

Geophysical monitoring conducted at IG PAS

Centrum Badań Ziemi i Planet



Institute of Geophysics
Polish Academy of Sciences

Mariusz Majdański

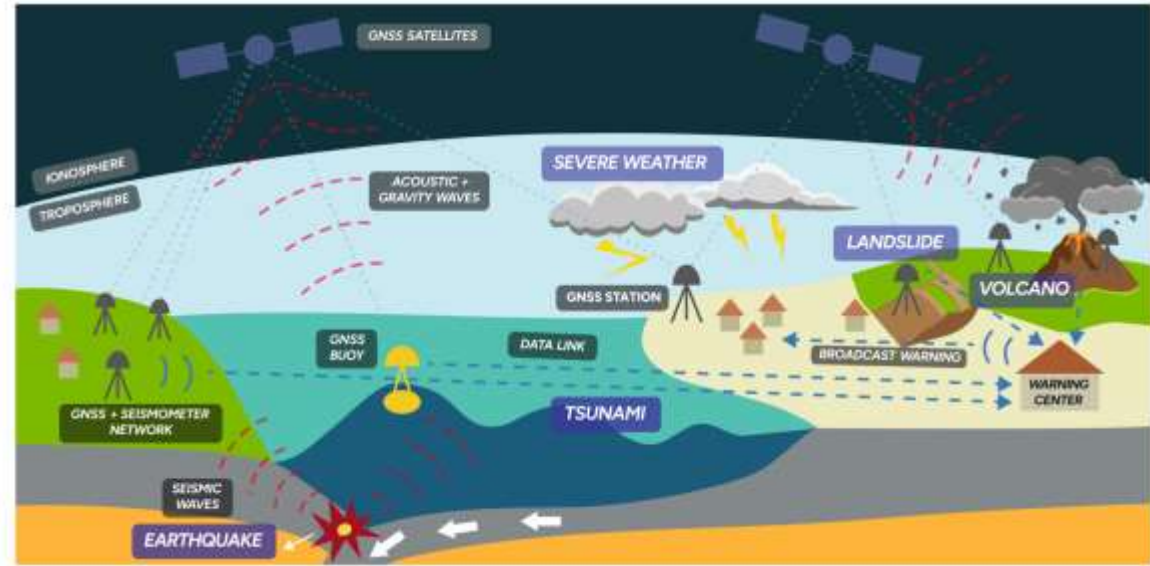
Sopot, 28 Nov 2024

Monitoring of global geophysical fields

In general **Geophysical fields** contain:

- Seismology (earthquakes, tsunami)
- Satellite navigation (GNSS)
- Earth's Magnetic field
- Atmospheric measurements used for basic research

In details also various measurements related to geohazard and risk mitigation, exploration and exploitation of georesources, impact of climate change, etc.



By Roland Hohensinn & Mirjam Jobst

IG PAS monitoring

Institute of Geophysics PAS is the only institution in Poland that conducts monitoring of global geophysical fields in terms of:

- Seismology
- Geomagnetism
- Selected elements of atmospheric physics



Central Observatory in Belsk

The Institute manages **observatories and stations in Poland** and in the **Polish Polar Station Hornsund** in the Spitsbergen archipelago.

The observatories in **Belsk**, **Świder**, **Racibórz**, **Książ** and on the **Hel Peninsula** and the permanent seismic stations in **Suwałki**, **Niedzica**, **Góra Klasztorna** and **Kalwaria Pałacowa** register geophysical phenomena, continuously providing data to the World Data Centres.

Seismological monitoring in Poland – Dept. Of Seismology:

Open networks:

Natural and anthropogenic activity monitoring in **global** and **regional** scale – ***Polish Seismological Network***
(the backbone network)

The monitoring focus on anthropogenic seismicity only:

- Legnica Głogów Copper District – ***LUMINEOS***

- Reservoir seismic activity in Pieniny mountains – ***SENTINELS***

Mobile network MOZEP – e.g. used to monitor seismicity in the vicinity of shale gas production near Wysin, Poland.

70 SP seismometers 8s – 160Hz
30 SP seismometers 1 – 100Hz
20 BB seismometers 120s – 50Hz
(including posthole devices)
more than 10 strong motion
sensors DC – 200Hz

Other networks:

Involvement in monitoring of potential nuclear power plants in Poland – 4 different sites

Monitoring of area of Bogdanka underground coal mine – monitoring stopped in December, 2023

Monitoring of natural seismicity in Poland – together with Polish Geological Survey.

Seismic station on Arctowski Antarctic Base – together with IBB PAS

Involvement in seismological monitoring of the water reservoir in Vietnam, in collaboration with VAST

Paper:

Rudziński, Ł., S. Lasocki, B. Orlecka-Sikora, J. Wiszniowski, D. Olszewska, J. Kokowski, and J. Mirek (2021). *Integrating Data under the European Plate Observing System from the Regional and Selected Local Seismic Networks in Poland*, Seismol. Res. Lett. 92, 1717–1725, doi: 10.1785/0220200354,

