CzechGeo/EPOS - List of Sections and Networks

http://www.czechgeo.cz/en/

Partners:

IG CAS – Institute of Geophysics of the CAS, v.v.i., Praha

CGS – Czech Geological Survey, Praha

IPE MU – Masaryk University, Brno, Faculty of Sciences, Institute of Physics of the Earth

FMP CU – Charles University, Praha, Faculty of the Mathematics and Physics, Department of Geophysics

FS CU – Charles University, Praha, Faculty of Science, Institute of Hydrogeology, Engineering Geology and Applied Geophysics

IGN CAS – Institute of Geonics of the CAS, v.v.i., Ostrava

IRSM CAS – Institute of Rock Structure and Mechanics of the CAS, v.v.i., Praha

RIGTC – Research Institute of Geodesy, Topography and Cartography, v.v.i., Zdiby

RI includes five thematic sections (leading institution in parentheses)

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   - West Bohemian Local Seismic Network – WEBNET
   - North Moravia Local Seismic Network - MONET
   - Icelandic Local Seismic Network – REYKJANET
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   - Long-term Monitoring of the Slope Deformations – SLOPNET
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5. Section of geological and geophysical databases (CGS)
    - Czech Geological Survey Data Research Infrastructure – CGS-DRI

1. Section of seismology (IG)

Czech Regional Seismic Network – CRSN (supervised by Jan Zedník)

Czech Regional Seismic Network (CRSN) is a distributed RI consisting of 20 permanent broadband seismological stations operated by IG CAS (10), IPE MU (4), IRSM CAS (3), FMP CU (1), RIGTC (1) and IGN CAS / Technical University Ostrava(1) which cover the territory of the Czech Republic.

The oldest station Praha (PRA) was founded in 1927. Stations Pruhonice (PRU) and Kasperske Hory (KHC) were established in the late 50s. After the strong earthquake swarm in West Bohemia in 1985-1986, the Novy Kostel (NKC) station was put into operation in the epicentral region. Other stations have been added since the 90s so that the current configuration of the network was reached. IG-CAS has forty years of experience with operation of broadband seismic stations.

Stations of the CRSN are equipped with digital 24bit data-acquisition systems and broadband seismometers. Seismometers are mostly installed on concrete vaults and situated in remote places suitable for undisturbed recording. Recharged batteries are used as power supply. The data are transferred in real time to the data centres at IG-CAS, Prague and IPE-MUNI in Brno, mostly by the Internet provided by CESNET. Digital data are collected and processed at the data centres and exchanged with European and worldwide data centres and neighbouring seismic networks as well. Continuous data transfer started in 2000. Commercial licensed software is used for state-of-the-art processing. Data are available through the web pages of the CzechGeo project (http://www.czechgeo.cz/) as well as on data portals of the European and worldwide data centres. CRSN keeps an open access policy. Data are freely available both on-line and off-line. CRSN has been a part of the European Data Centre ORFEUS since 1988, and has participated in European projects Meredian, Neries and the EPOS research infrastructure project. CRSN is one of the RIs of the European RI project EPOS. Several grants of the Grant Agency of the Czech Republic were focused on the use of the CRSN data.

Major tasks of the CRSN are:

- to monitor earthquake activity on the territory of the Czech Republic and neighbouring regions
- to provide high quality data for research of world's seismicity, strong earthquake source processes, and the structure of the Earth.

Permanent seismic stations form the backbone of international research projects such as Celebration 2000, Alps 2002, Bohema or the planned AlpArray project, which study the structure of the crust and upper mantle in Europe. Thanks to advanced software used in the data centre, CRSN provides fast location and alert messages to seismological data centres and the Czech integrated rescue system when strong regional and global earthquakes happen.

Major innovations in the instrumentation of seismic stations of the CRSN were made in 2003 and during 2010-2013 in the frame of the CzechGeo/EPOS project. Therefore, CRSN is well equipped and comparable with other advanced regional seismic networks in Europe. However, some of the stations still need to be upgraded. A few stations with higher noise will be moved to new, quieter sites. To keep up with the rapid development of technologies, it is envisioned to perform another upgrade of both data acquisition systems and seismometers in the next 7 years.

West Bohemian Local Seismic Network – WEBNET (supervised by Josef Horálek)

IG CAS and IRSM CAS

The WEBNET network monitors seismicity in the W-Bohemia/Vogtland earthquake-swarm region (latitude ≈ 49.8°N to 50.7°N, longitude ≈12°E to 13°E) and is operated in cooperation of the Institute of Geophysics (IG) and Institute of Rock Structure and Mechanics (IRSM) of the Czech Academy of Sciences.

W-Bohemia/Vogtland earthquake-swarm region is a unique European intra-continental area that exhibits simultaneous activity of various geodynamic processes. Active tectonics is manifested by persistent seismic activity and emanations of CO2. The seismic activity is characterized by frequent occurrence of earthquake swarms. The swarm-like seismicity are scattered in the area of about 40 km x 60 km, however, larger swarms (~ ML > 2.5) cluster predominantly in the focal zone Nový Kostel (NK) which dominates the recent seismicity of the whole region, with more than 90% of the total seismic moment that has been released in the last thirty years. Notable earthquake swarms in the last thirty years occurred in 1985/86, 1997, 2000, 2008 and 2011 with the strongest events of ML = 4.6, 2.9, 3.3, 3.8, and 3.7; an exceptional ML = 4.4 mainshock-aftershock sequence occurred in 2014. The largest equivalent local magnitudes did not exceed ML = 5.

