Large Research Infrastructure CzechGeo/EPOS and Related Projects
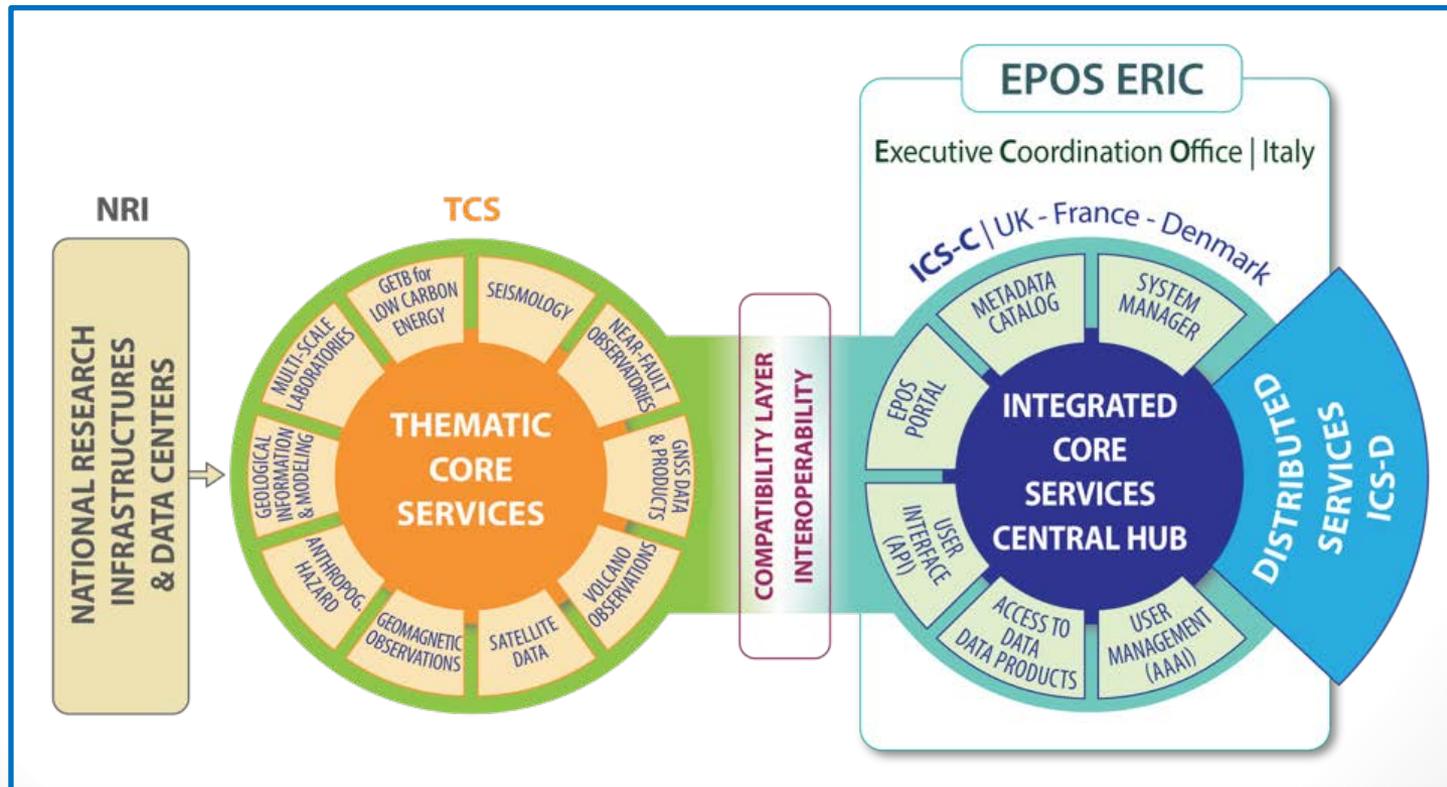
Pavel Hejda

Large Research Infrastructures – Europe

- In 2002 **ESFRI** (European Strategy Forum on Research Infrastructures) was established bringing together the EU Member States and defining the priorities for developing excellent research infrastructures of pan-European character and impact.

- EPOS (European Plate Observing System) was included into the ESFRI Roadmap in 2008.

- EPOS mission is to integrate the diverse and advanced European Research Infrastructures for solid Earth science, and build on new e-science opportunities to provide users with advanced services (visualization tools, advanced analysis, etc.)

- In 2009 the Institute of Geophysics was invited to join the initiative towards "preparation" of Preparatory Phase of the European Plate Observing System.

European Plate Observing System – EPOS

EPOS Preparatory Phase Project (2010 – 2014) – one partner per country
EPOS Implementation Phase Project (2015 – 2019) – 47 partners
(Research Institute of Geodesy, Topography and Cartography and
Institute of Geophysics CAS), 6 associate partners, 25 countries involved.

Large Research Infrastructures – CZ

- Specific legal instrument for financing research infrastructures of the Czech Republic was established in 2009. The Ministry of Education, Youth and Sports (MEYS) was entitled to be the national authority for funding the Large infrastructures for research, experimental development and innovation.

- The first National Roadmap was compiled in 2010.

- A special financial tool was necessary, as production, collection and distribution of data did not belong to activities financially supported within the scope of the new Methodology of Assessing Research.

- "LRI is a unique research facility, including its acquisition and related investment costs and the costs of ensuring its activities that are essential for comprehensive research and development with heavy financial and technological demands and which is approved by the Government of the Czech Republic and **established by one research organisation for the use of other research organisations**".

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State Budget for the R&D&I area

Institutional Budget

Methodology of Assessing Research
based on results

- article Jimp (Wos, SCOPUS, ERIH)
- article (selected national journals)
- proceedings
- books
- patents
- utility models
- prototypes
- certified methods
- software
- *no support for data collection or operation of large labs*

Targeted support

usually projects/grants limited in time (~3 years) without continuation

- Grant Agency
- Technology Agency
- …..
- …..
- funding of large research infrastructures; periodical assessment, national roadmap => higher stability
- ….

Large Research Infrastructures – CZ

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CzechGeo/EPOS 2010 – 2015

- Czech geoscience institutions responded in 2009 to the Call for Proposal and started integration of the scattered stations and networks into CzechGeo/EPOS – Distributed System of Permanent Observatory Measurements and Temporary Monitoring of Geophysical Fields in the Czech Republic – Development and Operation of the National Node of the Pan-European EPOS Project.