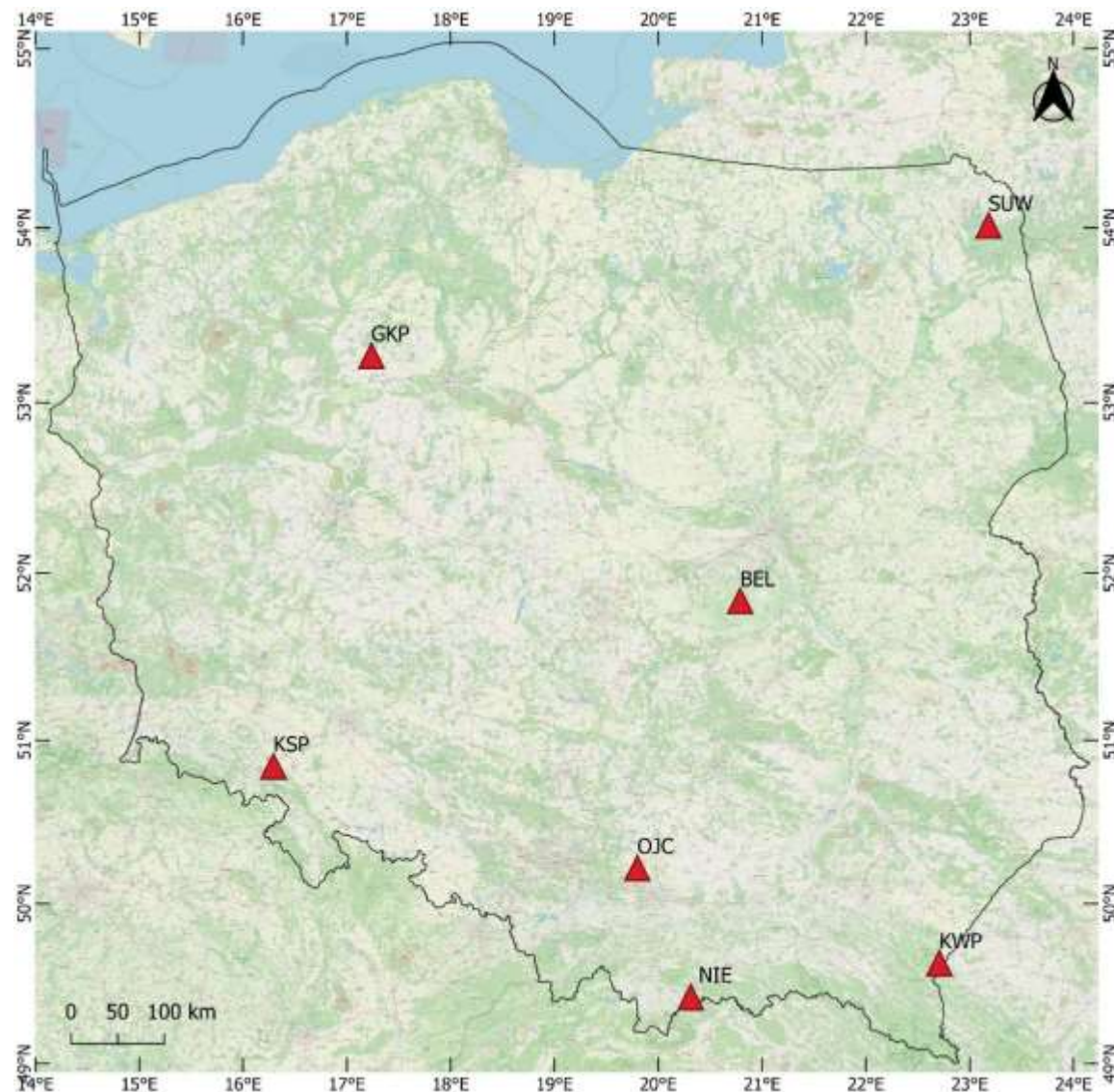
PLSN – Polish Seismological Network

- 7 broad – band stations in Poland +
- 1 broad – band station in Hornsund (Spitsbergen, Arctica)
- 1 broad – band station in King George Island (south Shetland Island, Antarctica) - ARCT

STS2 seismometers
update with **EDR-209** recorders

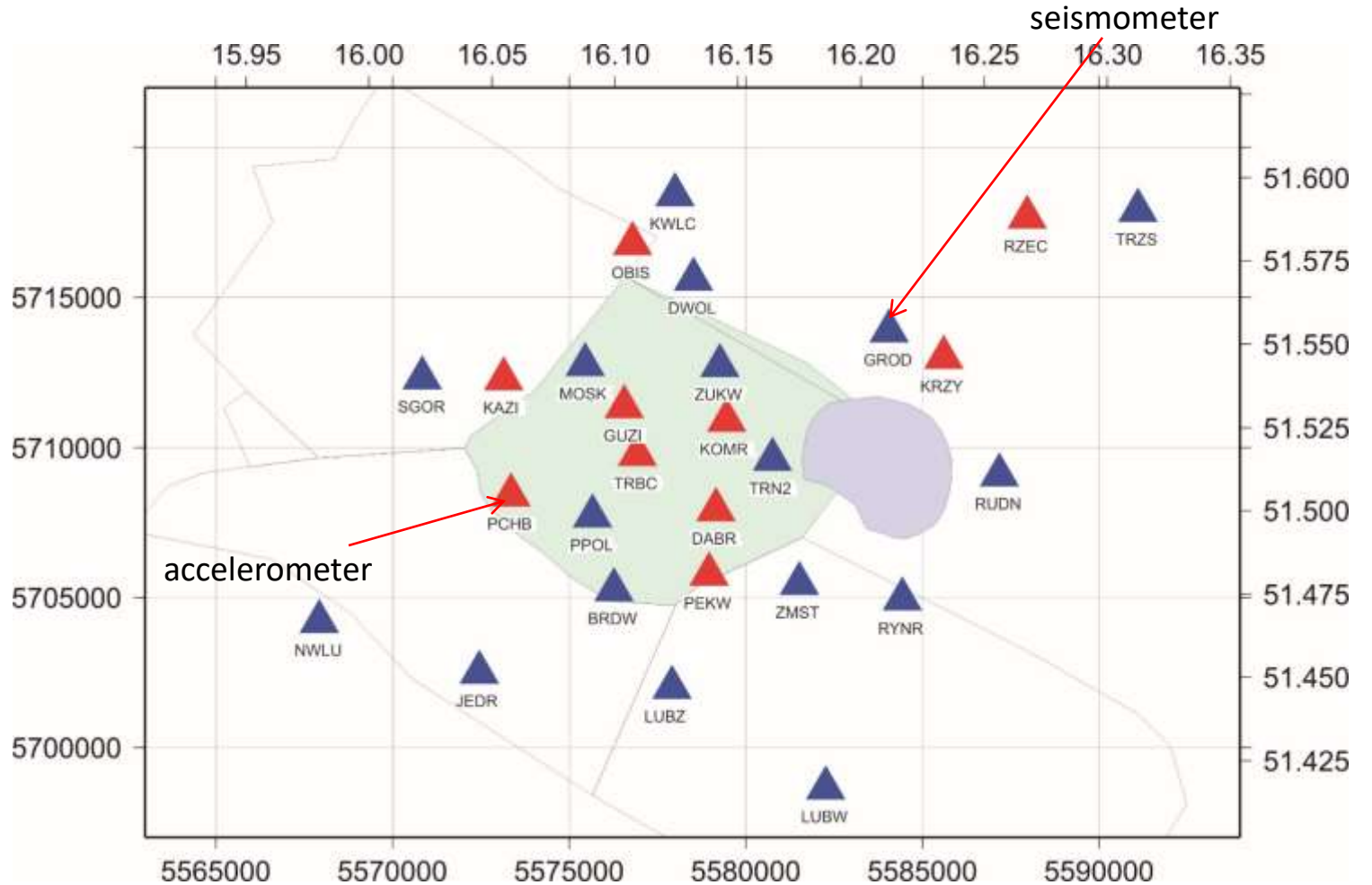
Nanometrics PH120s - **ARCT**

Rudziński, Ł., S. Lasocki,
B. Orlecka-Sikora, J.
Wiszniewski, D.
Olszewska, J. Kokowski,
and J. Mirek (2021).



