region based on permanent GPS movements. Studia Geophysica et Geodetica, 53, No. 3, 329–341. DOI 10.1007/s1 1200-009-0021-y.
Schenk, V., Schenková, Z. and Jechumtálová, Z.: 2009b, Reply to Comment of T. Fischer and J. Horálek on "Geodynamic pattern of the West Bohemia region based on permanent GPS movements" by V. Schenk, Z. Schenková and Z. Jechumtálová. Studia Geophysica et Geodetica, 53, No. 3, 345–350. DOI 10.1007/s1 1200-009-0023-9.
Schenk, V., Schenková, Z., Mantlík, F. and Grácová, M.: 2009c, GPS permanent and epoch measurements and geodynamic pattern of the Bohemian Massif (Central Europe). EUREF Publication No. 17, Mitteilungen des Bundesamtes für Kartographie and Geodäsie, 42, Frankfurt am Main, 145–146.
Schenková, Z., Schenk, V., Mantlík, F. and Grácová, M.: 2007, Regional geodynamic network HIGHLANDS, the Bohemian Massif. Acta Geodyn. Geomater., 4, No. 4 (148), 207–215.
Schenková, Z., Kottnauer, P., Schenk, V., Cajthamlová, M., Mantlík, F. and Kujal, R.: 2009, Investigations of the recent crustal movements of the eastern part of the Bohemian Massif using GPS technology. Acta Research Reports, No. 18, 17–25.

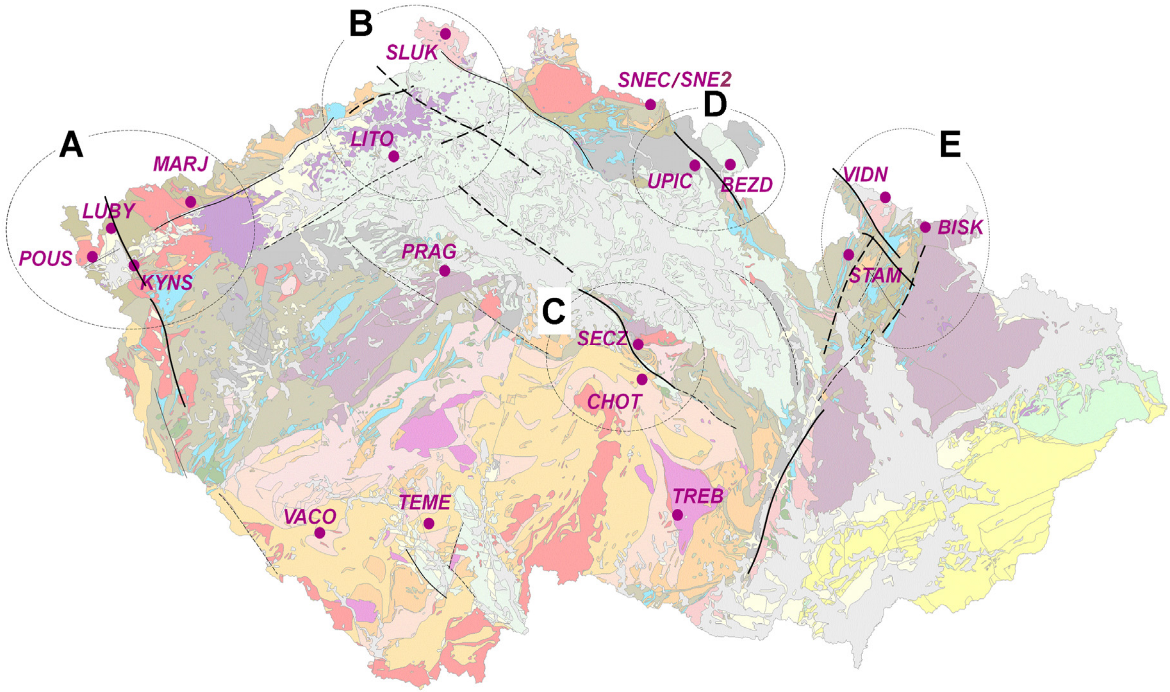

Fig. 1 Location of the GEONAS network stations, with respect to tectonic systems and faults; A – Mariánské Lázně fault zone; B - Elbe lineament and Krušné hory fault system; C - Železné hory fault; D - Hronov-Poříčí fault zone; and E - Marginal Sudetic fault system.