- Participating institutions
  - Institute of Geophysics of the CAS (IG CAS) – Hosting Institution
  - Masaryk University, Faculty of Sciences, Institute of Physics of the Earth (IPE MU)
  - Charles University in Prague
    - Faculty of the Mathematics and Physics, Department of Geophysics (FMP CU)
    - Faculty of Science, Institute of Hydrogeology, Engineering Geology and Applied Geophysics(FS CU)
  - Institute of Geonics of the CAS, Ostrava (IGN CAS)
  - Institute of Rock Structure and Mechanics of the CAS, Praha (IRSM CAS)
  - Research Institute of Geodesy, Topography and Cartography, Zdiby (RIGTC)

CzechGeo/EPOS 2016 – 2019

CzechGeo/EPOS – Distributed System of Permanent Observatory Measurements and Temporary Monitoring of Geophysical Fields

- Czech Geological Survey was invited to join the RI team (in accordance with the EPOS strategy)

The Infrastructure (about 20 networks and data centers) was divided into five Sections:

1. Section of Seismology (IG CAS)
2. Section of GNSS and Gravimetry (RIGTC)
3. Section of Crust Geodynamics (IRSM CAS)
4. Section of Geomagnetism (IG CAS)
5. Section of Geological and Geophysical Databases (CGS)

CzechGeo/EPOS 2016 – 2019

1. Section of Seismology
- 6 networks, over 70 stations
- pool of 63 mobile stations
- Near Fault Observatory planned in West Bohemia
- Seismological Software Centre

2. Section of GNSS and Gravimetry
- 3 permanent networks, 50 stations
- epoch-style observations on 60 sites
- Gravimetric Observatory
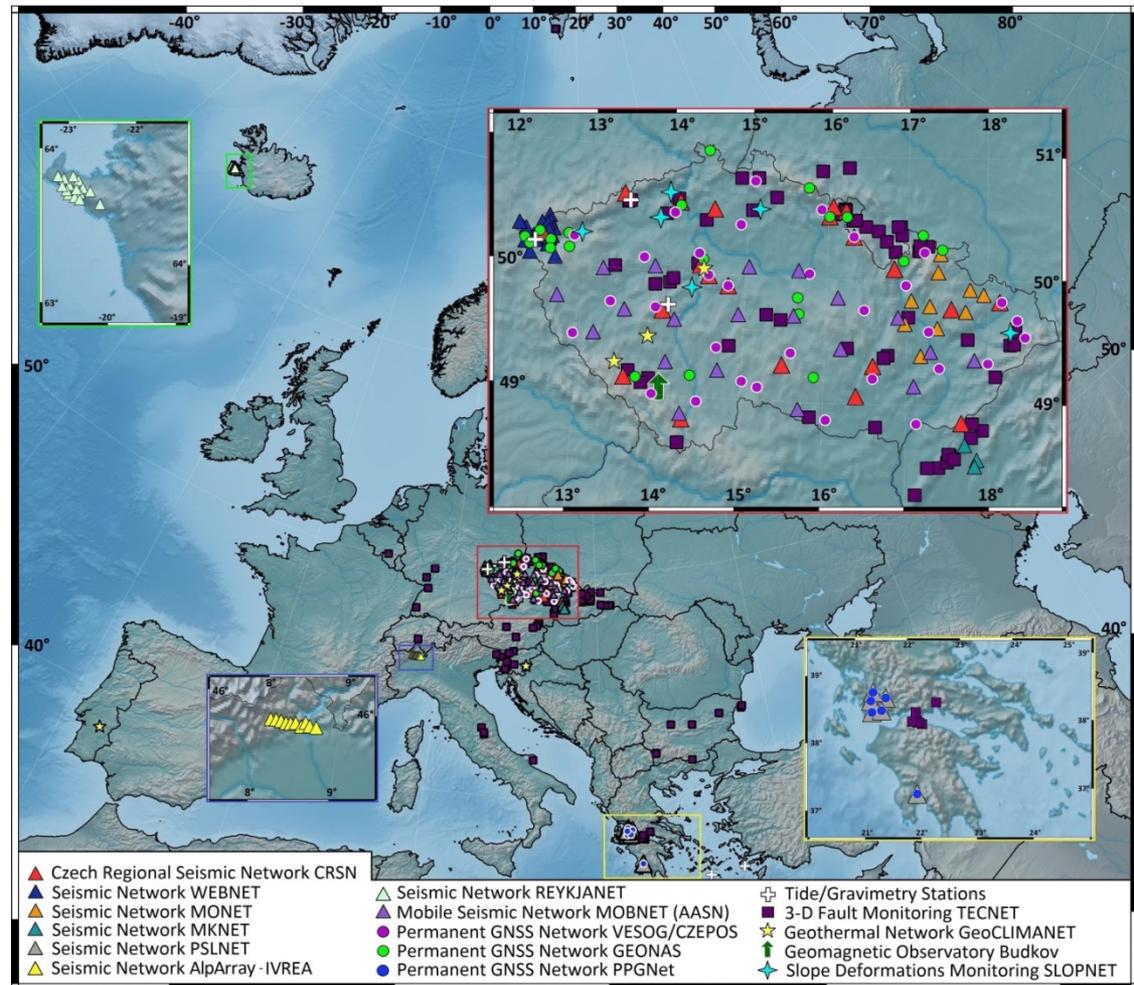- GOP Data, Analytic and Software Centre

3. Section of Crust Geodynamics
- monitoring of fault displacement (160 sites), slope deformation (10 sites), temperature profile in boreholes (5 sites)
- tide observatories

4. Section of Geomagnetism
- Geomagnetic Observatory
- geomagnetic and magnetotelluric mobile sets

5. Section of geological and geophysical databases

Czech Regional Seismic Network CRSN
Seismic Network WEBNET
Seismic Network MONET
Seismic Network MKNET
Seismic Network PSLNET
Seismic Network AlpArray - IVREA
Seismic Network REYKJANET
Mobile Seismic Network MOBNET (AASN)
Permanent GNSS Network VESOG/CZEPOS
Permanent GNSS Network GEONAS
Permanent GNSS Network PPGNet
Tide/Gravimetry Stations
3-D Fault Monitoring TECNET
Geothermal Network GeoCLIMANET
Geomagnetic Observatory Budkov
Slope Deformations Monitoring SLOPNET

Activities of all sections and or results based on their data will be presented in the next talks.