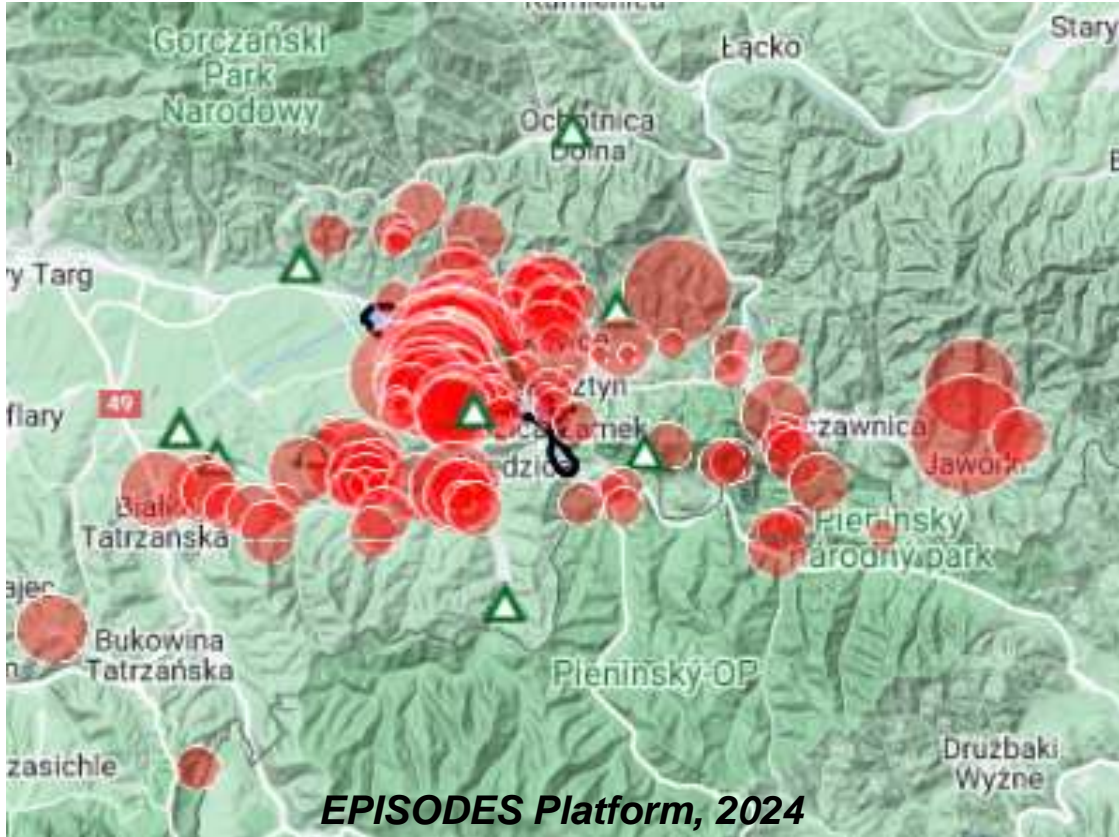
LUMINEOS

Started in 2013 with 4 stations, updated in 2015-16 with 25 stations and in 2023 with 4 broad-band stations



SENTINELS

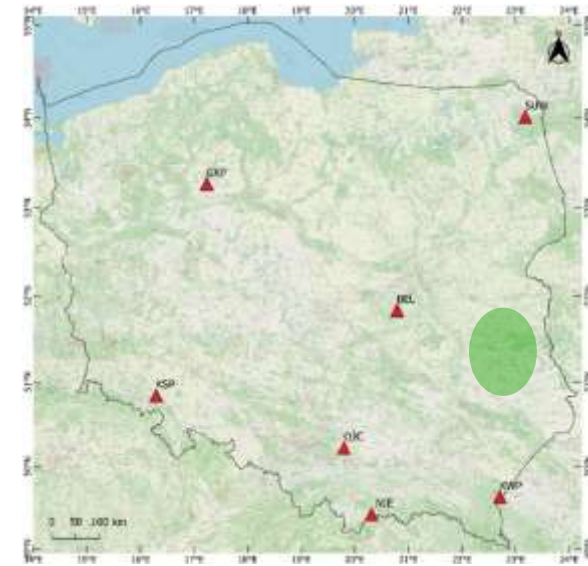
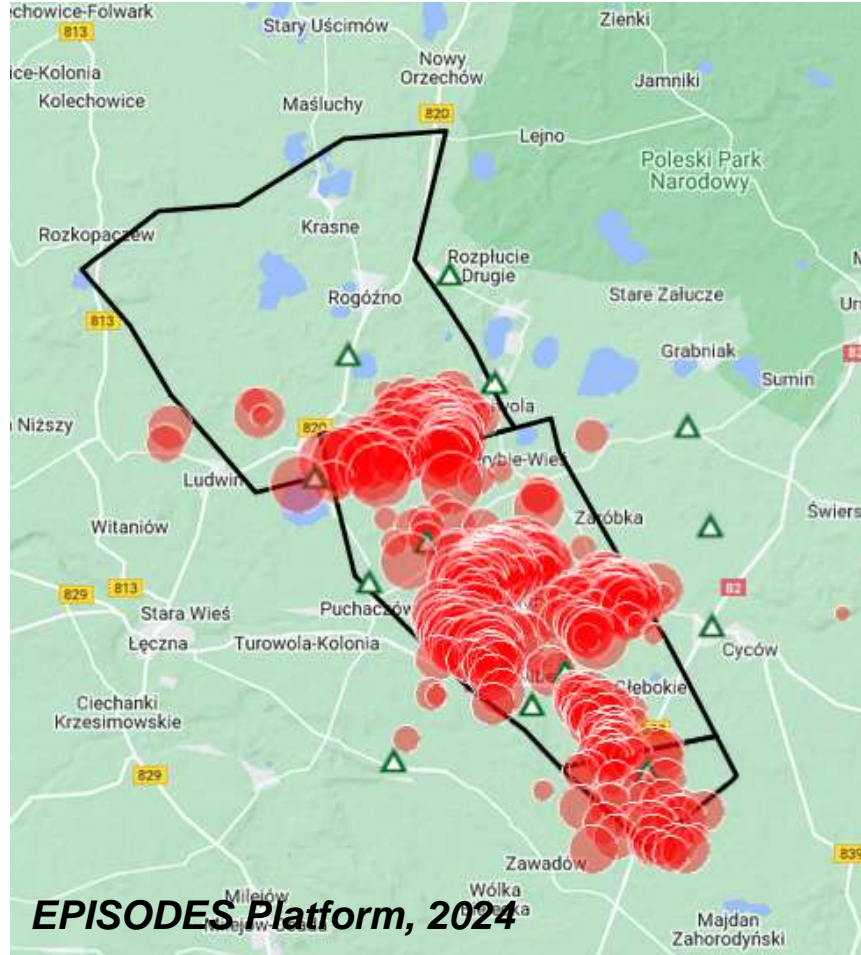
8 sites for seismometers VE-53BB



around 50 events with **M** up to 3.2

BOIS Bogdanka coal mine

12 sites for seismometers VE-53BB



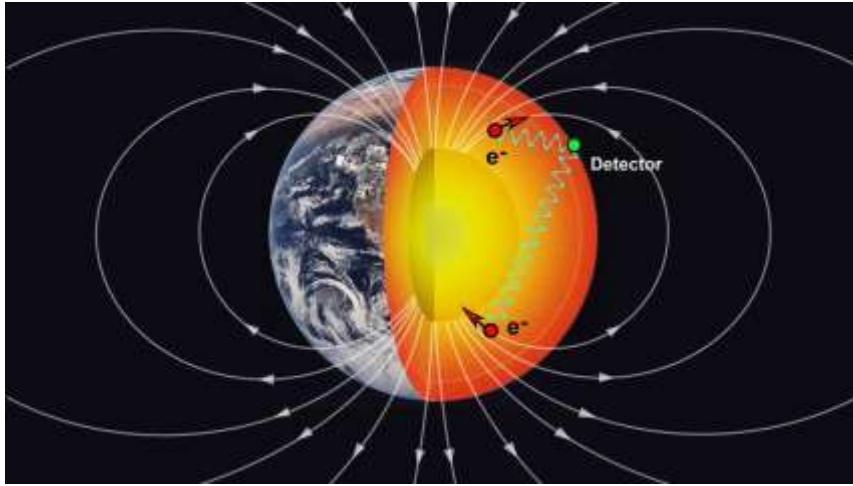
relatively new activity with **M** up to **3.7**