Currently WEBNET consists of 14 broadband stations with the Internet access and 8 short-period autonomous stations. The broadband stations are equipped with Güralp CMG3-ESP sensors (T0 = 30s) and Centaur acquisition systems (24 bits resolution) by Nanometrics. The sensors are fixed to bedrock in dry wells. The stations are connected to the Internet via the WaveLan net. Thus data from these stations are available in a nearly real time.

The autonomous short-period stations are equipped with the LE3-D sensors (T0 = 1s) and low-power acquisition systems GAIA, both pertaining to the MOBNET seismic pool of the IG CAS. The sensors are placed in special vaults on a concrete pillars connected with bedrock, about 2 m below the surface. The stations are supplied from batteries. A storage capacity of the Gaia is about ten months (SD memory cards), data are downloaded together with the battery exchange once in two months or as needed (e.g., in case of larger local seismic activity). State-of-health of the stations is reported each day via SMS.

The WEBNET network covers the area of about 900 km2. All the stations operate in the continuous mode, the sampling rate of 250 Hz is used. The WEBNET database includes catalogs and seismograms of about 80 000 events recorded since 1991.

North Moravia Local Seismic Network – MONET (supervised by Petr Špaček)

IPE MU and IGN CAS

The MONET network is a basic infrastructure for monitoring seismicity in the extensive geodynamically active region of the NE Bohemian Massif adjacent to the Western Carpathians´ orogenic front. This region exhibits numerous signs of regionally anomalous, Late Cenozoic to recent tectonic activity. Another important source of regional seismicity comes from the mining activities in the Karvina area and the adjacent Polish coal regions.

Until recently two sub-networks were independently developed and operated by IPE MU Brno and IGN CAS Ostrava, which resulted in a gradual increase of the number of permanent and temporary seismic stations in variable arrangements. Therefore, IPE MU and IGN CAS agreed on integration of their monitoring infrastructures into a single network which will enhance the monitoring capacity and quality of seismic observations in the region.

At present, MONET consists of 10 short-period stations with sampling rate of 100-200 Hz. Seven stations are accessible via GSM or Internet which enables a continuous data transfer in near-real time to the data centres in IPE MU and IGN CAS. Two stations are operated off-line, one of them in the trigger mode. Recorded data are analysed manually (event detection, determination of the P- and S-wave onsets, location) to assure correct interpretation of weak events occurring in the broad region under study.

A major upgrade of 6 temporary stations to permanent ones and switching to near-real time data transfer was carried out in the scope of the CzechGeo 2010-2015.All data have been made available in the open access mode. The plan for the next stage is to upgrade 3 temporary stations to permanent ones (years 2017-2020), to install at least one new permanent station (years 2017-2018, all stations with near-real time telemetry) and to upgrade the data centres. These upgrades will allow to increase the number of well-constrained focal mechanisms and to improve our knowledge on the extent and internal structure of the main seismogenic zones.

Icelandic Local Seismic Network – REYKJANET (supervised by Josef Horálek)

IG CAS and IRSM CAS

The REYKJANET network monitors seismicity on the Reykjanes Peninsula in South-West Iceland (latitude ≈ 63.8°N to 64.1°N, longitude ≈ 21.5°W to 22.3°W); it has been operated in cooperation of the Institute of Geophysics (IG) and Institute of Rock Structure and Mechanics (IRSM) of the Czech Academy of Sciences since 2013.

The Reykjanes Peninsula is the onshore part of the mid-Atlantic plate boundary between the North America and Eurasia Plates that extends from the south-west to the east and forms a pronounced oblique rift along the whole peninsula; the plate motion rate there is about 20 mm/year in E-W direction and about 5 mm/year perpendicular to it (Sæmundsson and Einarsson, 2014; Einarsson, 2015). The Reykjanes Peninsula is highly complex geophysical structure with an ongoing interaction between volcanic and tectonic activity which is manifested by persistent swarm-like seismicity and reoccurrence of interplate earthquake swarms with local magnitudes exceptionally up to ML=5.0.

REYKJANET consists of 15 autonomous stations which cover the area roughly 60 km x 20 km. Fourteen stations are broadband, equipped with the Güralp CMG 40-T, T0 = 30s, and one station is short period, equipped with the LE3-D sensors, T0 = 1s, by Lennartz. The sensors are placed in special vaults on a concrete pillars connected with bedrock. Lower-power GAIA data acquisition systems, which pertain to the MOBNET seismic pool of the IG CAS, are used. All the stations operate in the continuous mode with the sampling rate of 250 Hz. A storage capacity of acquisition systems Gaia is about ten months (SD memory cards), data are downloaded once in three months. State-of-health of the stations is reported once every forty eight hours via SMS. During the REYKJANET operation two larger activities, the offshore ML=5.0 swarm of October 2013 and the ML=3.9 swarm of February 2016, were recorded.

The REYKJANET stations are deployed in unpopulated area, so they are supplied from batteries which are recharged by solar panels combined with a wind turbine. REYKJANET is operated with the technical assistance of the Iceland Geosurvey (ÍSOR).

Little Carpathians Local Seismic Network – MKNET (supervised by Jiří Málek)

IRSM CAS in co-operation with the Geophysical Institute SAS Bratislava

The Dobrá Voda area is one of the most seismically active zones on the territory of Slovakia. It is situated in the transition zone between the Eastern Alps and the Western Carpathians. The MKNET seismic network is an effective tool for studying seismicity in this region.