Fig. 3 Configuration and equipment of the GEONAS stations.
1 - main power supply, 2 - GPRS modem, 3 - GNSS receiver Topcon GB-1000, 4 - ethernet switch, 5 - battery 225 Ah, 6 - minicomputer for data pre-processing (processor VORTEX86/166 MHz, 40GB HDD or CF 32GB, Debian GNU/Linux), 7 - battery charger, 8 - ethernet switch 100 Mbit/s, 9 - undervoltage protection, 10 - cooling system

GPS data available - 9/2006

Station\\Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
BEZD	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
BISK	100	100	99	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99	99	100	100	99	100	100	100	100	100	100	100	
CHOT	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99	100	100	100	100	100	100	100	100	
KYNS	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	
LITO	54	99	100	99	99	99	99	99	99	99	100	100	99	100	99	99	99	99	99	99	99	100	99	99	99	99	99	99	99	99	
LUBY	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
MARJ	99	99	99	100	100	100	99	100	99	100	99	100	100	99	100	100	100	100	100	99	100	100	100	100	100	100	100	100	99	99	
POUS	99	99	99	99	99	99	99	99	99	99	99	100	99	99	99	99	99	100	99	99	99	99	99	99	99	99	99	99	100	99	
PRAG	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	67						
PRAH	100	100	100	98	100	100	98	100	100	100	99	56	100	32	25			39	100	100	100	92	92	100	100	100	100	100	100	100	
SECZ	100	100	100	100	100	99	100	100	100	100	100	100	100	100	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
SLUK	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
SNE2	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99	100	100	
SNEC	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
STAM	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
TEME	100	100	100	100	100	100	100	100	100	100	100	100	58	62	100	100	100	100	100	100	100	99	100	100	100	99	100	100	100	100	
UPIC	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
VACO	99	100	100	100	100	100	100	100	100	100	99	100	100	100	100	100	100	100	100	100	100	100	100	100	94	75	99	99	99	99	
VIDN	100	100	100	100	100	100	99	100	100	100	100	100	100	100	99	100	100	100	100	100	100	100	100	100	100	100	95	22	4	54	

Table shows number of registered epochs in % of all possible epochs.

Legend: > 95 % | > 75 % | > 50 % | > 25 % | > 0 % | No data | * Data processing in progress

Month: 9 Year: 2006 Parameter: % of registered epochs Redraw

Optional actions: [View RINEX creation overview]

Fig. 5a www data quality interface check - sample of quality maps.

GPS station MARJ - data available for year 2007

Month\\Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Jan 07	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	50	64	62	98	100	100	100	100	100	99	100	100	99
Feb 07	99	98	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99	99	100	100	100	100	100			
Mar 07	100	100	99	100	100	100	100	100	100	100	100	99	100	100	100	100	100	100	99	100	100	100	99	99	99	99	100	99	100	100	100
Apr 07	100	100	96	99	97	87	83	87	95	99	99	99	100	99	100	100	99	99	99	99	99	99	99	99	99	99	100	99	99	100	
May 07	99	99	100	100	100	99	100	100	100	99	99	100	100	99	99	98	99	100	100	100	100	100	100	100	100	99	100	99	100	100	100
Jun 07	100	100	100	100	100	100	99	100	100	100	100	100	100	100	100	99	100	100	100	100	99	100	100	100	100	89	100	96	100	96	
Jul 07	100	100	100	100	100	100	100	99	100	100	100	100	100	99	100	100	100	100	96	100	100	100	100	100	100	100	100	100	100	100	100
Aug 07	100	99	99	99	100	99	99	99	99	100	100	100	100	99	100	100	100	100	100	100	100	100	99	100	100	100	100	100	100	100	99
Sep 07	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	98	86	84	84	98	99	99	99	99	99	99	99	100	100	
Oct 07	100	100	100	99	99	99	99	100	100	100	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Nov 07	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
Dec 07	100	100	100	100	89	62	82	100	100	100	100	100	100	99	100	99	99	100	99	100	100	99	100	100	100	100		32	99	100	100

Table shows number of registered epochs in % of all possible epochs.

Legend: > 95 % | > 75 % | > 50 % | > 25 % | > 0 % | No data | * Data processing in progress

Station: MARJ Year: 2007 Parameter: % of registered epochs Redraw

Registration interval
% of registered epochs
% of registered observations
Missing data

For information about data availability plea… sm.cas.cz.

© IRSM CAS C…

Fig. 5b Availability of GNSS data from the MARJ station in 2007.