Section of Seismology

Czech Regional Seismic Network (CRSN) - the backbone of seismic observations (19 permanent broadband seismological stations operated by 6 institutions)

WEBNET (23 stations) - a basic tool for a detailed investigation of physical processes in the earthquake foci and the upper-crust structure in the West Bohemia/Vogtland earthquake-swarm region

MONET (10 stations) - seismological network monitoring the anomalously active region in northern Moravia and Silesia

MKNET (16 stations) in western Slovakia, operated in cooperation with Slovak Academy of Sciences

PSLNET (12 stations) - performed in cooperation with the University of Patras, Greece, as a part of the Hellenic seismic network

REYKJANET (15 stations) - newly established semipermanent network on Reykjanes Peninsula (Iceland), which is the onshore continuation of the mid-Atlantic ridge that separates the Euroasian and North American plates.

MOBNET – pool of more than 60 mobile stations employed mostly in large international seismic experiments.

Seismological Software Centre – more than 100 portable open-source public-domain computer programs related to seismic wave propagation, together with their hypertext documentation and demo data.

Daily seismograms of the CRSN and WEBNET
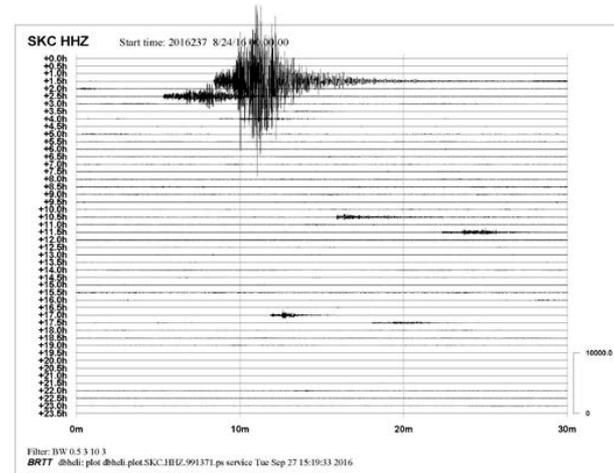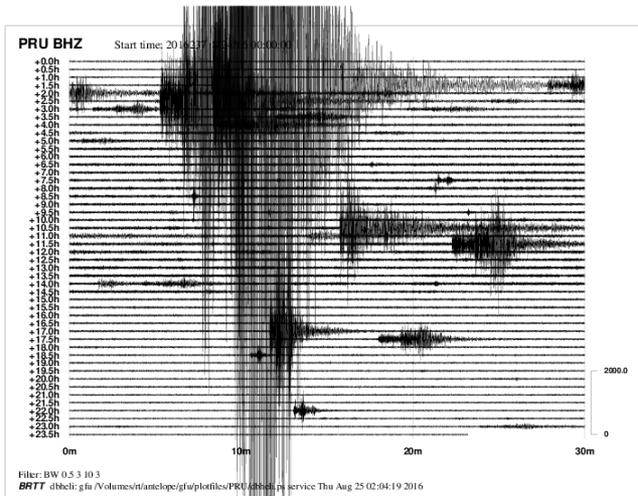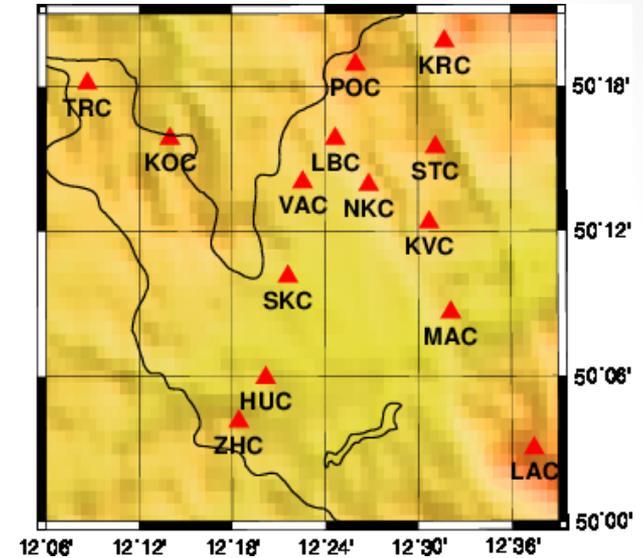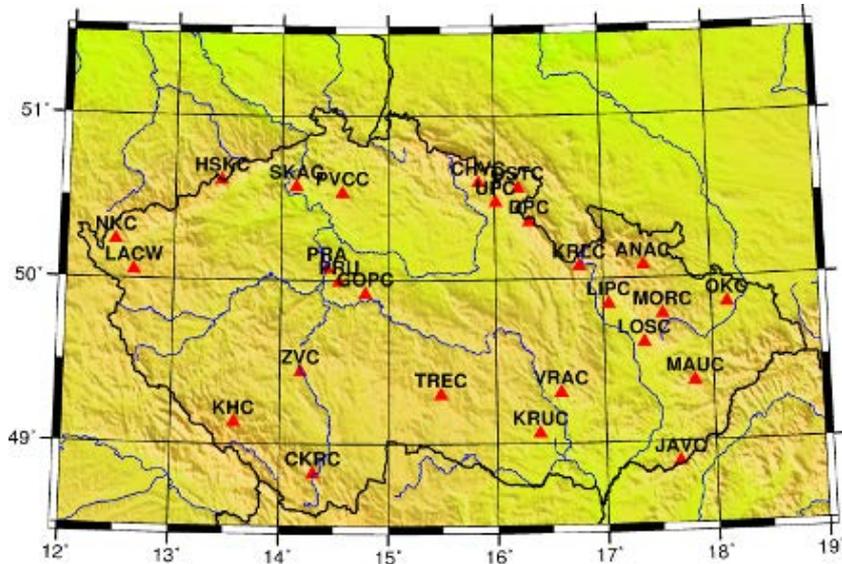
MONET – Northern Moravia and MKNET – Little Carpatians
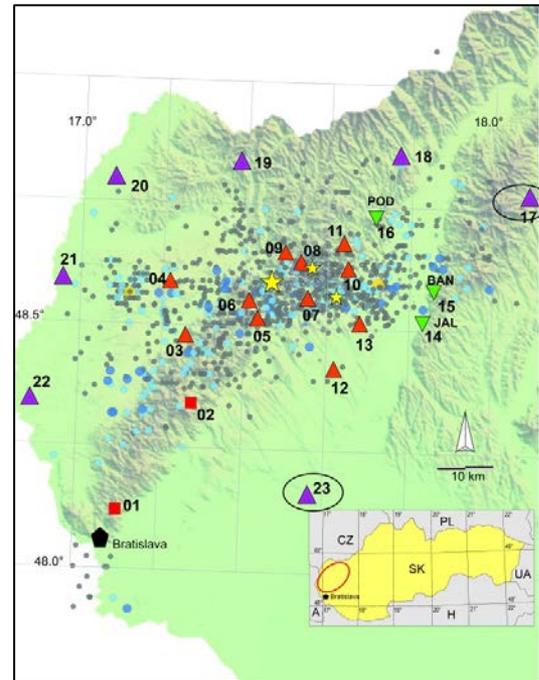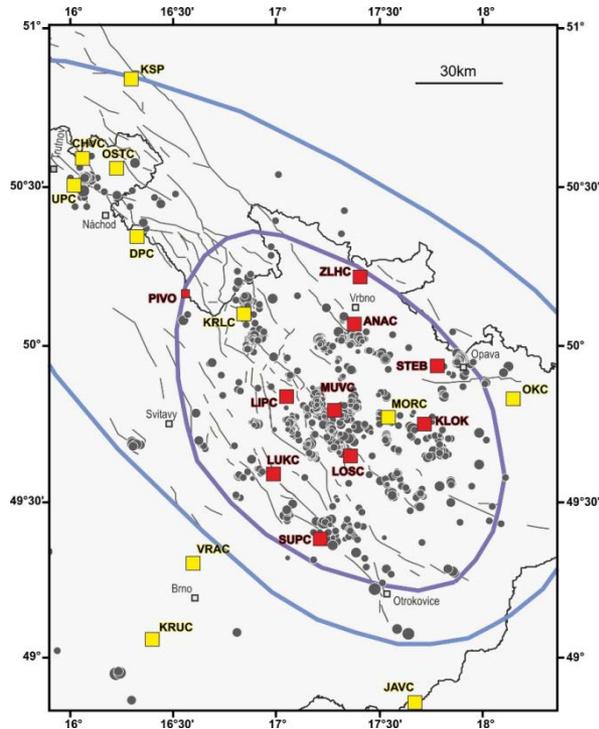
Characterized by occurence of moderate historical earthquakes, regionally anomalous rate of microseismicity and other expressions of geodynamic activity