At present, MKNET consists of 11 three-component seismic stations with short period SM-3, Lennartz Le3D and Guralp CMG-40T-1 seismometers. The IRSM operates three seismic stations – POD, BAN and JAL. These stations are currently connected to the Internet enabling on-line data transfer. The POD and JAL stations are equipped with CMG-40-T seismometers while the BAN station uses only a short period Le3d seismometer.

Data from the MKNET are processed manually using software package with interactive tools.

The plan is to build two additional seismic stations equipped with broadband Guralp seismometers. These new stations will be connected through the Internet to enable an on-line data transfer. In addition an upgrade of the BAN station with the broadband Guralp seismometer is planned.

Access to data will be free on demand.

Patras Seismic Network – PSLNET (supervised by Vladimír Plicka)

FMP CU in co-operation with the University of Patras

Joint Czech-Greek seismic observations (since 1997) are performed in cooperation with Seismological Laboratory, Department of Geology, University of Patras as a part of the Patras seismic network (PSLNET). This is a sub-network of the Hellenic Unified Seismic Network (HUSN). The PSLNET seismological network includes eight broadband seismographs (BB) and ten accelerographs (SM). The most of the instruments are Guralp equipments (7xCMG-3T, 9xCMG-5T), the rest are Nanometrics

seismographs (Trilium 120 and Titan). Data transfer to the data centre in Patras is facilitated either via satellite or via GPRS Internet. Simultaneously, the data are stored on USB drives at the stations (Guralp CMG-DCM or CMG-DAS unit) http://seis12.karlov.mff.cuni.cz/greece/.

Data are distributed to the partner's institutions in real-time. Other users can obtain the data on e-mail request. Strong motion instruments (accelerographs) without telemetry work in a stand-alone regime and the data are archived twice a year. Data are distributed using standard protocols (Seedlink, Scream server, NaqsServer). In addition, most stations contain the registration apparatus, which ensures continuity of data in case of a telemetry problem (satellite, GPRS, WiFi). Data formats are gcf (Guralp compressed format) and minimised. Two stations are providing the data to the ORFEUS international data centre.

Finally, it should be emphasized that all the mentioned efforts are closely related to the Corinth Rift Laboratory, a broad European initiative (since 1991), recently integrated in the EPOS road map as one of the European Near Fault Observatories. The presently running European projects with similar objectives are REAKT and NERA.

RI is fully functional and does not consider any significant expansion. The main goals in the following 7 years will be:

- stable operation of seismic stations
- facilitating data telemetry for all stations to provide real-time data
- updating software for transmission, distribution and processing of data
- developing software for automatic data processing

Mobile Seismic Network – MOBNET (supervised by Jaroslava Plomerová)

IG CAS

Pool of mobile seismic stations MOBNET was set up in 2003. At present, the MOBNET pool consists of 63 seismometers, 31 of which are the high-quality broad-band (BB) STS2 or Guralp CMG seismometers and 32 are short-period (SP) Le-3D seismometers, and 55 GAIA I-III data-acquisition systems (DAS), having extremely low power consumption (less than 1W) which is beneficial for field deployments.

Stations of the pool (seismometer + DAS) are deployed according to a schedule created in dependence on requests of individual user groups. Both seismometers and the DAS are almost all the time running in different experiments and/or recording local seismicity according to current situation. The instruments of the pool have been involved in several mostly international passive experiments in different European regions whose tectonics differ substantially, e.g., LAPNET (2007-2009), PASSEQ (2006-2008), RETREAT (2003-2006), MOSAIC (1998-1999), BOHEMA I-IV (2001-2014), EgerRift (2007-2011). The experiments aimed at recording digital waveforms at dense arrays of seismic stations for detailed studies of the Earth structure. Since summer 2013, all BB seismometers and GAIA DAS have been deployed along a NS band from the Erzgebirge mountains through the Bohemian Massif across the E. Alps to Trieste within the project AlpArray-EASI, a part of the large international AlpArray project, which will deploy ~ 400 stations and cover a broad region around the Alps. The MOBNET pool represents significant component of the backbone array there as well as in the regional sub-projects (EASI).

The part of the MOBNET pool (Gaia II) deployed as temporary stations enhanced the monitoring capacity and quality of observation of the permanent WEBNET network greatly. It appeared invaluable during significant earthquake swarms in 2008, 2011, 2013 and 2014. Data collected by this joint dense network of well-equipped stations meeting the world's up-to-date standard allowed advanced processing and revealing many important features of the zone and the energy release there. Fifteen DAS units from the MOBNET pool are currently in operation in the REYKJANET experiment monitoring swarm seismicity in S. Iceland.

In almost non-stop operation, the DAS and sensors are exposed severe conditions in the field and during relatively frequent transportation in addition. The DAS life-time is estimated to about 10 years. Thus, regardless partial updates done, they need to be replaced to keep the pool at its current high level. The oldest GAIA I DAS from 2003 urgently need to be replaced. In 2017-2019 fifteen GAIA DAS is expected to be replaced from OPVVV. Remaining 15 DAS GAIAI and GAIA II (from 2005), i.e., 27 new GAIA DAS and 3x Nanometrics DAS ares planned to be substituted in2020-2022 years.

Modern seismometers are electronic instruments as well. Though their life-time is longer compared to the DAS, it remains limited. We estimate a need of a replacement of 5 STS2 seismometers and change of 20 Le-3D sensors by Guralp CMG-3ESP seismometers during the next 7 year period. The replacements of DAS and sensors indicated will keep the current size of the MOBENT and enable to collect high-quality seismic data in the frame of seismological experiments in coming years.