Our data and metadata are shared with:

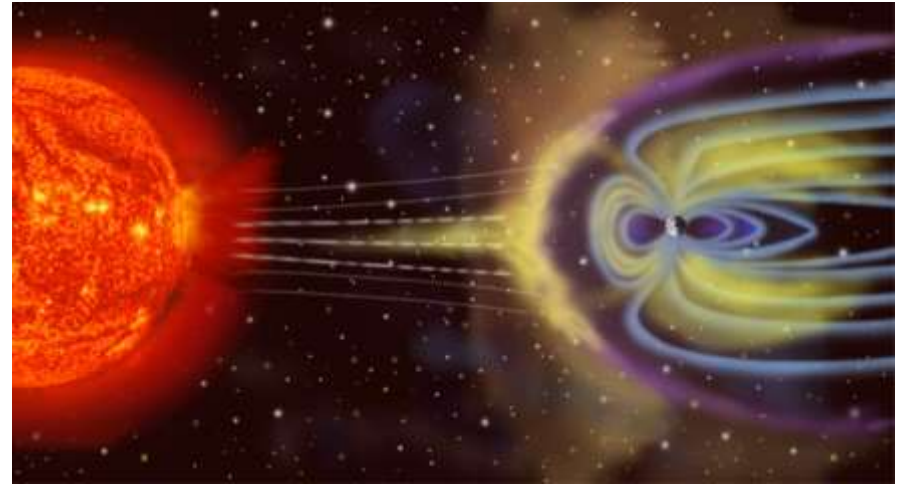
- **EPOS** Thematic **C**ore **S**ervice **A**nthropogenic **H**azards (TCS AH)
- **E**uropean – **M**editerranean **S**eismological **C**entre: EMSC
- **I**nternational **S**eismological **C**entre (ISC)
- ORFEUS – EIDA
- NORSAR (HSPB - Hornsund)



Earth's magnetic field



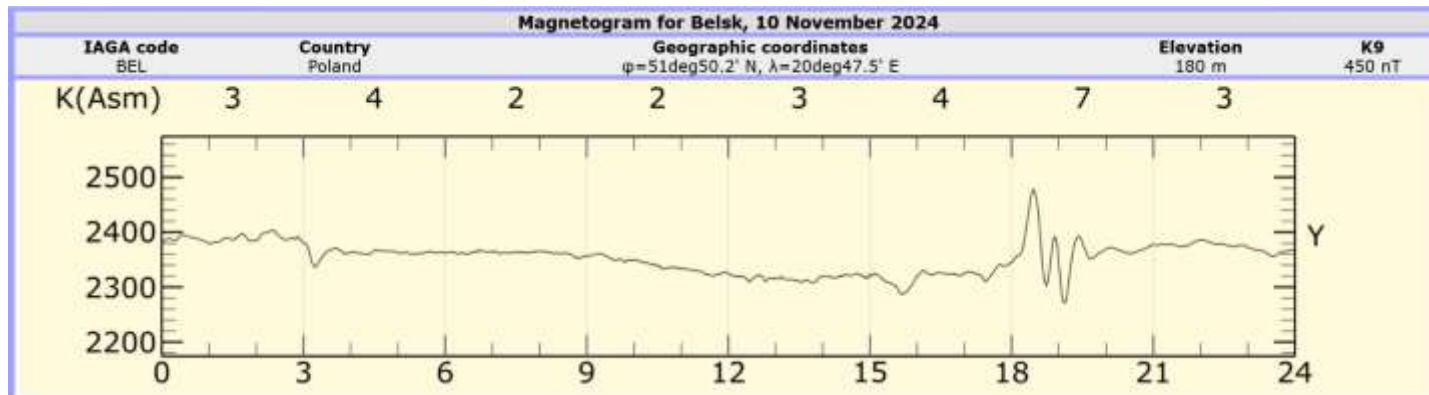
Earth's magnetic field generated in the outer core



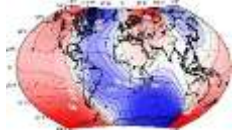
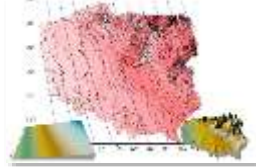

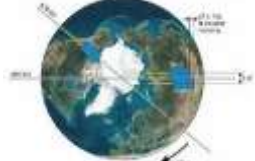
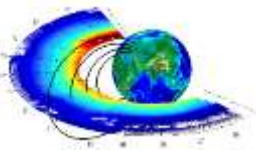

Influence of the Sun on Earth's magnetic field
(max. 5% disturbance during major storms)

The Geoelectromagnetic Laboratory in Belsk

- ❑ Several times a week, manual measurements are taken, mainly related to the changes in Earth's magnetic field over time. The accuracy of declination measurements is 5 arc seconds, which is about 500 times more precise than even with a high-precision compass.
- ❑ Automatic recording of the magnetic field every 1 sec, these measurements are mainly related to the study of the magnetosphere and ionosphere.
- ❑ Public real-time sharing of magnetic data
 - in graphical form to everyone on our Institute's website <http://rtbel.igf.edu.pl/>
 - in digital form to the INTERMAGNET network and other cooperating programs and organizations.
- ❑ Developing observation methodologies for Polish geomagnetic observatories.



