Institute of Geophysics
Polish Academy of Sciences

PUBLICATIONS
OF THE INSTITUTE OF GEOPHYSICS
POLISH ACADEMY OF SCIENCES

Geophysical Data Bases, Processing and Instrumentation

447 (M-37)

Achievements of the Institute of Geophysics, PAS: Annual Report 2022

Warsaw 2023 (Issue 4)

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C O N T E N T S

Editorial note

This Monograph outlines the recent achievements of the **Institute of Geophysics, Polish Academy of Sciences**, focusing on the main strategic areas: Geosystem Processes, Earth Structure and Georesources, Anthropogenic and Natural Geohazards, Climate Change and Polar Research.

The publication is a reviewed and formatted version of the **Annual Report 2022**, providing information about the research done at the seven departments (Seismology, Atmospheric Physics, Lithospheric Research, Theoretical Geophysics, Hydrology and Hydrodynamics, Magnetism, Geophysical Imaging, and Polar and Marine Research), together with the Institute's infrastructure, instrumentation, projects that have been completed or are under way, as well as editorial, educational and many other activities.

We hope the information contained in this monograph may be useful for a broader audience, in particular those who may find the presented materials applicable in their work, or perhaps arrange a co-operation with the Institute.

The Editors
of the *Publications of the Institute of Geophysics PAS*

1. GENERAL

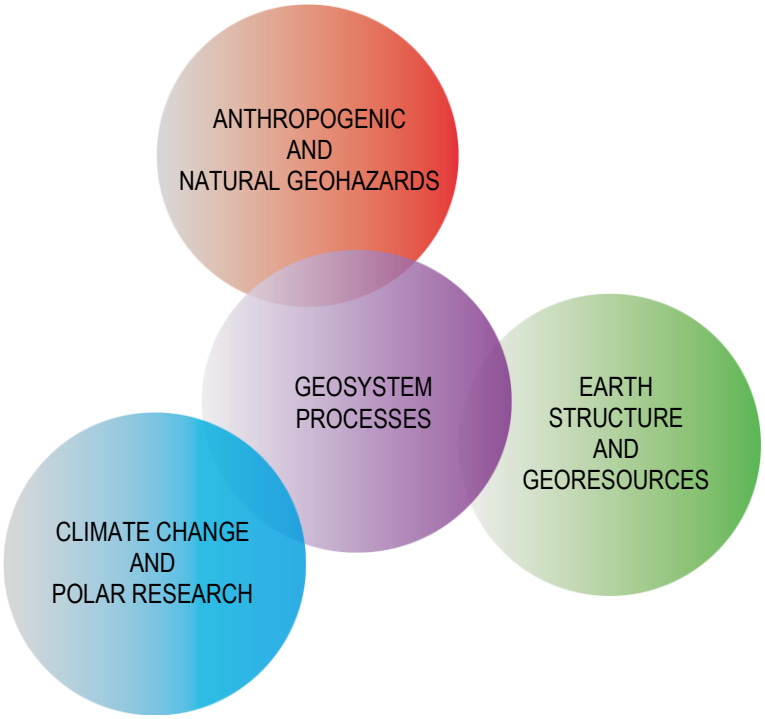
Beata Orlecka-Sikora, Mariusz Majdański, Beata Fromeliusz, Krzysztof Otto

1.1 The mission of the Institute of Geophysics, Polish Academy of Sciences

- Studying geophysical processes for better understanding of the mechanisms controlling the Earth's system and risk management
- Working for the benefit of the society and economic development
- Development and maintenance of strategic research infrastructure
- Geophysical monitoring
- Training future leaders of scientific community

1.2 Research areas

The main research areas and their interrelations, as described below:



Main research areas of the Institute of Geophysics PAS.

1.2.1 Anthropogenic and natural geohazards

The study of the risks and consequences of sudden and catastrophic processes in the lithosphere, atmosphere, magnetosphere and hydrosphere has been within the scope of scientific research at the Institute for many years. The research engages the latest analytical methods, specialized equipment and laboratories, including two stations located in both polar regions. Methodologies encompass both basic and applied science, and include mathematical and physical modelling of natural phenomena, magnetic analysis of soil, water and air pollution, seismic monitoring of natural and induced earthquakes, geophysical imaging of shallow and deep Earth structure, hydrological measurement of seas, rivers and lakes, and investigations of the cryosphere and polar environment in the Arctic and Antarctica.

1.2.2 Geosystem processes

The Geosystem Processes Working Group is a very inclusive group, which combines expertise spanning from atmospheric sciences to lithospheric research, magnetism and hydrology. The complexity of the geosystem dynamics from the deep geological past to the present necessitates a transdisciplinary approach of study. Particular aims for the next few years involve the maintenance and further development of the Polish geophysical monitoring system (seismic, magnetic, atmospheric), determination of the influence of ozone layer dynamics on the UV radiation, study of atmospheric electricity and its interactions with aerosols, and investigation of crust structure and dynamics through seismic soundings, including the unravelling of the earthquake source physics and physics of subduction zones.

1.2.3 Earth structure and georesources

The traditional domain of research in this thematic group was the recognition of the structure of the Earth's crust and upper mantle using various seismic (active, passive, refractive, and reflective) and (electro) magnetic methods, as well as paleogeographic research and tracking selected tectonic processes on the basis of palaeomagnetic analyzes. In the energy sector, our methods can be used in projects related to the production of geothermal energy, underground hydrogen storage, capture and underground storage of CO_2 or underground storage of radioactive waste. In the case of searching for mineral resources, including the so-called critical raw materials, it is important to reduce the cost of exploration and its impact on the natural environment through a greater share of non-invasive geophysical research.