Annual operating costs of the MOBNET pool are ~10k/unit, which include: installation, operation, service, data collection from stations running in the autonomous regime and necessary repairs. The operation of the entire pool is 550k/year. The operation costs of a part of the pool included in passive seismic experiments were covered by grants of the GAAV, GACR and ACSR supports in the last three years. 450k will be put in the CzechGeo budget.

Near Fault Observatory planned in West Bohemia – NFOWEB (supervised by Tomáš Fischer)

Cooperation of FS CU and IG CAS

The West Bohemia/Vogtland earthquake-swarm region is a unique European intraplate area that shows past-to-present geodynamic activity being manifested by persistent swarm-like seismicity and strong degassing of magmatic-derived CO_2. In this respect, the seismic swarms and CO_2 flow represent direct data on geodynamic processes in depth. While the seismic activity has been monitored by the WEBNET seismic network since 1992, the CO_2 flow has been observed by the CARBONET network since 2009. At present it consists of six online monitoring stations located in the mofette areas. Both these networks are situated on the Earth surface, which limits their detection capability. While seismic observations are interfered by seismic noise of anthropogenic origin and by near surface attenuation limiting the frequency content, the CO_2 flow is influenced by temperature variations and varying soil moisture.

In order to avoid the above-mentioned effects, we plan to extend WEBNET and CARBONET to depth and build a near fault geodynamical observatory consisting of three boreholes of 300-500 m depth situated in the broader area of the Cheb basin.

It will include two main parts:

- 3-D seismic array: each borehole will be equipped with two three-component short-period borehole seismometers located on two levels and with a surface seismic station/array.
- CO_2 monitoring network: selected boreholes will host gas probes for monitoring of the flow of CO_2 of deep origin and other gas parameters in stable temperature conditions.

In the next stage (2020-2022) the near fault observatory NFOWEB will be also supplemented by a deep geothermic exploration well in order to obtain reliable estimate of heat flow in the geodynamically active area of West Bohemia. The only available heat flow value in the area is based on the industrial temperature log done in the 70s in the borehole destroyed a long time ago.

Besides, the boreholes will be open for installing further devices suitable for geodynamic monitoring of an active tectonic area.

The proposed Near Fault Observatory will be a part of the prepared RI of Near Fault Observatories in EPOS that involves so far 6 areas in different tectonic environment in Italy, Greece, Turkey, Switzerland and Iceland, aiming to produce high resolution multidisciplinary geoscience data.

Primary data will be available to the CzechGeo partners in near-real time, depending on the technical constraints.

Seismological software centre (supervised by František Gallovič)

FMP CU

The centre established within the CzechGeo project contains more than 100 portable open-source public-domain computer programs related to seismic wave propagation, together with their hypertext documentation and demo data. The development of the software took over 30 years.

The Centre provides the up-to-date ray-based software for seismological applications.

The Centre has over 130 registered users and an unknown number of non-registered users. It provides about 100,000 source code files a year.

2. Section of GNSS and gravimetry (RIGTC)

Network of Permanent GNSS Stations – VESOG (supervised by Jakub Kostelecký)

RIGTC

The network of 11 permanent GNSS (Global Navigation Satellite System) stations is located at research and academic institutions in the Czech Republic. The GOP operational centre is responsible for data dissemination and maintenance of the network. Infrastructure produces primary observations (pseudo-ranges and carrier-phases) for precise location, geo-kinematics, reference frame, GNSS-meteorology and other purposes.

The network of 11 continuously operating GNSS stations is equipped with Topcon, Leica, Java and, Trimble GNSS receivers. All stations are located in the Czech Republic, on roofs of academic or research institution buildings. They are operated by an operation centre from the Geodetic observatory Pecny using an in-house developed software.

Development plan for the next years is to keep the current number of VESOG stations as it is. Thus, only the maintenance and replacement of the receivers, antenna and other site-related sensors is planned in order to increase the data quality and quantity in terms of supporting all navigation systems, modern GNSS signals and frequencies. Investments are planned for the upgrade of a single GNSS receiver and antenna per year in both (VESOG and PPGNet) networks.

The observed data (pseudo-ranges and carrier-phases) are provided in hourly files with 1 second sampling rate. The data available from the measurements are checked and stored in files with standard format (RINEX). Other outputs are provided by other parts of the RI (GOP data, analytic and software centres).

The VESOG network closely cooperates with the national Network of permanent GNSS stations in the Czech Republic – CZEPOS. The CZEPOS network is operated by the Land Survey Office in Prague. Five stations of the VESOG network provide data to the CZEPOS network. The data from the CZEPOS network with 30 second sampling rate and older than 18 months are available for scientific purposes in the frame of CzechGeo/EPOS project.

The resulting GNSS data are used by scientific, academic and commercial users for developing support products and for providing services and end-user applications in multi-disciplinary domain.

Data with 1 second sampling rate will be available through a data centre upon user registration. From some stations, the data with 30 second sampling rate are distributed to the International GNSS Service (IGS – http://www.igs.org/) and EUREF Permanent Network (EPN – http://epncb.oma.be/) and are freely accessible via regional or global data centres.

Interaction and communication with users is via e-mails, web interface is provided for general description and availability of the data (http://gopoc.pecny.cz/gopoc.html). The web interface for data distribution in the frame of CzechGeo/EPOS project is accessible at http://www.pecny.cz/CzechGeo/.

All users have the same access to the outputs. Additionally, data are provided to GOP data and analytic centres for generating high-level data to the community (orbit and clock products, coordinates and velocities, troposphere and others etc.).