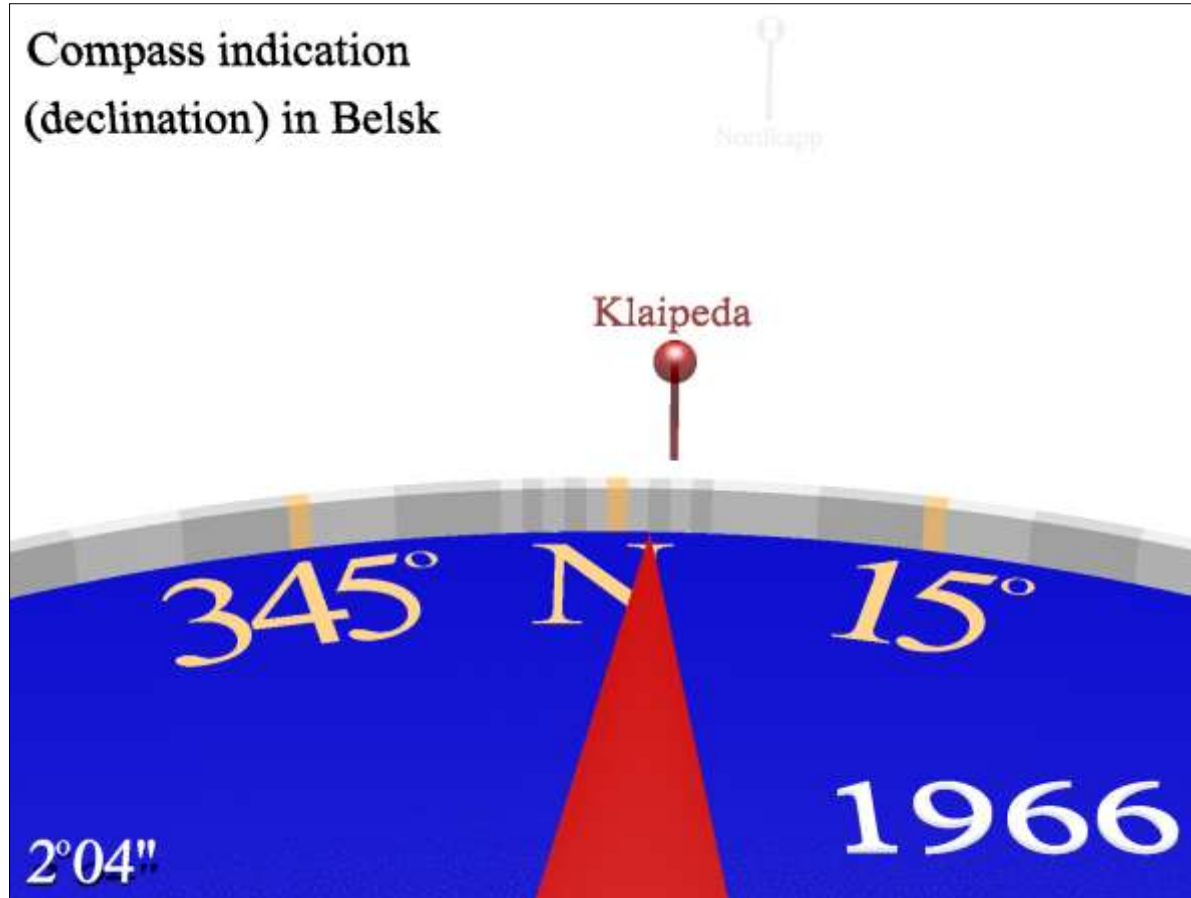
Examples of using geomagnetic observations in Belsk

| | |
|---|---|
| <p>Global models and maps of Earth's magnetic field used, among other things, in navigation (based on INTERMAGNET, which includes 3 Polish IG PAS observatories, including Belsk.)</p> |  |
| <p>Magnetic map of Poland are carried out by Institute Geodesy and Cartography. Belsk serves as a reference for this work.</p> |  |
| <p>Real-time data from Belsk is provided to Heliogeophysical Prediction Center at Space Research Centre of PAS for various works, including those related to space weather and communications conditions.</p> |  |
| <p>Belsk, Hel, Hornsund provide every month so called Quasi-Definitive data for the ongoing ESA SWARM satellite mission (3 satellites) studying Earth's magnetic field.</p> |  |
| <p>Studies of the magnetosphere and ionosphere (IMAGE, EMMA networks). Contributions come from 3 observatories (Belsk, Hel, Hornsund) and 3 permanent magnetic stations of IG PAS (Birzai, Suwalki, Polesie)</p> |  |
| <p>In Belsk tests and comparisons of magnetic instruments, such as compasses, are conducted</p> |  |



Compass readings in Belsk

Compass indication
(declination) in Belsk



- 1924 3 deg west
- 1944 0 deg
- 1965 2 deg east (opening date of Belsk Observatory)
- 2024 7 deg east

The Department of the Atmospheric Physics – Instruments and Data (COG Belsk and Warsaw)



A

B

C

Instruments on the roof of building No.6 at Belsk

A - Dobson spectrophotometer

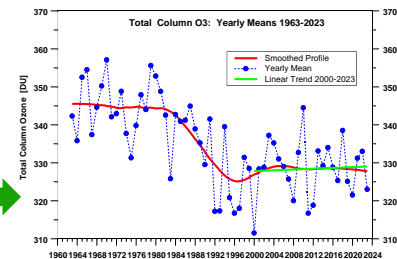
B - Brewer spectrophotometer

C - Kipp & Zonen UVS-AE-T radiometer

- Ozone Measurements:** the Dobson (since 1963, Photo A) and Brewer spectrometer Mark II (since 1991, Photo B) Continuous monitoring of total column ozone, the ozone vertical profile (the Umkehr method)
Data archived at: World Ozone and Ultraviolet Data Centre (WOUDC), PANGAEA data base, IG PAS Data Portal.

Fig.1 Yearly means (1963-2023) of total column ozone at Belsk (in Dobson unit, blue circles). Smooth profile (red curve) and linear trend (green line) in the period 2000-2023.

Figure 1



- Solar Ultraviolet (UV) measurements:**

UV spectra in the range 290-325 nm at Belsk from the Brewer spectrophotometer Mark II since 1995

UV spectra in the range 290-363 nm in Warsaw from the Brewer spectrophotometer Mark III since 2001

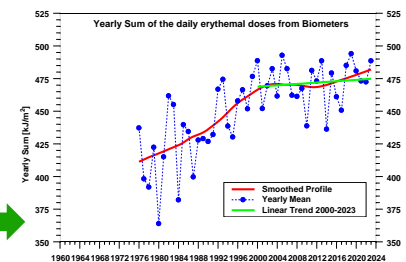
Intensity and daily dose of the biologically weighted solar radiance causing skin redness from 1-minute recording – the longest (1976-2023) homogenized time series of UV observations in Europe:

Various broad-band radiometers were used: Robertson Berger (1976-1992), Solar Light Mod. 501 (1993-2013) and Kipp & Zonen UVS-AE-T (2014-up to now, Photo C)

Data archived at: PANGAEA data base.

Fig.2 Yearly sums (1976-2023) of the daily erythemal exposures at Belsk (in KJ/m², blue circles). Smooth profile (red curve) and linear trend (green line) for the period 2000-2023.

Figure 2



Atmospheric electricity measurements at IG PAS

Stanislaw Kalinowski Geophysical Observatory at Świder – atmospheric electricity station since 1929. Measurements of:

- atmospheric potential gradient (PG)
- density of electric current
- positive and negative air conductivity
- In addition: meteorological observations & aerosol concentration measurements

Operation of Local Lightning Detection Network in Warsaw area

Polar areas:

- since 1986 electric field strength (= PG) measurements at Polish Polar Station Hornsund and for a while (2013-2017) at Arctowski Antarctic Station
- Since 2017 operation of Safir 3000 lightning detection station