1.2.4 Climate change and polar research

Modelling future hydro-climatic conditions at global and local scales is one of the key challenges in earth sciences. With the observed changes in hydro-climatic conditions, the threats to social and economic development increase. Therefore, it becomes particularly important to identify future conditions and develop adaptation to reduce the effects of potential threats. The polar zones are the fastest-changing and most important terrestrial and marine areas for understanding the global change, also in relation to other locations, including Poland. This is particularly important for the assessment of, e.g., climate change scenarios, rising ocean levels, the evolution of the biosphere, and its adaptation to new conditions.

2. ACHIEVEMENTS

2.1 Anthropogenic and natural geohazards

APPLICATION OF FOCAL PLANE DIRECTIONS FOR ESTIMATING GROUND MOTION MODELS WITH GENERAL REGRESSION NEURAL NETWORKS

J. Wiszniowski

Published in: *Pure Appl. Geophys*. (2022), **179**, 1197–1207, DOI: 10.1007/s00024-022-02975-4.

This work deals with an improvement of seismic hazard analysis. Our purpose was to investigate the ground motion models (GMM), whose predictors include focal mechanisms. We investigated GMMs based on a generalized regression neural network (GRNN), which calculates the conditional expected value of the GMM. The GRNN consists of four specialized layers: input, pattern, summation, and output (Fig. 1). The inputs of the GRNN are the ground motion predictors.

A new approach to GMM was applied, different from the one consisting of the estimation of GMM as a function of predictors. In the presented solution, all previous measurements are included in the model, while the issue came down to the search for metric spaces of predictors. Only the functions determining distances for given features are important. It reduces the problem of creating GMMs to the study of different metric distances between parameters.

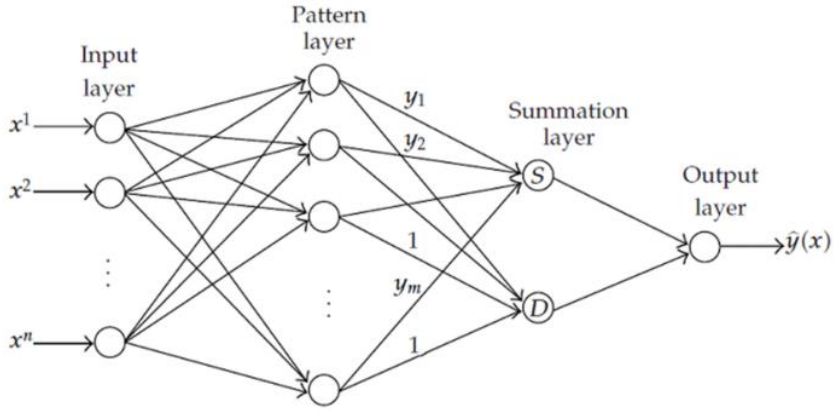


Fig. 1. Diagram of the GRNN, where n is the number of inputs and m is the number of neurons in the pattern layer.

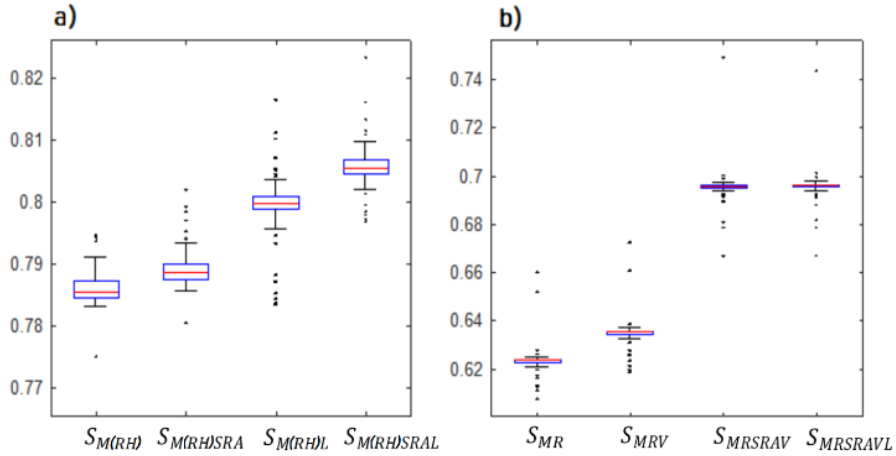


Fig. 2. Box plot of one-event delete jacknife LOEOCV values for several metric space sets for: a) LGCD and b) NGA-West2 data. Predictor symbols are: MR or M(RH) – magnitude and distance, V – V_{30}, SR – strike and rake angles of the focal mechanisms, A – azimuth, L – epicenter coordinates.

The criterion for choosing the metric spaces of the parameters is to minimize a cross-validation error. We investigated and applied a modification of the leave-one-out cross-validation – the leave-one-event-out cross-validation (LOEOCV) method, in which all records of each event are removed, a model is constructed based on the other records, errors are calculated for records of the removed event, the process is repeated for each event, and errors are cumulated. This approach allows a wide variety of predictors in various combinations of metric spaces to be easily examined.

The Lubin-Głogów Copper Basin, affected with intense mining induced seismicity, was the main source of data for the GMM research but due to the uniqueness of the used model, the application of GMMs for the global NGA-WEST2 earthquake database was also tested.

It was shown, using a one-event out jackknife, that the improvement of GMM by using many predictors including the focal mechanism parameters was statistically significant (Fig. 2).