Geodynamic GNSS network – GEONAS (supervised by Jan Blahůt)

IRSM CAS

The Geodynamic Network of the Academy of Sciences (GEONAS) is a network of permanent GNSS stations performing continuous observations of geodynamic movements on territory of the Czech Republic. GEONAS started to operate in 2001 with two stations (on Sněžka and Biskupská kupa). Nowadays, it consists of 20 permanent stations, four of them have been incorporated within EUREF Permanent Network EPN. All stations operate with the 30 second sampling rate. The configuration was designed to cover various geological structures.

The stations are equipped with old Aschtec Z-18 and Topcon GB1000 receivers capable of monitoring US NAVSTAR satellite signals of the GPS system as well as Russian GLONASS satellite signals. Some

stations are equipped with new Topcon NET-G3A receivers capable to monitor signals of the newly-built EU Galileo system in the future. All stations are connected online to the IRSM operational centre where the recorded data are automatically checked. Data processing is performed using the Bernese software package.

Network od Permanent GNSS Stations in Greece -PPGNet (supervised by Jakub Kostelecký)

RIGTC and FMP CU

In the framework of CzechGeo, RIGTC and FMP CU jointly operate six permanent GNSS (Global Navigation Satellite System) stations in Greece, which are merged into Greek network of permanent GNSS stations. The joined facility consists of 15 stations. The locations were selected in cooperation with Greek and French partners (National Observatory of Athens, http://www.gein.noa.gr/services/GPS/noa_gps.html, École normale supérieure, https://gpscope.dt.insu.cnrs.fr/chantiers/Corinthe/). Five of the GNSS stations (Katochi, Paravola, Kato Retsina, Lepenou, Rigani) have been designed to monitor recent motions near the Patras and Corinth Gulf. The stations are located in public or academic buildings.

The GNSS station Valyra complemented the accelerograph network in the southern Peloponnese near the city of Kalamata which was built in response to highly increased seismic activity in 2011. The region has been known for destructive historic earthquakes of magnitude greater than 6 (M>6). For example, the Kalamata city experienced an M6.6 earthquake in 1986, causing heavy damage and killing 20 people.

The infrastructure provides primary measurements (pseudoranges and phases). The GNSS stations are equipped with Leica, Trimble and Septentrio GNSS receivers and antennas. The observed satellite systems are GPS NAVSTAR, GLONASS and Galileo. The Trimble and Septentrio receivers detect only GPS NAVSTAR system. The data are accessible to the public and they are also transferred to the National Observatory in Athens and to the METRICA company in the frame of data exchange.

The usage of static and transient displacement measured with the space geodesy methods using low-rate (30 s) and high-rate (>1.0 Hz) GNSS data, respectively, represents an important constraint stabilizing inverse problem of the slip distribution and evolution on faults during earthquakes, significantly complementing seismic measurements. This is an important modern contribution of the GNSS use to the study of recent tectonic movements and regional stress fields.

Finally, it should be emphasized that all the mentioned efforts are closely related to the Corinth Rift Laboratory (a broad European initiative running since 1991), recently being integrated in the EPOS road map as one of the European Near Fault Observatories. The presently running European projects with similar objectives are REAKT and NERA.

West Bohemia Geodynamic Observatory – WEBGEODYN (supervised by Jan Mrlina)

IG CAS

The observatory is located in seismogenic region of the Bohemian Massif which exhibits geodynamic unrest mainly manifested by swarm-like seismicity and crustal-fluid activity. It consists of semi-regional GPS, gravity, and precise levelling networks which are designed for epoch-style observations. In addition, the permanent GPS station NKOS and 3 hydrological wells are included. The observation started in 1993-4.

The main aim of the WEBGEODYN observations is to assess the impact of earthquake activity on surface movements, groundwater level variations, and temporal changes of the gravity field. Such assessment is important for water-resource management, spa resorts and local communities.

The most of the WEBGEODYN components will need a reconstruction due to long time of operation. We plan the replacement of the GPS receiver at the permanent geodetic station NKOS by a GNSS multi-signal receiver (GPS+Glonass+Gallileo), nearly real-time data transfer to IG CAS, and upgrade of the processing system. For the control and/or setup of stations in galleries, forest, etc., purchase of Trimble Total Station will be needed.

Greek Volcanic Islands Monitoring – GREVOLCAN (supervised by Jan Mrlina)

IG CAS in co-operation with the Kapodistrian University of Athens.

There are two existing networks for GPS-Gravity monitoring of active volcanoes on the islands of Nisyros and Thira in Greece. They are designed for epoch-style observations. With respect to insufficient number of observation sites, the networks will be equipped with additional stations respecting the latest developments of volcanic and earthquake activity. The objective is to monitor magmatic and tectonic processes in the interior of the volcanoes that represent hazard for local population and properties. The data will be available to local authorities and academia as technical reports.

We started our epoch gravity measurements in 2012 and plan to continue in regular campaign-style observations until 2022, so that the results will be statistically significant. In addition, we intend to set up a station in the Nisyros crater to perform short-period GPS and gravity measurements.

Gravimetric station Pecný – GSP (supervised by Vojtech Pálinkáš)

RIGTC

The gravimetric station Pecný is a part of the Geodetic observatory Pecný, located 35 km south-east of Prague in a quite area near to village Ondřejov. Main objective of the station is to provide continual measurements of gravity variations with low noise levels in a wide range of periods (from minutes to long-term changes). Two type of measurement techniques are used to reach this goal: 1) repeated absolute gravity measurements by FG5 type of absolute freefall gravimeters and 2) continual measurements of gravity variations by the relative superconducting gravimeter (SG) OSG-050. Combination of data from these techniques is able to provide gravity variations with highest time resolution (sampling interval of 1 sec), long-term stability and traceability to SI units. Such products can be used for scientific studies in geodynamics, seismology, hydrology and metrology.