Main building of Świder observatory



← Wilson antenna at Świder for measuring electric current density

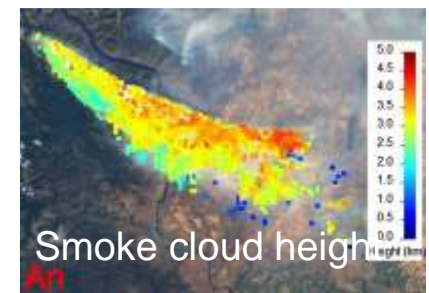
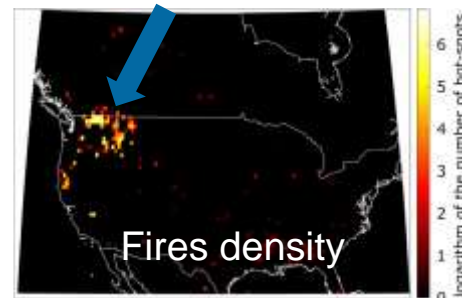
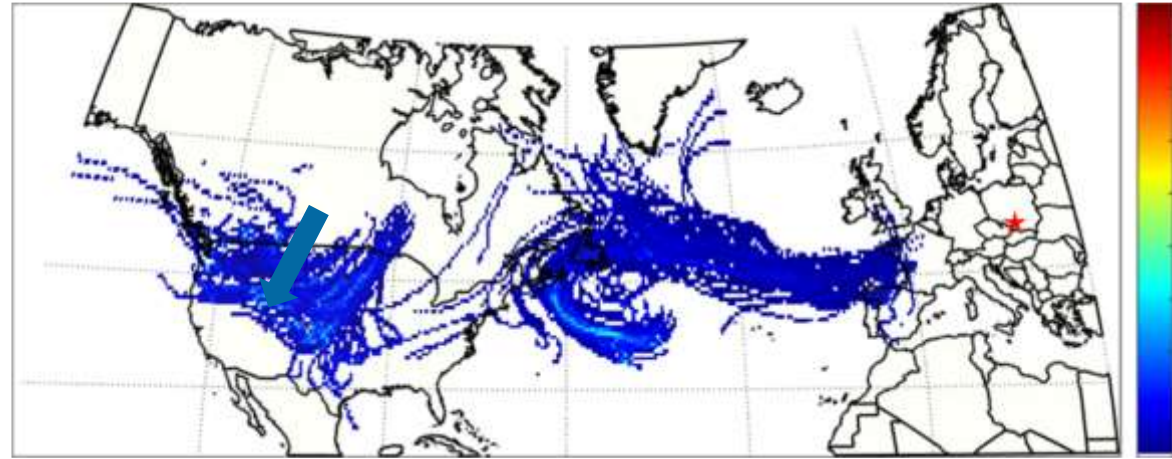
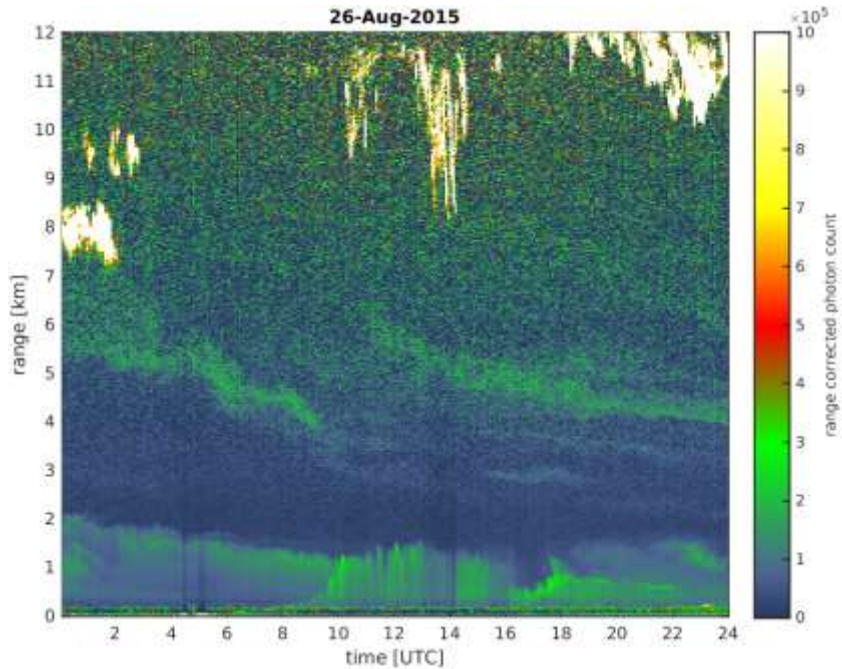