EXPOSURE TO SOLAR UV RADIATION OF POLISH TEENAGERS AFTER THE FIRST COVID-19 LOCKDOWN IN MARCH–APRIL 2020

A. Czerwińska, J.W. Krzyścin

In Poland, schools were closed from March to June 2020 due to the COVID-19 epidemic. During the lockdown (March–April), everyone was advised to stay at home. From May, students were allowed to spend time outdoors. During collected: date, school name (so that the teacher can be contacted in case of problems with the questionnaire), age, weight, height, skin phototype (selected from the attached list), sunscreen with its Sun Protection Factor (SPF) if used, type of activity, head cover, amount of vitamin D supplementation, style of dress. Also, teenagers recorded the time of observation, type of cloud cover, geographical coordinates of the outdoor site, maximum daily temperature and total column ozone (TCO3) prediction from the Tropospheric Emission Monitoring Internet Service (https://www.temis.nl/uvradiation/nrt/uvindex.php). A total of 146 anonymous questionnaires were registered for the study. Survey responses provided input to a radiative transfer model to estimate erythemal and vitamin D doses obtained by teenagers during outdoor activities.

The results from 48% of the questionnaires indicated that students' exposure exceeded 1 MED (minimal erythema dose) during the day. Corresponding doses of sun-synthesized vitamin D in excess of 1000 IU (International Units) and 2000 IU were estimated from 77% and 66% of the surveys, respectively. Only 12% of the teenagers declared to use sunscreen. The overexposure (>1 MED) increased with age. It was found in 72% and 26% of surveys among the students aged 17–18 and 12–14, respectively (Fig. 1). Teenagers seem to have tried to com-

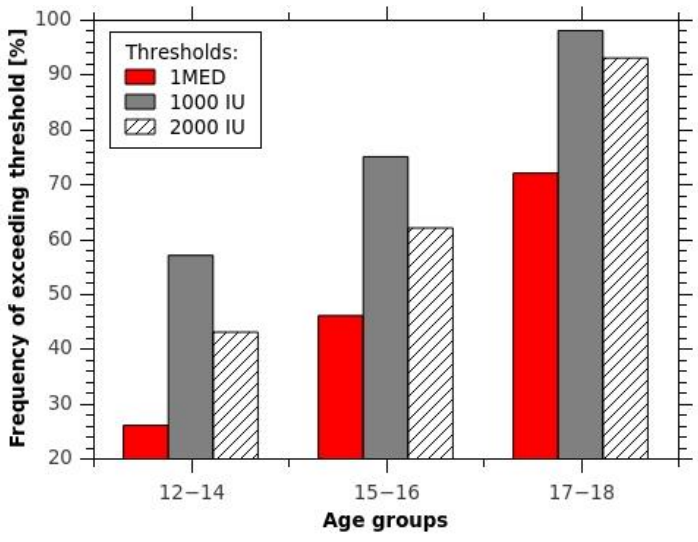


Fig. 1. Frequency of exceeding the threshold of 1 MED, 000 IU, and 2000 IU of vit. D equivalent to oral supplementation in three age groups of participants.

pensate for the lack of sunlight during the lockdown by engaging in outdoor activities permitted since May. This put them at risk of developing erythema, but they could improve their vitamin D.

To improve vitamin D levels without the risk of sunburn, teenagers' self-awareness needs to be changed. The time outdoors should be controlled, also the most exposed parts of the body (e.g., arms, ears, forehead) should be protected (covered, or sunscreen applied). We noticed that even if our participants had the knowledge of photo-protection (the researcher gave online lectures for project participants on the risk of sun exposure, in a non-scientific language), they did not put it into practice. Therefore, we agree that social campaigns should be targeted at this age group. Perhaps the solution would be to present amusing educational videos on social media (Facebook, Instagram, and TikTok) and/or smartphone apps.

For more details see: Czerwińska, A., and J. Krzyścin (2022), Exposure to solar UV radiation of Polish teenagers after the first COVID-19 lockdown in March–April 2020, *Int. J. Biometeorol.* **66**, 2021–2032, DOI: 10.1007/s00484-022-02337-8.

INTEGRATION OF CHEMICAL FRACTIONATION, MÖSSBAUER SPECTROMETRY, AND MAGNETIC METHODS FOR IDENTIFICATION OF Fe PHASES BONDING HEAVY METALS IN STREET DUST

B. Górka-Kostrubiec, R. Świetlik, T. Szumiata, S. Dytłow, M. Trojanowska

Published in: *J. Environ. Sci*. (2023), **124**, 875–891, DOI: 10.1016/j.jes.2022.02.015.

Street dust is one of the most important carriers of heavy metals (HMs) originating from natural and anthropogenic sources. Integration of chemical fractionation, Mössbauer spectrometry, and magnetic methods proved useful in identifying iron containing phases as well as chemical fractions of traffic-related HMs favored by Fe-bearing phases in street dust. The classification of HMs into five chemical fractions differing in mobility and bioaccessibility revealed that iron is most abundant (over 95%) in the residual fraction followed by the reducible fraction (Fig. 1). HMs were present in reducible fraction in the following order: Pb > Zn > Mn > Cr > Ni > Fe > Cu, while they bound to the residual fraction in the following order: Fe > Ni > Cr > Mn > Pb > Cu > Zn.

It was found that the fine-grained fraction with an average diameter of < 63 μm was the most enriched in traffic-related HMs such as Zn, Pb, Fe, Cu, Cr, Ni, and Mn. Consequently, the pollution load index assessing the total degree of HM contamination was over 2–3 times higher for the fine-grained fraction compared to the coarse-grained fraction.

The magnetic and Mössbauer outcomes revealed the existence of several magnetic phases in dust. The signature of the anthropogenic origin of street dust is the presence of strongly nonstoichiometric and defected grains of magnetite, the porous surface of which could be good carriers for the propagation of HMs.