The station Pecný is providing SG data through the International Geodynamics and Earth Tide Service (IGETS) of the International Association of Geodesy. The service was established in 2015 and the IGETS data base is hosted by GFZ German Research Centre for Geosciences. Data availability is realized by a FTP server which can be accessed by ftp://igetsftp.gfz-potsdam.de. The access to the FTP server requires a username and a password, obtained by a registration procedure on the IGETS data base website (http://igets.gfz-potsdam.de). Available are raw gravity data (sampled at 1 sec and decimated at 1-min) and corrected data at several product levels.

The station Pecný is developing a web tool SGNoise (http://oko.pecny.cz/grav/) for near real-time analysis of SG data, that is able to provide helpful service for operators and data users. It provides time series of gravity variations and careful analysis of noise levels that is directly connected with the data applicability for different kind of scientific studies.

GOP (Geodetic observatory Pecny) Data, Analytic and Software Centre (supervised by Jan Douša)

RIGTC

The GOP data centre collects and disseminates national, European and global GNSS observations and GOP products in the form of files at ftp://ftp.pecny.cz/LDC and selected data and products also via real-time streams using NTRIP protocol with the source table available at http://ntrip.pecny.cz.

The GOP analytic centre was established in 1997 within the sub-commission for the European Reference Systems (EUREF) of the International Association of Geodesy (IAG) and since that time it has provided operational solutions of the EUREF GNSS permanent network (EPN) in support of the maintenance of European reference frame. Recently, GOP has been reoriented to the reprocessing activity to provide a unique solution for full EPN network to the 2nd EUREF Reprocessing. During the last years, GOP also provided, in co-operation with the Land Surveying Office, a national solution for the EUREF Densification (http://epncb.oma.be/_densification/). Based on national contributions, the project aims at providing dense velocity field in Europe and it is supposed to contribute to the European Plate Observing System (EPOS) in future. Since 2003, GOP analytic centre has contributed to the EIG EUMETNET GNSS Water Vapour Programme, EGVAP (http://egvap.dmi.dk) providing two operational GNSS tropospheric products (global and regional) in near real-time fashion in support of numerical weather forecasting. GOP has developed and is maintaining the Trop-NET system (http://www.pecny.cz/Joomla25/index.php/trop-net) for coordinated GNSS-based tropospheric parameter production for the E-GVAP. All the permanent GNSS stations available from the Czech research infrastructure were integrated into relevant GOP solutions – daily coordinates and their long-term combination as the final and rapid products and tropospheric parameters in near real-time products.

GOP also contributes to the EPOS-IP project (https://www.epos-ip.org/) with developing the G-Nut/Anubis software http://www.pecny.cz/Joomla25/index.php/gnss/sw/anubis for data quality control of multi-GNSS constellations, including all modern frequencies, signals and navigation data. The tool is distributed as open-source under the GNU GPL Version 3 licence and since 2014 it has been used by more than hundred users worldwide. It is also a unique contribution from GOP to the development of the future GNSS data dissemination system within the EPOS infrastructure.

3. Section of Crust Geodynamics (IRSM)

Monitoring 3-D Fault Active Displacement – TECNET (supervised by Josef Stemberk)

IRSM CAS

Systematic building of a network for monitoring of 3-D fault displacements using an optical-mechanical gauge TM71 (patented by IRSM CAS) started in 2001. The main advantage of the device is the possibility to record movements on-site directly across a fault plane, and yielding very accurate results of 3D fault movements and of the rotation of the blocks. Measuring devices are placed across the faults preferentially in the underground (caves, galleries) to minimize the undesired influence of exogenous or anthropogenic processes.

The TecNet currently consists of more than 160 gauges situated on tectonic faults within the Czech Republic (66 sites), Slovakia, Slovenia, Poland, Germany, Austria, Switzerland, Italy, Greece, Bulgaria, Belgium, Spain and Norway (for sites´ position see http://www.tecnet.cz/). Measurements in the caves or galleries without power source are performed at one month frequency. At sites with available electricity source, the fully automated devices are mounted, with a direct connection to the internet or GSM where possible. The frequency of data readings is depending on the site, ranging from one day to one hour. Data samples from selected sites are accessible on http://www.tecnet.cz/online monitoring. Data are processed in the IRSM and are freely accessible on request.

During 2016 several new automated monitoring sites were established in Switzerland (Grimel laboratory) Bulgary (Biserna Cave), Slovenia (Postojna Cave) and Czechia (Josef Gallery by Mokrsko). … sites were additionally fully automated in Czechia (Strašín Cave, Zbrašov Aragonite Caves), Germany (Loretto tunnel in Freiburg, Darmstadt in Darmstadtium), Svalbard (Hornsund 3) and Slovenia (Kostanjeviška Cave).

New type of 3-D fault displacement monitoring based on micro-changes of magnetic field is tested in Lorette Cave (Belgium), Bedřichov Gallery (Czechia), Hierro (Canary Isles, Spain) and Pottschach Cave (Austria).