Electric field mill at Świder for PG measurements →



Safir 3000 antenna in Hornsund

Trajectories for separate layer in free troposphere – long range transport



Racibórz, obserwatorium IGF PAN

Monitoring in Polish Polar Station Hornsund on Svalbard



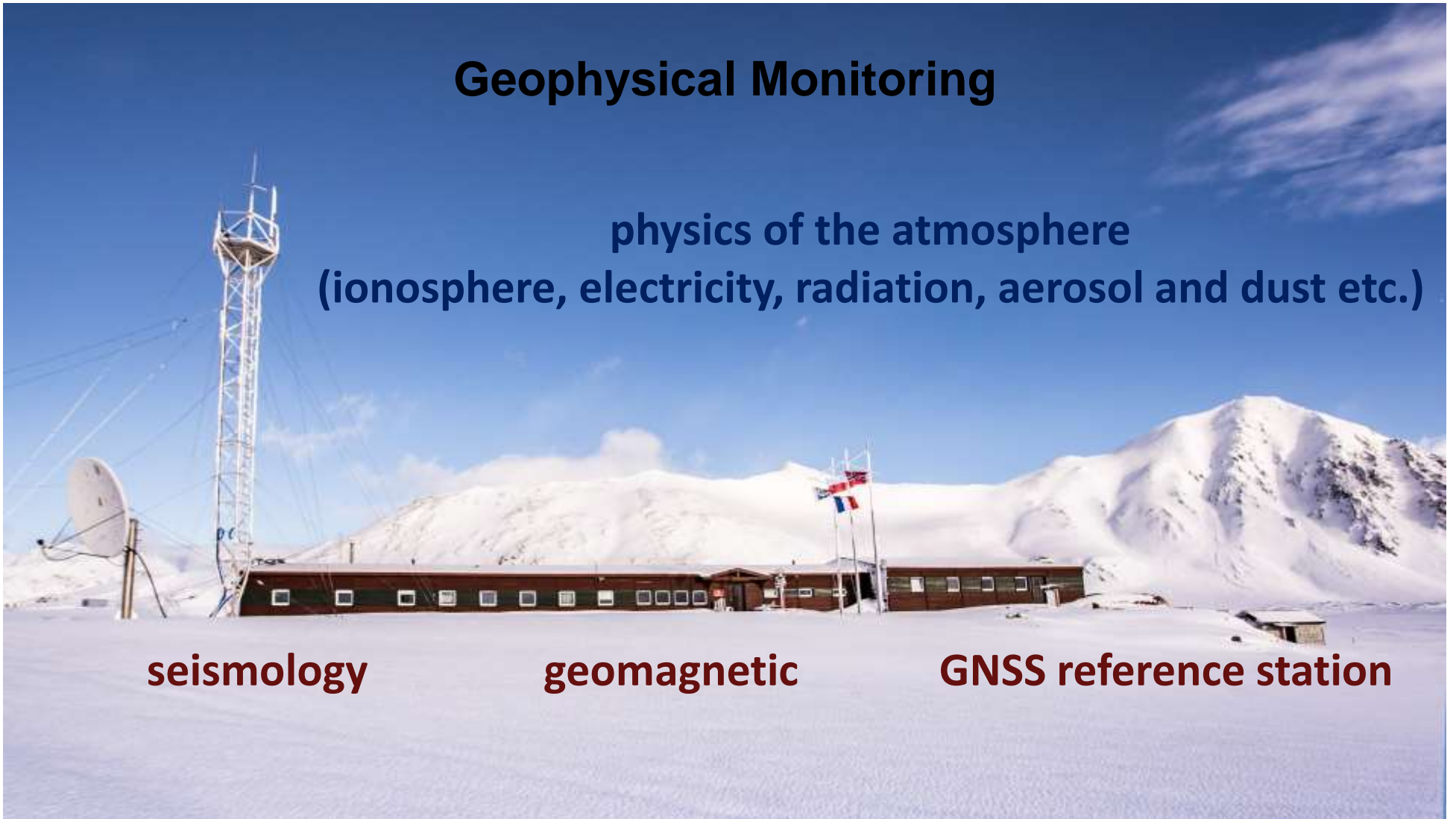
Geophysical Monitoring

physics of the atmosphere
(ionosphere, electricity, radiation, aerosol and dust etc.)

seismology

geomagnetic

GNSS reference station



Environmental monitoring

meteorology

hydrology and
hydrochemistry

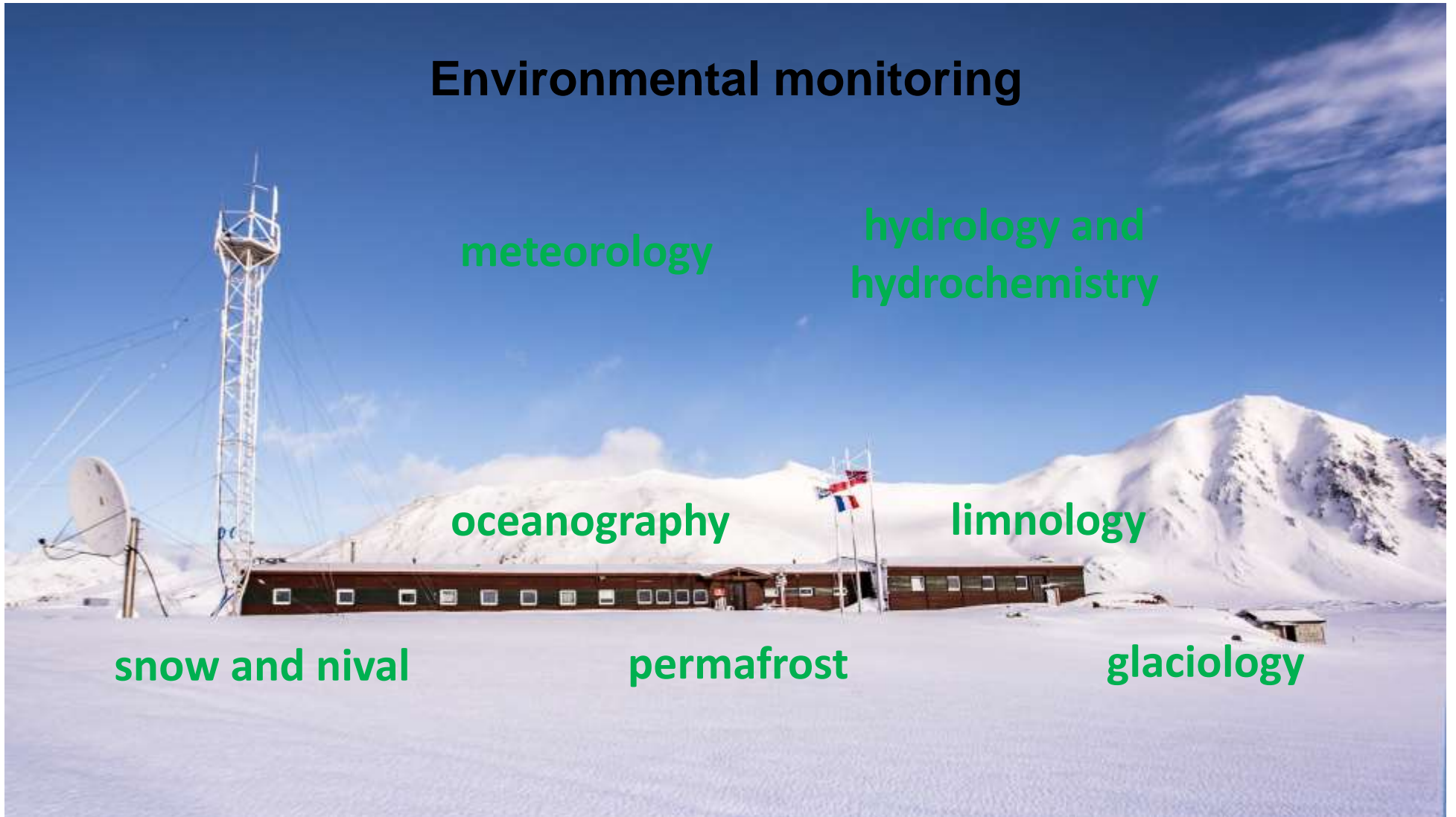
oceanography

limnology

snow and nival

permafrost

glaciology

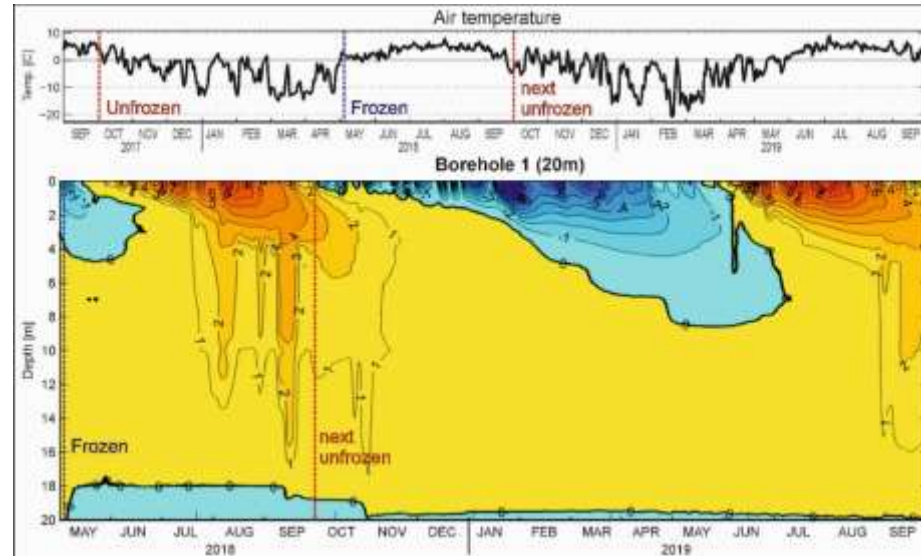


The **Hornsund Polish Polar Station** (Spitsbergen) is year-round laboratory for research in the following fields:

Meteorology, Seismology, Earth magnetism, Ionospheric research, Glaciology, Atmospheric physics and optics, Environmental research.