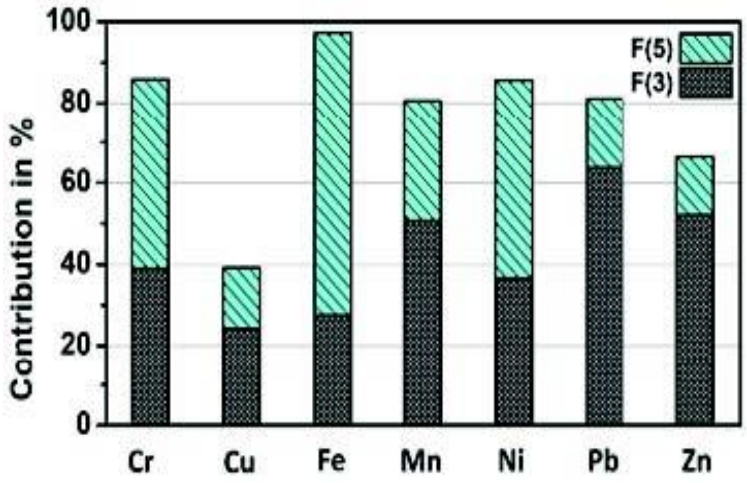


Fig. 1. Average contribution of traffic-related heavy metals to reducible F(3) and residual F(5) chemical fractions of street dust.

Admixture of magnetite with maghemite is also possible, along with a significant contribution of hematite, which was easily detected by Mössbauer spectrometry. The presence of metallic iron and iron carbides in the investigated street dust samples was found to be a feature distinguishing them from industrial fly ashes.

Magnetic measurements seem to be especially efficient in the screening test of the environmental samples as well as provide value-added information on the chemical composition, and mineralogical and domain structure of magnetic particles incorporated in the dust. Both mineral composition and domain structure of magnetic particles are useful features for determining the anthropogenic activities that give rise to pollution, together with the magnetic particles that are typical of these sources.

2.2 Geosystem processes

DEVELOPMENT OF SEISMIC PROCESS BEFORE THE M 8.3 ILLAPEL, CHILE, 2015 EARTHQUAKE OBSERVED IN AN EQUIVALENT DIMENSION SPACE

Y. Mahmood, S. Lasocki

Published in: *Proc. XXVIII General Assembly of the International Union of Geodesy and Geophysics (IUGG), 11–20 July 2023, Berlin, Germany* (2023), DOI: 10.57757/IUGG23-0923.

Description: Non-random, stochastic features of seismic series express the dynamics of seismic processes. Studies of these features may help to unravel earthquake predictability problems. Continuing the previous study of the clustering of seismicity before the *M* 8.2 Tehuantepec, Mexico, 2017 earthquake, we analyzed the seismic process preceding the *M* 8.3 Illapel, Chile, 2015 earthquake. We applied the same approach as in the previous study, i.e.:

1. We reparametrized the seismic catalog. The new parameters of seismic events were: the event's magnitude, *M*, the interevent time, *dt*, and the orthodromic epicentral distance (interevent distance), *dr*, between this and the preceding event.
2. We transformed *M*, *dt*, and *dr* to equivalent dimensions (Lasocki 2014).
3. We constructed a data window comprising 100 consecutive earthquakes and we were sliding this window by 20 events.
4. In each window, we calculated the average distance between earthquakes in 3D equivalent dimensions space of {*M*, *dt*, *dr*}:

$$d_c = \frac{1}{4950}\sum_{k=1}^{99}\sum_{j=k+1}^{100}\sqrt{\left(MC_k - MC_j\right)^2 + \left(DT_k - DT_j\right)^2 + \left(DR_k - DRT_j\right)^2} \ ,$$

   where *MC*, *DT*, *DR* are equivalent dimensions of *M*, *dt*, *dr*, respectively. d_c, representing the degree of earthquake clustering in the window, was linked to the occurrence time of the last event in the window.
5. We studied variations in time of d_c in the series of earthquakes before the Illapel earthquake.

A group of 1000 events of magnitudes ≥ 4.5 that occurred before the Illapel earthquake was analyzed. The time series of d_c is shown and compared with the results obtained previously for the Tehuantepec earthquake case in Fig. 1. There was a distinct increasing trend of d_c from the middle of 2013 to the middle of 2015 (Fig. 1a). A similar trend was also observed before the Tehuantepec earthquake (see Fig. 1b). Both earthquakes were preceded by signals of d_c. In the Illapel earthquake case, the signal was shorter-term (two years); in the case of the Tehuantepec earthquake it was long-term (ten years). The similarity of d_c changes is interesting as those two earthquakes resulted from quite different loading conditions.