The region of seismin activity, recently up to ML = 3. The historical 1906 earthquake of magnitude 5.7 is shown by yellow star.

Reykjanet - Reykjanes Peninsula Network
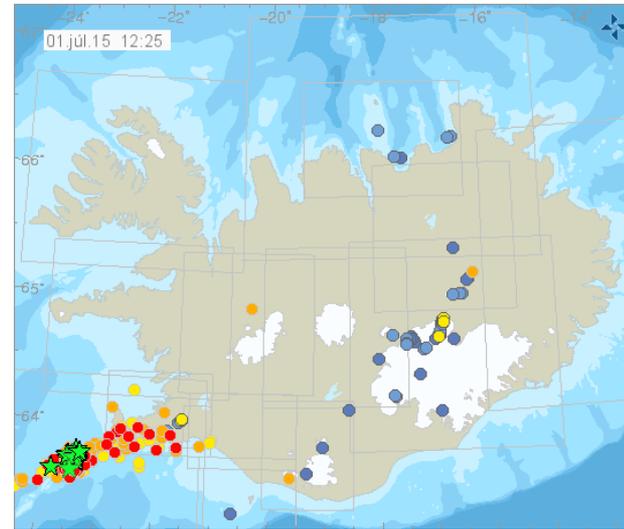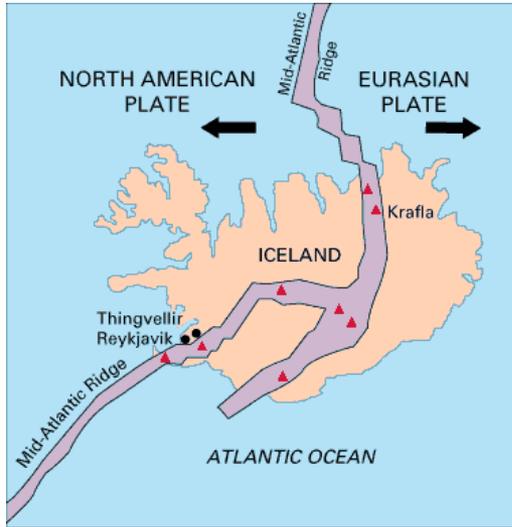
Reykjanes Peninsula - onshore continuation of the mid-Atlantic rift

swarm-like seismicity at a contact of lithospheric plates earthquake swarms – up to magnitude ML = 5+ Iceland

Expert and technical support: Iceland GeoSurvey – ÍSOR, Icelandic Meteorological Office - IMO

Section of GNSS and Gravimetry

GNSS (Global Navigation Satellite System) permanent networks
- **VESOG** (6 stations)
- **CZEPOS** (24 stations) – in cooperation with
- **GeoNAS** (18 stations)
- **PPGNet** (6 stations) in north-west part of Corinth Gulf (Greece)

Operational and data centre of GOP (Geodetic Observatory Pecný) ensures data distribution to the international community.

GNSS observations carried out periodically

- **WEBGEODYN** West Bohemia Geodynamic Network

- **HORNSUNDNET** on Svaldbard - monitoring of tectonics and the glacial-isostatic uplift

GREVOLCAN Greek Volcanic Islands network of GPS-gravity monitoring of active volcanoes on the islands of Nisyros and Thira

Gravimetric laboratory Pecný equipped with relative superconducting and absolute gravimeters, contributed to the Global Geodynamic Project (GGP).