Long-term Monitoring of the Slope Deformations – SLOPENET (supervised by Jan Blahůt)

IRSM CAS

The network of long-term monitoring of the slope deformations has been steadily growing since the beginnings of the 1970s. The most significant sites covers numerous slope deformations in different geological environments are included into SLOPENET network. The field data will be used for landslide risk assessment, for mitigation measures, and for estimating the influence of global climate changes on the potential changes in landslide frequency of occurrence.

During 2016, several landslide sites have been instrumented. Firstly, three rain gauges with automated monitoring were installed in Český ráj, České středohoří a Beskydy Mts. (the most landslide prone areas in Czechia). Temperature sensors and crackmeters were installed near Vrané nad Vltavou, Drábské světničky and Karlovy Vary. They are used to monitor rock fall prone areas and temperature influence on rock fall generation. An inclinometer was installed in Třebenice (České středohoří) to monitor shallow landslide movement. This site was also equipped by automated

groundwater level monitoring. Automatic wire extensometers were installed in Čeřeniště landslide (České středohoří) and Ondřejník deep-seated gravitational slope deformation (Beskydy Mts). Currently online transmission of the monitored data is being prepared.

Czech Earth Tide Observatories – CZET (supervised by Jan Mrlina)

IG CAS

The early tiltmeter station in Příbram (PRIB) was established already in the 1950s in a deep mine shaft as the first tilt observatory in Eastern Europe. At present, it is equipped with two tiltmeters. In addition, it hosts seismic station PBCC of CRSN.

The Skalná Observatory (SKAL) is located in the West Bohemian seismically active region. It is equipped with a tiltmeter with photo-electric pickups, weather-station and a gravimeter. In addition, there is a seismograph belonging to RI WEBNET, and a dilatometer belonging to RI TECNET. The data will contribute to worldwide Earth tide database (formerly International Centre for Earth Tides).

The Jezeří Observatory provides two important components to the monitoring system of the large ČSA open-pit brown coal mine. The coal mining company, Severočeská Energetická, a.s., needs these measurements for active control of the steep slope blocks dynamics and stability. The slope is considered as a hazard to the mine, personnel and technology. The tiltmeter stations Jezeří 1 and Jezeří 2 (JEZE) are located in a mine gallery under the Jezeří Castle on the slopes of the Krušné hory (Ore Mts). Two hydrological monitoring wells can indicate unusual variations of groundwater level that may cause landslides. The measurement is highly appreciated by the company, as it helps to increase the safety of the large-scale mining operations. Apart from regular reports, the company can also check the real-time raw data on a dedicated web page. The expenses to cover the observations for the mining company are not claimed in the RI budget, of course.

Ongoing effort concerns construction of a new type of pendulum tiltmeter, which is foreseen as a replacement off the current station instrumentation. Apart from that, some components of the data transfer system will need an upgrade as well.

Geothermal Climate Change Network - GeoCLIMANET (supervised by Jan Šafanda)

IG CAS

Recent climate warming is related to the changes of the energy budget on the Earth´s surface and to the increasing surface temperature. Variations of the temperature on the surface penetrate into the subsurface. This signal is contained in the temperature-depth profiles obtained by precise temperature logging in boreholes several hundred metres to 2 - 3 km deep and can be used to reconstruct the ground surface temperature history on the time scale of several past centuries up to the last glacial/Holocene transition, respectively.

The key issue in interpreting the reconstructed histories in terms of the long-term climatic variability is the relationship between the soil and surface air temperatures.

Meteorological factors like precipitation, cloudiness, wind, soil moisture, thickness and duration of the snow cover and environmental factors such as the type of a vegetation cover are suspected to influence markedly the air-soil temperature difference.

The GeoCLIMANET consists of the following experimental test sites:

- Two observatories with three boreholes (150 m, 50 m and 40 m) complemented by soil temperature measurements on the grounds of the Geophysical Institute in Prague, which represents the environment of the large city agglomeration, monitor coupling of the air, soil and bedrock temperatures and the effect of the different vegetation cover in an area of occasional soil freezing.
- The observatory Kocelovice, 90 km south of Prague in a typical countryside area with 40 m deep borehole monitors coupling of the air, soil and bedrock temperatures in an area of regular soil freezing.
- The field observatory Svojšice has been established to monitor effect of the slope orientation and angle on the soil temperatures in a countryside area with regular soil freezing.
- The observatory Malence in Slovenia with 100 m deep borehole monitors coupling of the air, soil and bedrock temperatures in a typical Slovenian countryside area in warm climate with marginal soil freezing. The observatory is run together with the Slovenian Geological Survey, Ljubljana, Slovenia.
- The observatory Caravelinha in Portugal with 150 m deep borehole monitors coupling of the air, soil and bedrock temperatures in a Portuguese countryside area in a subtropical climate without soil freezing. The observatory is run together with the Geophysical Centre of the University Evora, Portugal.

In order to get statistically relevant data on the air, soil and bedrock temperature coupling, long-term observational series are necessary. This is the primary purpose of the network. However, it can also provide data valuable in other scientific and technical fields including meteorological models, forestry, agriculture or heat energy storage and extraction.

4. Section of Geomagnetism

Geomagnetic Observatory Budkov and Mobile Equipment – GEOMAG (supervised by Pavel Hejda)

IG CAS

The observatory is located at Budkov near Prachatice, at a place which is distant from sources of man-made disturbances of the geomagnetic field. The observatory is equipped with two digital systems. CANMOS, installed in 1992 in co-operation with the Geomagnetic Observatory of the Geological Survey of Canada consists of a triaxial Narod S-100 ring-core magnetometer, an ELSEC 820 PPM magnetometer, and a control unit based on MS-DOS operating system. The main parts of GDAS system are DMI suspended fluxgate magnetometer, Overhauser proton magnetometer and Pentium-type embedded PC with QNX4 operating system and SDAS data acquisition software developed by British Geological Survey. A set of Quartz variometers of Bobrov type was equipped by photosensors with feedback and put in operation in 2016. A new fluxgate electronics with lower high-frequency noise has been developed and put into operation in testing mode.