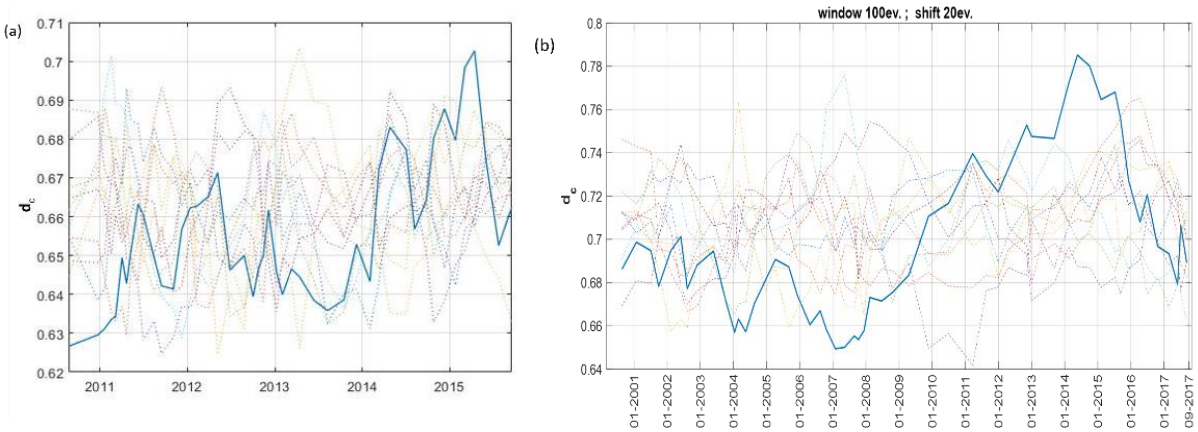


Fig. 1. Time changes of the average distance between the events in the 3D (dt × dr × m) equivalent dimensions space in an ensemble of n consecutive events: (a) M 8.3 Illapel, Chile, 2015 earthquake, and (b) M 8.2 Tehuantepec, Mexico, 2017 earthquake.

Reference

Lasocki, S. (2014), Transformation to equivalent dimensions—a new methodology to study earthquake clustering, *Geophys. J. Int*. **197**, 2, 1224–1235, DOI: 10.1093/gji/ggu062.

PREDICTION OF NUMERICALLY MODELED EARTHQUAKES USING SUPERVISED MACHINE LEARNING

P. Klejment

The purpose of this research was to develop a supervised machine learning approach for predicting laboratory earthquakes by using DEM (Discrete Element Method) numerical models. DEM models allow analysis of various processes in a way unavailable in the laboratory. This is especially important in the case of a phenomenon as complex as an earthquake. Faults usually have a structure resulting from the action of external forces, and between the rocks there may be a granular layer formed as a result of rock crushing. This means that the stability of a fault depends on many parameters.

A DEM model was prepared, in which the above-mentioned factors (referred to as micro-parameters) were taken into account. Due to computational costs, the model is only a reduced fragment of the real fault. 1680 simulations were initially performed, treating the microparameters of the model as independent variables in the language of supervised machine learning, and the macroparameter (fault stability estimated by the bulk friction coefficient) as the dependent variable. Among the eight tested algorithms, Random Forest turned out to be the most effective with a very good r2 metric equal to 93%.

So far, a simplified regular model of stress accumulation on a fault has been generally assumed (in laboratory and numerical models). An improved DEM model was created to take into account the random nature of stress changes in the fault. Such a model was applied to try to predict the stick-slip phenomena using supervised machine learning, using only current measurements of the model state (changes in energy, rotation of particles and other physical quantities). An important part of this approach is an attempt to predict movements within the numerical fault not on the basis of the history of previous movements, but only on the basis of current signals recorded in the model.

METHODS FOR QUALITATIVE AND QUANTITATIVE ASSESSMENT OF THE TRANSFORMATION OF PORE GEOMETRY OF A ROCK AS A RESULT OF KARSTIFICATION

R.P. Sharma, M. Białecki, M.P. Cooper, A.P. Radliński, P. Szymczak

We develop methods for qualitative and quantitative assessment of the transformation of pore geometry of a rock as a result of karstification. We apply these tools to characterize dissolution-induced changes in Miocene limestone samples collected from a quarry located near Smerdyna (Poland), where intense epikarst development is observed, with the formation of hundreds of solution pipes. Partially dissolved samples collected in the immediate vicinity of the pipes are compared with undissolved samples collected 1.5 m away (see Fig. 1).

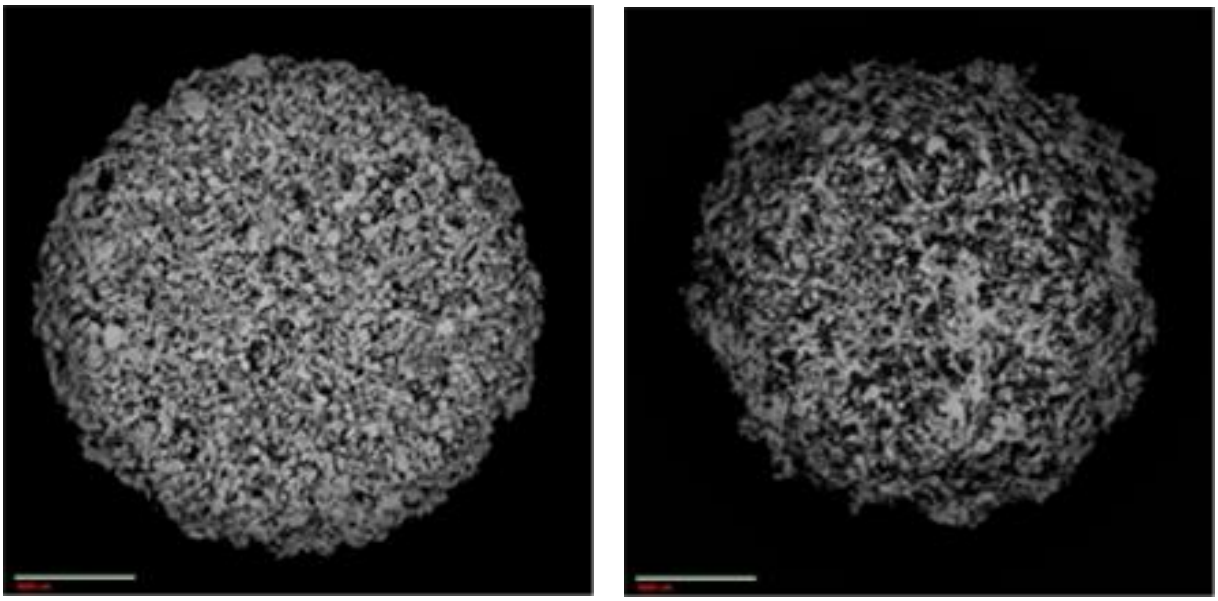


Fig. 1. The tomographic images of the undissolved sample (left) and naturally dissolved sample (right).