CzechGeo – GNSS national portal

Data: CZEPOS (24), VESOG (6), GeoNAS (18) **Greece:** PPGNet (6)

(also seismic stations PSLNET, collaboration with Czech and Greece partners)

Analysis: Near real-time troposphere monitoring → GNSS-Meteorology
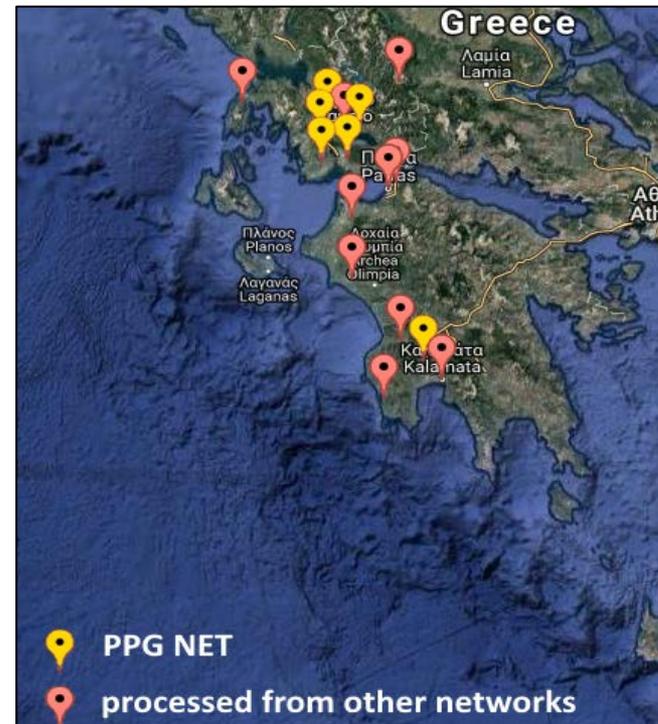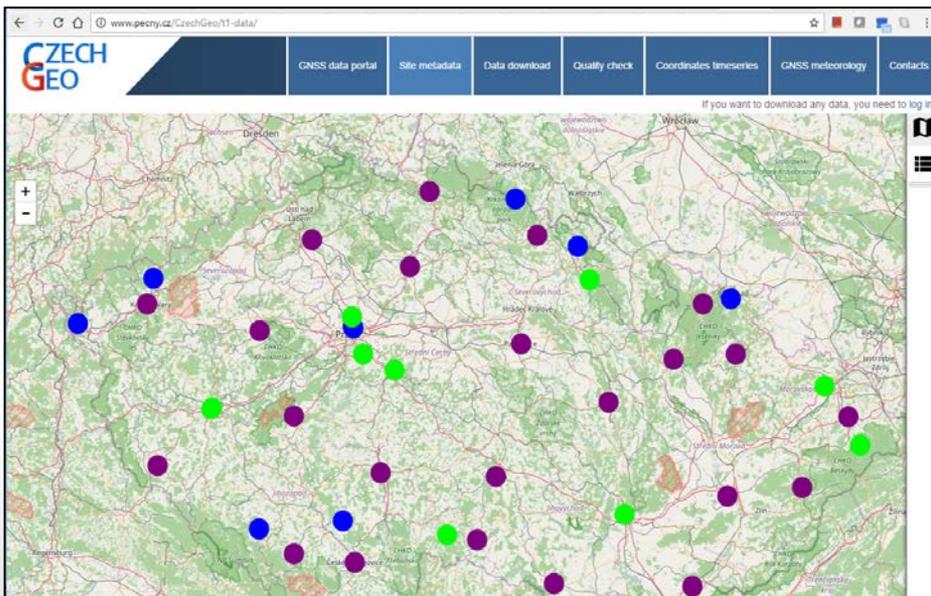
Analysis: Czech solution → EUREF Densification → EPOS dense velocity field

Analysis: Homogeneous re-analysis → EUREF → Terrestrial Reference Frame

http://www.pecny.cz/CzechGeo   **(GNSS data)**

http://www.czechgeo.cz   **(national portal)**

EUMETNET
The Network of European Meteorological Services

euref

PPG NET

processed from other networks

16

EPOS-IP – Implementation Phase

WP10: GNSS Data and Products

→ Responsible for implementation of GNSS Thematic Core Service

→ Partners + Associated partners: 10+3 (Leader: R. Fernandes)

Tasks:

1 – Strategic activities and governance (coordinator C. Bruyninx)

2 – Interaction with GNSS community (coordinator R. Fernandes)

3 – Interoperability with EPOS ICS (coordinator P. Crocker)

4 – GNSS data dissemination (coordinator J. Dousa)

5 – GNSS data gateway (coordinator A. Walpersdorf)

6 – GNSS products (coordinator A. Socquet)

7 – GNSS product gateway (coordinator M. Bos)

GOP main contribution to Task 4:

→ Development of system for seamless data dissemination

→ GNSS data quality control (G-Nut/Anubis software)

Task 4: GNSS Data dissemination

GLASS – GNSS Linkage Advanced Software System
→ software for a seamless access to GNSS data over Europe
→ concept of virtualization (meta data dissemination)
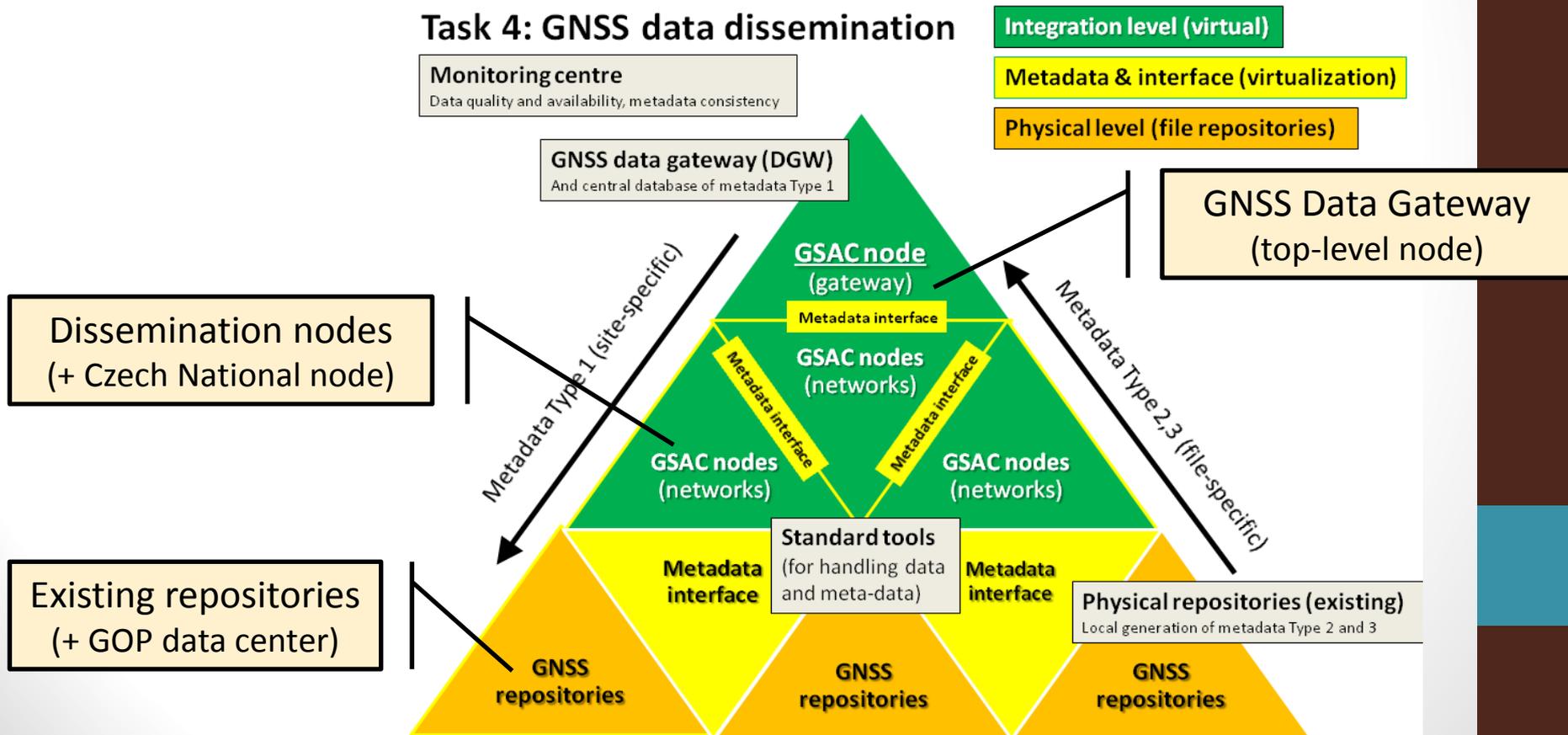
Task 4: GNSS Quality Control