Unique Polar Laboratory PolarPOL

PolarPOL was appointed by the Minister of Science and Higher Education on February 26, 2011. It functions as a National Research Center in the framework of the Polish Road Map of Research Infrastructures and, at the same time, as a separate infrastructural unit of the Institute of Geophysics PAS.

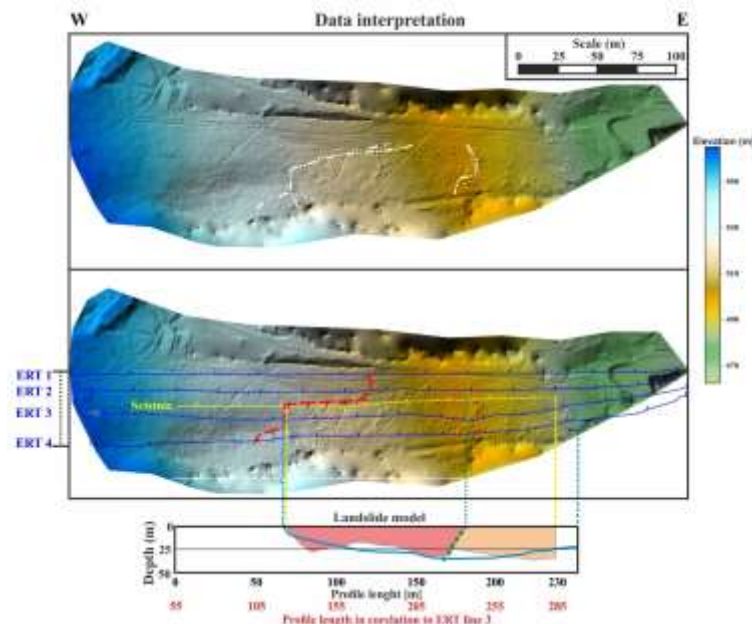


After Majdański et al. PPP, 2022

Environmental seismology

Active seismic, supported with ERT and GPR methods, used in time-lapse mode allows to study the change in medium, thus **tracing hydrogeological processes**.

IG PAS study the condition of the **landslide** at the Cisiec ski resort over the **last 6 years**.



Geophone seismic & DAS

Environmental seismology

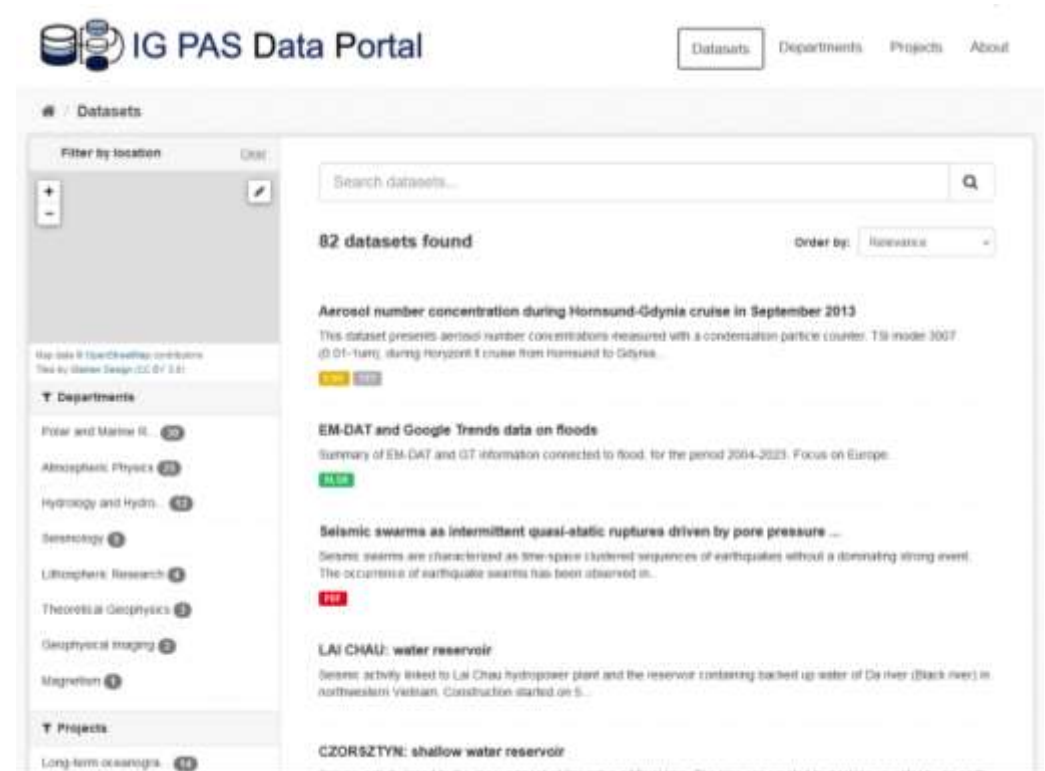
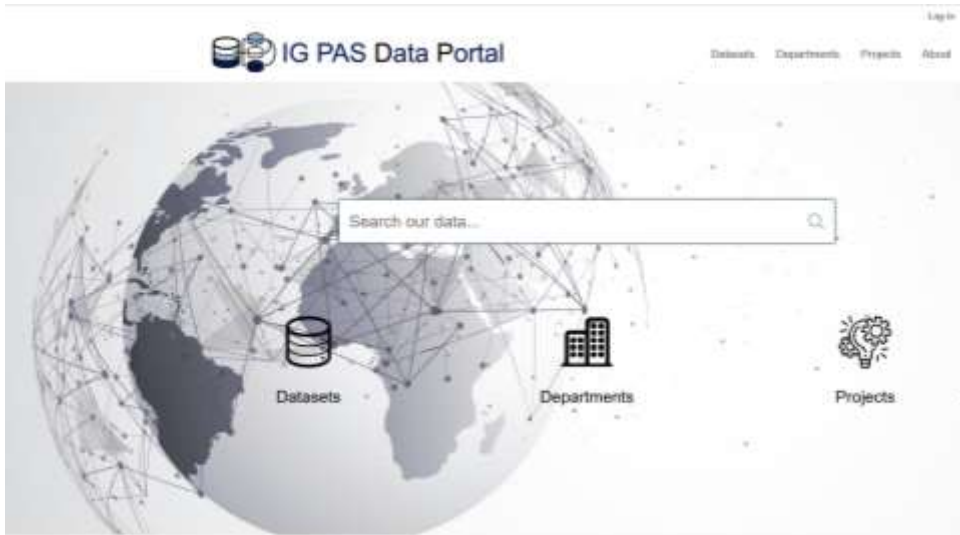
Head Dam on the Rybnik reservoir

Combined geophysical methods (seismic, ERT, GPR) allows to track **structural health and hydrogeological processes** in Earth-filled dams and embankments.

Rybnik dam is monitored over the last two years including effects of the **major flood** on September 2024.



IG PAS data portal



Data
curation



Open
data



FAIR

Thank you for your attention!



Institute of Geophysics
Polish Academy of Sciences

Earth and Planetary Research Centre