For both types of samples, 26 micron resolution grayscale X-ray scans have been performed, and cubical regions of interest of 506^3 voxels size, which corresponds to (13.156 mm)^3, have been studied. Images have been segmented by tuning the grayscale threshold to match the experimentally measured porosity values of respective samples. Additionally, based on the segmented tomograph of undissolved sample another geometry – S3 – was numerically created in order to mimic a uniform dissolution of the rock up to a porosity equal to that of the dissolved sample.

The irregular geometry of the pore space, vast majority of which forms a single connected component, can be conveniently characterized by a local thickness function, which corresponds to a diameter of the largest sphere that fits within the pore space and contains a given point. We have compared thickness distributions of undissolved and dissolved samples, as well as numerically generated uniformly dissolved samples (see Fig. 2). Such a comparison allowed us to quantify the extent of homogeneity of the natural karstification process. To further characterize pore geometry, we have calculated the ellipsoid factor, which – based on the axis lengths of the fitted ellipsoids – can be used to characterize how prolate or oblate the pore space locally is. Next, we have used (modified) Flinn diagram to quantify differences between undissolved, numerically eroded and naturally dissolved samples, especially those indicating pore merging and inhomogeneous dissolution (see Fig. 3).

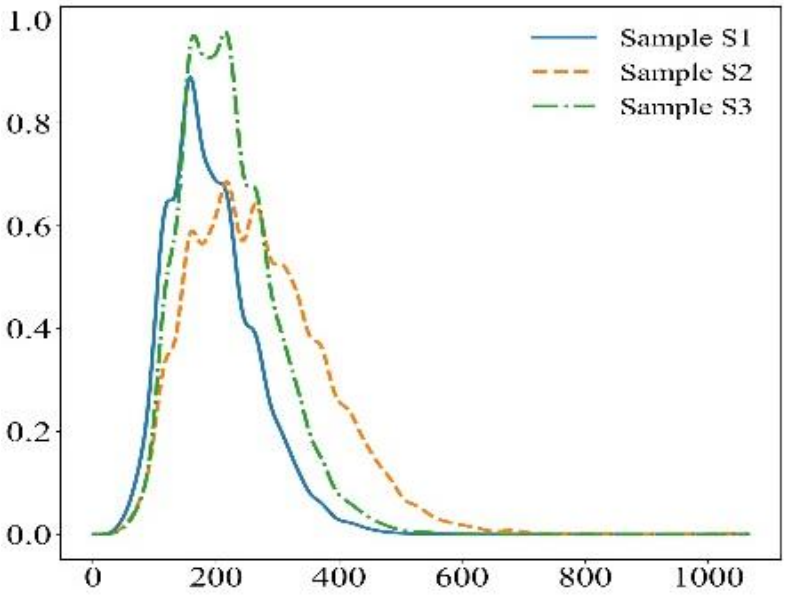


Fig. 2. Local thickness distribution for the undissolved sample S1, naturally dissolved sample S2, and numericallly created sample S3. Figure taken from Sharma et al. (2023).

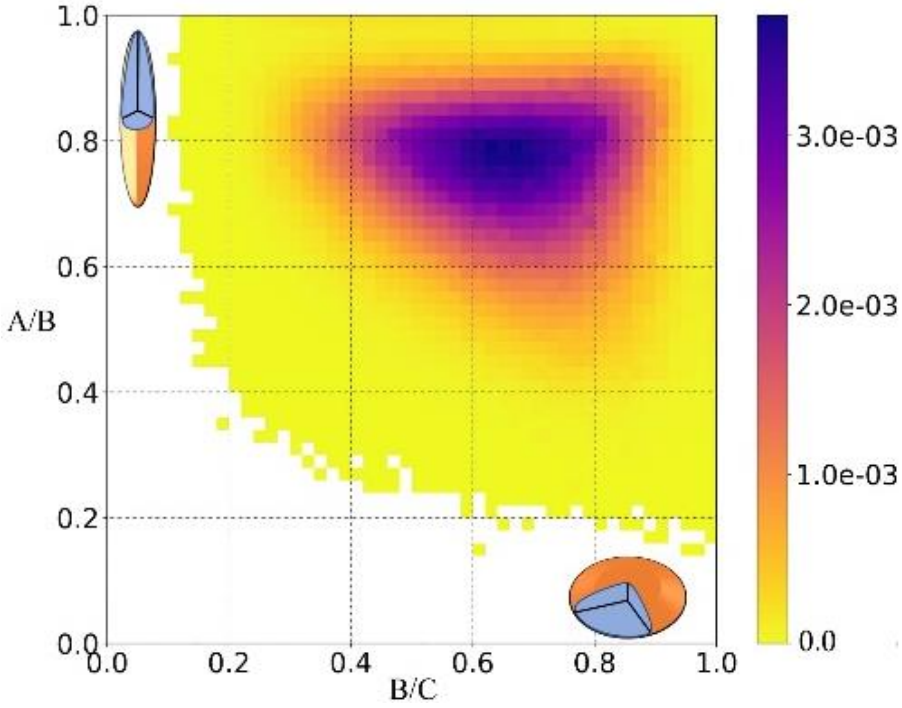


Fig. 3. Flinn diagram of the undissolved sample S1. Color scale represents fraction of elipsoids with a shape given by its axes A⩽B⩽C. Different position on the diagram differentiate between oblate (pancake-like) shapes (for A/B→0 and B/C→1) and prolate (cigar-like) shapes (for A/B→1 and B/C→0). Figure taken from Sharma et al. (2023).