Motto: *Scientific data collection is an irreversible process that needs to be controlled and observed data properly qualified and quantified*

Goals of GNSS data quality control

- Data providers – benefit of early (on-site) data qualification
- Data users – easier data selection, data and metadata quality
- Network coordinators – optimal control over data dissemination including metadata, modernization monitoring etc.

Data quality control

- quantitative – as possible as algorithm-independent
- qualitative – necessarilly algorithm-dependent
- complex – optimally via data processing

G-Nut/Anubis software

Free software developed at GOP for multi-GNSS data quality control

➔ Main GOP contribution to EPOS Thematic Core Service for GNSS

http://software.pecny.cz/anubis

Main software functionality:

- Summary statistics over key parameters
- Data availability – data gaps, small pieces
- Observation-specific statistics
- Phase processing (cycle slips, clock jumps)
- Azimuth/elevation information for sky plots
- Pseudo-range multipath and signal noise
- Standard positioning, repeatability, GDOP
- Consolidation of navigation messages
- Format and metadata control

GOP7 - Satellite sky tracks (azimuth-elevation plot)

Václavovic P, Douša J (2016), **G-Nut/Anubis - open-source tool for multi-GNSS data monitoring**, *IAG Symposium Series, Springer, Vol. 143*
Václavovic P, Douša J, Gyori G (2013) **G-Nut software library - state of development and first results**, *Acta Geodyn Geomater*
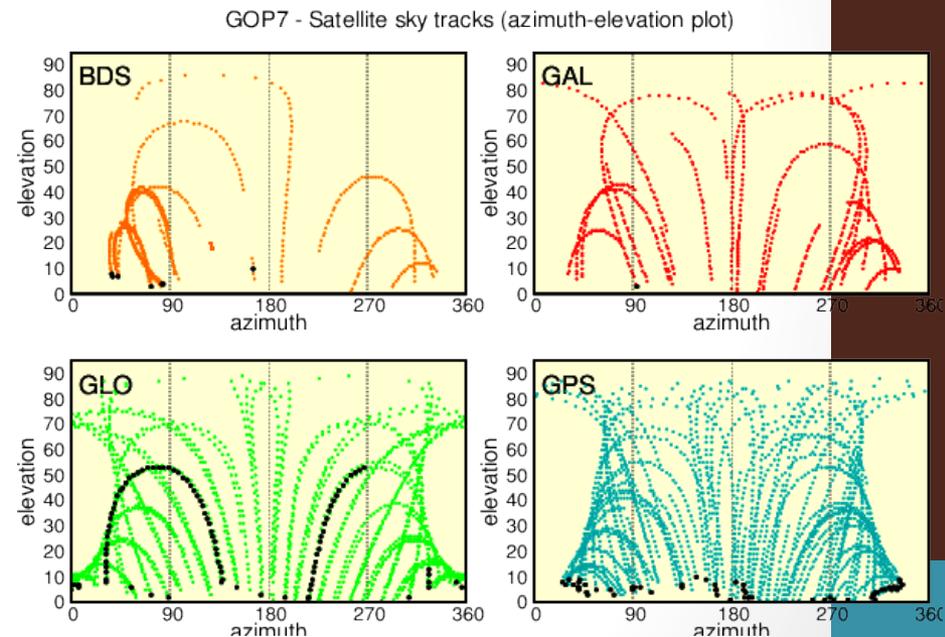
Section of Crust Geodynamics

Earth Tide observations

- observatories Příbram and Skalná

- tiltmeter-seismograph stations Jezeří 1 and Jezeří 2 aimed at monitoring the slopes of Krušné Hory (Ore Mts) above an extensive open-pit lignite mine (support by private company)

SLOPENET – a long-term monitoring of the slope deformations and timely warning against the slope sliding.

TECNET – monitoring 3-D fault active displacements (about 150 stations) situated on tectonic faults in 12 European countries

GeoCLIMANET – Geothermal-climate-change network of stations in the Czech Republic, Slovenia and Portugal

NFOWEB – Near Fault Observatory planned in West Bohemia

Tiltmeter-seismograph stations Jezeří

monitoring the slopes of Krušné Hory (Ore Mts) above an extensive open-pit lignite mine (support by private company)

Tiltmeter-seismograph stations Jezeří

Giant landslide from January 2012

SLOPENET long-term slope deformations monitoring

engineering geological gauges

M — rod dilatometer

M — steel tape extensometer

M — TM-71 crack gauge

H — induction dilatometer

D — automatic extensometer

H — automatic TM-71

geodetic surveying

Q — levelling survey

M — total station survey

Q — TLS monitoring

special sensors & devices

M — water level gauge

H — soil humidity monitoring

M — time-lapse ERT

10 — automatic water level gauge

10 — automatic meteostation

Parade of methods

TecNet – 3D monitoring of fault slips

monitoring within caves
monitoring within rockwalls
monitoring within galleries

Precise measurements of tectonic creep, using a series of crack gauges known as TM-71s. More than 140 gauges are currently installed on tectonic faults within the Czech Republic, Slovakia, Slovenia and across Europe. In addition, more distal sites are located in Asia and South America.