Absolute measurements are carried out by DI magnetometer (fluxgate sensor mounted on non-magnetic theodolite Zeiss 010B). They must be performed manually, which is more demanding with regard to manpower. The observatory is part of the INTERMAGNET network of digital stations

producing high-quality data. The 1-minute data are transmitted in nearly real time to the Geomagnetic Information Node (GIN) in Edinburgh. Transmission of 1-second data was tsarted in 2014. The final set of annual data is published on DVD of the INTERMAGNET Project.

The observatory has been recently modernized. A new main building with workrooms and laboratory- open in 2010 - created better working conditions for the staff taking care of the observatory. The observatory was linked by optical cable to the Czech Academic Network (CESNET). The former data transmission via switched telephone network was thus replaced by much modern tools. The absolute house the magnetic cellar and observatory huts were linked with the central hub by optical lines and power network was also renovated. The buildings were also overhauled.

The absolute house has been frequently used for magnetometer testing in last two years. In cooperation with Czech Technical University in Prag and Czech Metrology Institute, triaxial fluxgate magnetometers and total intensity Overhauser magnetometers have been calibrated in the frame of race-track magnetometers stability testing.

The observatory data are completed by repeated (bi-annual) measurements at 7 points of the secular network. The repeat station measurements are coordinated in the frame of MagNetE initiative.

Mobile Magnetotelluric Set - MTMOB (supervised by Josef Pek)

IG CAS

The mobile magnetotelluric set is standardly employed in studies into the distribution of the electrical conductivity of the Earth's crust and upper mantle. In the recent decade, the instruments have participated in several experiments on a continental and regional scale (Central Europe Mantle geoElectrical Structure, CEMES; Electromagnetic Study of the Trans-European Suture Zone, EMTESZ; MT studies of the eastern margin of the Bohemian Massif and of the West Carpathians crustal structures.

The MTMOB set consists of two broad band systems GMS06 and two long period systems LEMI-417 for magnetotelluric field measurents.

The GMS06 systems by Metronix Geophysics, Braunschweig, Germany, consist of ADU06 data loggers (five channel 24 bit A/D converter, frequency range DC-20 kHz for each channel with three subbands, optional sampling rate with the maximum of 4 kHz in the LF band and of 40 kHz in the HF band, flash data storage, 32 bit CPU with precise GPS time base +/-130 ns, battery powered, power consumption with sensors attached typically 7 W) , MFS-05 magnetometers (broad band, low noise induction coil magnetometers, frequency range 4096 s - 8192 Hz) and EFP-06 non-polarizable Pb/PbCl electrodes.

The LEMI-417 systems by the Lviv Centre of the Institute for Space Research, NAS Ukraine, consist of a seven channel electronic unit (sampling rate 1 s, magnetic range +/-70,000 nT, resolution 10 pT, electric range +/-600 mV, resolution 75 nV, GPS synchronized, battery powered, with low power consumption of typically 1.2 W) and three-component fluxgate magnetometers with all three sensors accommodated in the same thermo-stable housing.

5. Section of geological and geophysical databases (CGS)

Czech Geological Survey Data Research Infrastructure - CGS-DRI (supervised by Dana Čápová)

CGS

The CGS-DRI as a part of the CzechGeo RI aims to provide effective access to geological, geophysical and related applied data held by the Czech Geological Survey and other members of the RI, using up-to-date technologies and both European and global standards. These valuable resources of data and access to existing relevant information is essential for the scientific research, namely when aimed to the prediction and mitigation of landslides, subsidence, earthquakes, flooding and pollution.

The CGS-DRI portal has provided the one-point-access to all relevant information. The existing geological, geophysical, soil, natural hazard zones, and other relevant data provided by the Czech Geological Survey and some other RI members has been evaluated for their relevance to EPOS, EGDI (Pan-European Geological Data Infrastructure), INSPIRE (DIRECTIVE 2007/2/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL), and to support the scientific research within the infrastructure observations and measurements.

The metadata catalogue has been developed and filled with metadata to provide comprehensive information on existing data and information resources, compliant with the relevant ISO and/or project-defined standards. The identified data resources has been analysed and harmonized, standard - compliant structures and data models has been developed and implemented. The technological and organizational infrastructure has been developed to support EPOS, EGDI and INSPIRE compliant access to available data. The data has been presented via web services using up-to-date standards and via user-friendly web applications.

CGS is actively involved in the implementation of the INSPIRE Directive in the CR and has actively supported technologically advanced way of provision of data compliant with the European standards. Implementation of the unified standards and principles can ease the data sharing within the currently establishing EPOS infrastructure. The built Pan-European Geological Data Infrastructure (EGDI), starting the pilot operation in the 2016, aims to develop interoperable, harmonized geoscientific information in multiple domains, based on the national knowledge and databases. To support this, the Czech Geological Survey together with the partner organizations makes an effort to prepare the national geoscience RI to be capable to fulfil the EGDI-compliant principles and needs.

The RI has been built to be sustainable and capable to provide thematically relevant metadata, discovery services, view services and download services in accord with the relevant international standards and rules defined by EPOS, EGDI and INSPIRE. The open and free access principles has been applied whenever possible.