The above analysis is complemented by the calculation of connectivity density – a topological measure of the degree to which a structure is multiply connected. Values obtained for samples S1, S2, and S3 indicate on "excessive" reduction of interconnections during natural dissolution, which may be understood on the basis of high degree of pore merging due to inhomogeneous dissolution.

Reference

Sharma, R.P., M. Białecki, M.P. Cooper, A.P. Radliński, and P. Szymczak (2023), Pore merging and flow focusing: Comparative study of undissolved and karstified limestone based on microtomography, *Chem. Geol.* **627**, 121397, DOI: 10.1016/j.chemgeo.2023.121397.

2.3 Earth structure and georesources

PASSIVE SEISMIC EXPERIMENTS IN POLAND AND CENTRAL EUROPE – ANIMALS, PACASE AND ADRIAARRAY

P. Środa, S. Abdollahi, M. Bociarska, W. Czuba, T. Janik, K.-Y. Ke, W. Materkowska, J. Rewers, and Working Group* (*Working Group: E. Gaczyński, M. Grad, M. Mendecki, M. Polkowski, J. Suchcicki, E. Szypuła, M. Wilde-Piórko, D. Wójcik)

The passive seismic experiment AniMaLS started in 2017 in the Polish Sudetes. One of the objectives was to study the anisotropy of the sub-crustal lithosphere and asthenosphere beneath the NE termination of the Bohemian Massif, with a complex lithospheric mosaic of several Proterozoic to Quaternary units. Temporary seismic network of 23 broadband stations was operated for ~2 years, providing broadband seismograms of local, regional, and teleseismic events which are currently analysed using shear-wave splitting, receiver function and surface wave dispersion methods. The results of the SK(K)S splitting show that the azimuths of fast polarization are mostly consistent and vary from WNW-ESE to NW-SE direction (Fig. 1). They correlate well with course of tectonic units and with strikes of major fault zones. The splitting is interpreted as a result of lattice-preferred orientation (LPO) of mantle olivine. Comparison with other seismic studies of the mantle anisotropy suggests that the orientations of fast polarization in the Sudetes are approximately consistent with those in neighboring areas, forming a larger-scale trend of fast orientations running sub-parallel to the East European Craton margin. This work is connected with the IG PAS project: "Determination of the seismic anisotropy of the lithosphere in the Lower Silesia area" (grant of Polish National Science Centre, agreement: UMO-2016/23/B/ST10/03204).

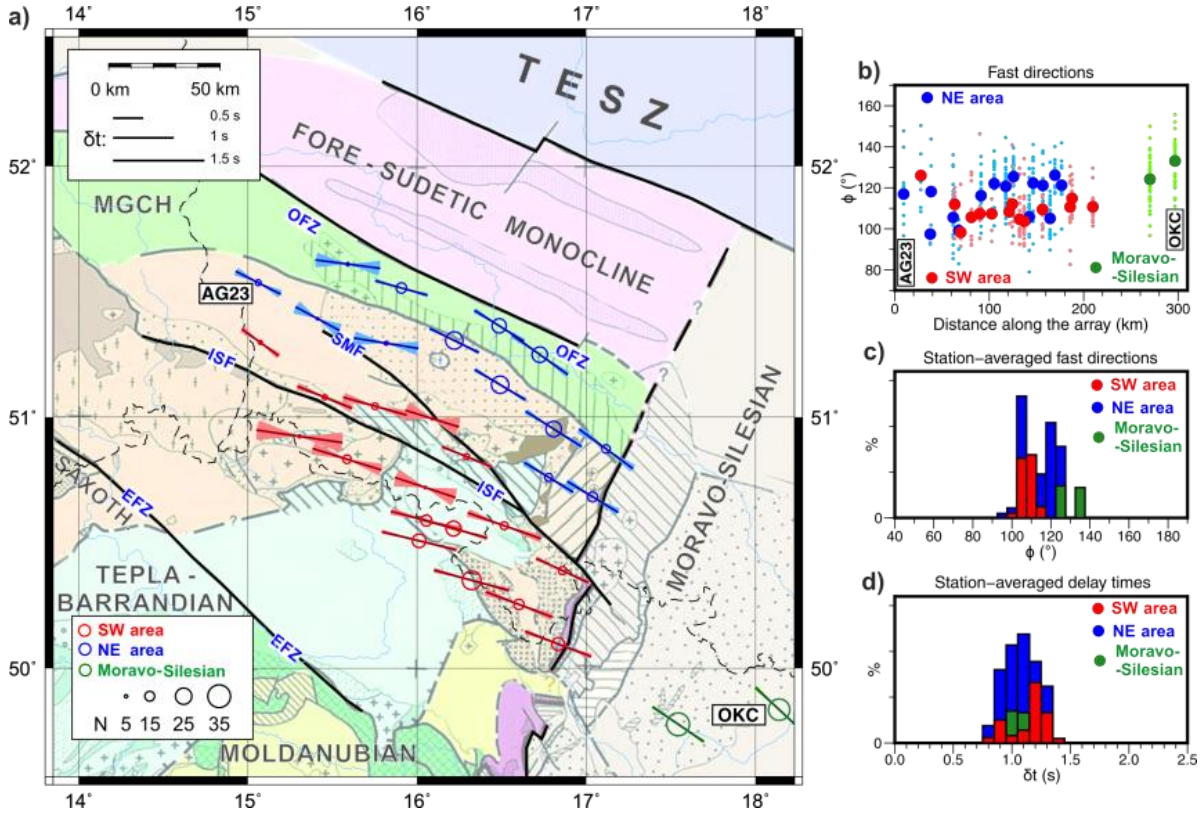


Fig. 1. Results of the SKS splitting study in Sudetes: a) map of station-averaged fast polarization azimuths and delay times, b) variations of fast polarization azimuth along the array, c) histogram of fast azimuths, and d) histogram of delay times. Blue, red, and green colours represent the NE, SW, and Moravo-Silesian regions, respectively. After Rewers and Środa (2023); tectonic map after Franke et al. (2017), modified.