Section of Geomagnetism

Budkov Geomagnetic Observatory – continuous geomagnetic observations, data distributed via INTERMAGNET network.

Mobile geomagnetic set is used for repeat station measurements and magnetic survey.

Mobile magnetotelluric set is used for the estimation of electric conductivity along selected profiles.
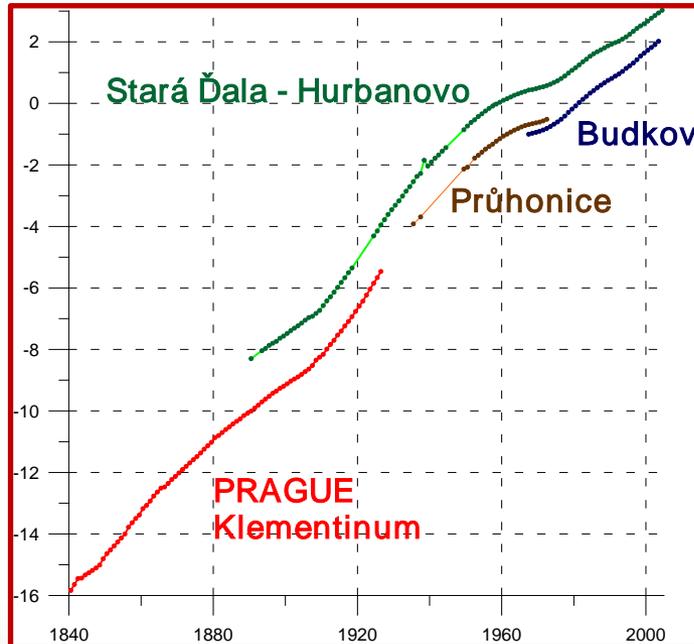
Declination in Prague, Budkov and Hurbanovo since 1840 demonstrate the importance of long-time series of observations for any Earth Science research.

Section of Geological and Geophysical Databases

The CGS-DRI (Czech Geological Survey Data Research Infrastructure) will provide effective access to geological, geophysical and related applied data with the use of up-to-date technologies of both European and global standards.

The geological and geophysics databases are of common interest of the entire geoscience community. Four presentations in the next hour will be devoted to these problems:

- Section of Geological and Geophysical Databases: the main activities in 2017

- Geophysical data and metadata and INSPIRE

- Inventory of geophysical data in CR

- Web map application to access seismic data

Organizational scheme

IG CAS (Main hosting institution)

```
Committee for large RI ── Chair ── Board of Directors ── International Scientific Board
                             │
                        Technical Committee
```

1. Section of Seismology

- Czech Regional Seismic Network - CRSN
- West Bohemian Local Seis. Network – WEBNET
- North Moravia Local Seis. Network - MONET
- Icelandic Local Seismic Network – REYKJANET
- Little Carpathians Local Seis. Network - MKNET
- Patras Seismic Network - PSLNET
- Mobile Seismic Network – MOBNET
- Near Fault Observatory planned in West Bohemia – NFOWEB
- Seismological Software Centre

2. Section of GNSS and Gravimetry

- Network of Permanent GNSS Stations - VESOG
- Geodynamic GNSS Network - GEONAS
- Network of Permanent GNSS Stations in Greece - PPGNet
- West Bohemia Geodynamic Observatory - WEBGEODYN
- Greek Volcanic Islands Monitoring- GREVOLCAN
- Gravimetric Station Pecny - GSP
- GOP Data, Analytic and software Centre

3. Section of Crust Geodynamics

- Monitoring 3-D Fault Active Displacement - TECNET
- Long-term Monitoring of the Slope Deformations – SLOPNET
- Czech Earth Tide Observatories – CZET
- Geothermal Climate Change Network – GeoCLIMANET

4. Section of Geomagnetism

- Geomagnetic Observatory Budkov and Mobile Equipment - GEOMAG
- Mobile Magnetotelluric Set - MTMOB

5. Section of Geological and Geophysical Databases

- Czech Geological Survey Data Research Infrastructure – CGS-DRI

Projects to support the infrastructure

2010 – 2015, LM2010008, CzechGeo/EPOS, MEYS (state budget)

- investments and non-investments to support operation of the infrastructure
- no support of research activities

2016 – 2019, LM2015079, CzechGeo/EPOS, MEYS (state budget)

- non-investments to support operation of the infrastructure
- no support of research activities

2017 – 2020, CZ.02.1.01/0.0/0.0/16_013/0001800, CzechGeo/EPOS-Sci, OP Research, Development and Education

1. Project management
2. Modernization of observatory infrastructure - investments
3. Performance of research programs

LM2010008, 2010 – 2015

	operational costs	personal costs	overhead	non-investments total	investments	Total
IG CAS	2 500	3 143	458	6 101	1 500	7 601
IRSM CAS	2 200	3 101	400	5 701	1 400	7 101
IGN CAS	70	414	20	504		504
IP MU	250	775	150	1 175	400	1 575
FMP CU	300	775	100	1 175		1 175
FS CU	150	216	92	458		458
RIGTC	700	775	100	1 575		1 575
Total	6 170	9 199	1 320	16 689	3 300	19 989

Yearly budget (in ths CZK)

19 989 000 CZK is approx. 740 000 €

LM2015079, 2016–2019

	personal costs	membership fees in intl. organizations	operational costs incl. overhead	investments	Total
IG CAS	2 797	720	2 422		5 939
IRSM CAS	2 484	50	2 087		4 621
IGN CAS	261		62		323
IP MU	907	25	349		1281
FMP CU	838		398		1236
FS CU	248		186		434
RIGTC	2 012		3 227		5 239
CGS	2 050	220	2 083		4 353
Total	11 597	1 015	10 814		23 426

Yearly budget (in ths CZK) for years 2016 and 2017

CzechGeo/EPOS–Sci, 2017 – 2020

	research activities	administrative	non-investments total	investments	Total
IG CAS	6 642	3 418	10 060	* 19 150	29 210
IRSM CAS	2 637	570	3 207	6 400	9 607
IGN CAS	440	160	600	1 200	1 800
IP MU	449	162	611	1 220	1 831
FS CU	2 819	1 133	3 952	8 900	12 852
RIGTC	1 166	233	1 399	2 800	4 199
CGS	1 266	315	1 581	3 150	4 731
Total	15 418	5 992	21 410	42 820	64 230

* including in-kind contribution (5% of the total investments)

CzechGeo/EPOS–Sci

- Research programs
  1. Investigation of intraplate seismicity on the territory of the Czech Republic and in close surroundings (SEIS)
  2. Structure of continental lithosphere and mapping LAB boundary in a broader surroundings of the Alps (DeepAlps)
  3. Development of infrastructure in the field of GNSS, gravimetry and Earth tides (GNSSgrav)
  4. Geodynamics
  5. Geological and Geophysical Data Infrastructure to Support Research

Common characteristics criteria of large research infrastructures

- **Uniqueness**

- **Open access**

- **National impact**

- **International overlap**

- **Excellence**

Specification of the criteria fits rather to large labs than to observational infrastructures and must be partly accommodated to our needs

Strong and week points of CzechGeo/EPOS with respect to these criteria are discussed on the next slides

Uniqueness

Large research infrastructure represents an exceptional and unique facility gathering critical mass of technological devices and knowledge expertise necessary for performing world-class research, technology development and innovation.

CzechGeo/EPOS integrates nearly all observational activities related to the solid Earth carried out by the Czech geoscience research and educational institutions.

It is indispensable for any geoscience research on the territory of the Czech Republic.

The data are frequently used by the worldwide community, usually in combination with data from neighbouring countries/regions or even with data from worldwide network in case of global studies.

Open access

Large research infrastructure is operated by a research organisation for the use of other entities from the research community and provides external users with services on basis of tenders evaluated by experts.

The observatory infrastructure is not designed for use by visiting scientists.

Open access

Access to data

Open: CRSN, GEOMAG, Seismological Software Centre (registration), CARBONET, VESOG GNSS (not all stations), GOP data, Gravimetric station Pecný, CGS-DRI-partly

Open on request: PSLNET, PPGNet, WEBNET (location of seismic events and life seismograms available on-line), MONET, NFOWEB, CZET Skalná, GeoCLIMANET, TECNET, MKNET, SLOPENET, CGS-DRI-partly

Embargoed for a limited time: REYKJANET, MOBNET, CZET Jezeří (funded by a commercial partner), CZEPOS, CGS-DRI-partly.

Data providers or data centre operators may apply regulations for commercial use of data (typically CC 4.0 BY NC)

National impact

Large research infrastructure has at least national importance, significance and impact within the Czech Republic.

CzechGeo/EPOS

- is indispensable for any geoscience research on the territory of the Czech Republic
- used in numerous research papers
- used in applications
- frequently used in Master and PhD theses
- students are also involved in data acquisition and processing

International overlap

Large research infrastructure is inter-linked with other research infrastructures within macro-regional, pan-European or global networks having significant international impact.

- international cooperation in operation of several networks (PSLNET, PPGNet – Greece, Reykjanet – Iceland, TECNET – stations in 15 countries)

- participation in large international research projects (recently AlpArray

- participation in EPOS (CzechGeo/EPOS was the first national consortium among EPOS countries established in 2010)

- contributing to global and regional data centres

International overlap

- **World or regional thematic data centres**
- **Seismic data**: ORFEUS (Observatories and Research Facilities for European Seismology) http://www.orfeus-eu.org/, EMSC (The European-Mediterranean Seismological Centre) http://www.emsc-csem.org, Geofon http://geofon.gfz-potsdam.de, IRIS http://ds.iris.edu/ds/ , International Seismological Centre http://www.isc.ac.uk/, NOAA Earth Information System https://www.esrl.noaa.gov/neis/
- **Data from GNSS stations**: EPN (EUREF Permanent Network) http://epncb.oma.be) and IGS (International GNSS Service http://www.igs.org). Freely accessible at http://epncb.oma.be/ftp/center/data/BKGE.RDC or at ftp://igs.esgn.ign.fr.
- **Gravimetric data:** IGETS (International Geodynamics and Earth Tide Service) http://igets.u-strasbg.fr)
- **Geomagnetic data**: INTERMAGNET (International Real-time Magnetic Observatory Network) http://www.intermagnet.org/index-eng.php, World Data Centre for Geomagnetism http://www.wdc.bgs.ac.uk/

Excellence

R&D results reached by using the large research infrastructure respond to socio-economic challenges and are of high-quality and highly relevant from the "value for money" point of view

Societal impact (examples)

- data from seismology monitoring are closely linked to seismic hazard at nuclear power plants and nuclear waste repositories
- SLOPENET network contribute to the security of infrastructures in the areas exposed to slope deformation
- CZET monitors slope stability around deep open pit mine
- WEBNET is cooperating with the company responsible for safety of water dams and reservoirs as well as with local authorities in case of intensive seismic swarms.
- seismic records of station VRAC are provided to IDC CTBTO in Vienna as a part of the international monitoring of nuclear tests

However, not highly relevant from the "value for money" point of view

Comment: Evaluation scale

The Excellence criterion corresponds to the Scale for 2017 evaluation. We passed the evaluation with grade 3.

2) The RI's quality and potential enables it to contribute to provision of services in the given sphere. However, the RI has only minor user community, limited importance and thus also limited relevance for the future development of research and innovation environment of the Czech Republic.

3) The RI's quality and potential enable good quality services to be provided in the given sphere. The RI shows significant usage possibilities and is relevant for the future development of research and innovation environment of the Czech Republic. **Nevertheless, the RI is not a crucial one for strengthening the competitiveness of the Czech Republic.**

4) The RI shows very high quality and high potential, but doesn´t reach the top-class standards of international excellence with respect to the uniqueness, originality, importance and impact on the user community. However, the RI is still highly relevant for the future development of research and innovation environment of the Czech Republic, **substantially contributing to strengthen the competitiveness of the Czech Republic**.

5) The RI is of excellent quality compared to the leading actors worldwide with respect to its uniqueness, originality, importance and impact on the user community. The RI is highly relevant for the future development of research and innovation environment of the Czech Republic as well as **inevitable for strengthening the competitiveness of the Czech Republic.**

Priorities of the next period

Modernization of the infrastructure according to the CzechGeo/EPOS-Sci project

To broaden open access to networks/data available on-line

Catalogue of existing data sources, metadata, identification of data for INSPIRE

Upgrade of web with more information for researchers, stakeholders and general public.