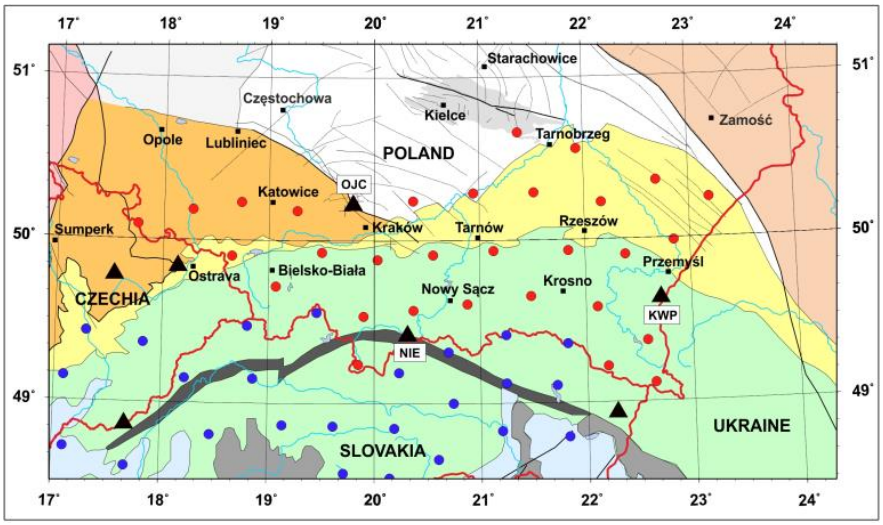


Fig. 2. Locations of Polish seismic stations of the PACASE and AdriaArray experiments. Red dots – Polish stations, blue dots – other stations of the experiment, black triangles – permanent stations.

The data acquisition for the PACASE passive experiment (Pannonian-Carpathian Seismic Experiment) started in 2019 and was completed in 2022. At present, measurements are continued in the frame of the AdriaArray project. The Polish team operates 30 broadband seismic stations in Southern Poland (Fig. 2). The PACASE area was covered with over 210 stations. This project concentrates on the area of the Carpathian orogen, Pannonian Basin, and Eastern Alps and involves 14 institutions from Czech Rep., Slovakia, Austria, Hungary, Germany, and Poland. The AdriaArray experiment is an extension of the AlpArray project, and covers young orogenic areas in central Europe – from Carpathians to Mediterranean, with Adria plate and adjacent regions as the main target. In total, over 400 seismic stations from over 30 institutions will be used. The main objectives of both projects involve: detailed geophysical study of the lithosphere-asthenosphere system; study of seismic anisotropy in relation to mantle fabrics, petrology and tectonic deformations, analysis of local seismicity, and developing a 3D seismotectonic model. Seismic interpretation methods as body-wave tomography, receiver functions, shear wave splitting, ambient noise techniques will be used. The Polish contribution in the PACASE is connected with the IG PAS project: "Passive Seismic Studies of the Lithosphere and Asthenosphere of the Southern Poland (Carpathian area)" (grant of Polish National Science Centre, agreement: UMO-2019/35/B/ST10/01628).

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Rewers, J., P. Środa, and AniMaLS Working Group (2023), Seismic upper mantle anisotropy beneath the Polish Sudetes from SKS splitting — Effect of present-day asthenospheric mantle flow deflected by cratonic keel?, *Tectonophysics* **846**, 229687, DOI: 10.1016/j.tecto.2022.229687.

HIGH-RESOLUTION IMAGING OF SUBDUCTION ZONE USING OCEAN BOTTOM NODES AND STREAMER DATA JOINTLY

T. Zand, A. Górszczyk, A. Gholami

High-resolution imaging of the deep lithospheric structure via the leading-edge migration methods using jointly ocean bottom nodes (OBN) and multi-channel streamer (MCS) data is the goal of this research. Least-squares reverse time migration (LSRTM) is a leading tool in imaging

complex geological structures, however needs regularization. We proposed a new regularization algorithm for LSRTM, called shifted total variation (STV) regularization (Zand et al. 2022). STV-LSRTM implemented in the frame of a nonlinear migration allows for the high-resolution and stable imaging in the presence of inaccurate initial velocity models as well as the capability of an stable update of the initial velocity, which allows us to integrate the information in different frequencies are attained by two different types of data, OBN, and MCS. The lower frequency content of OBN data, allows more stability in respect to inaccurate initial velocity. So, we inversed it first and used its result to update the initial velocity. Then the more accurate updated velocity is used for MCS data migration. Since the MCS data contains more higher frequency, they recover the finer structure of the image.

We demonstrate the performance of our method using academic crustal-scale model GO_3D_OBS (Górszczyk and Operto 2021). The part of the model used has the size of 18 km × 95 km and is included the broad range of features in a subduction tectonic environments, the top of the continental and oceanic crust and the mantle. The complexly shaped, small-scale, steeply dipping structures, and crustal-scale all makes this model challenging for seismic imaging. In Fig. 1, (a) is the true image, and (b) is the initial velocity. The MCS (c) and OBN (d) images are resulted by using (b). Updating (b) by (d) results (e). (f) shows the result of MCS migration using (e). Comparing (c), (d), and (f) (see red arrows) confirms the proposed algorithm eventuates in higher resolution images.

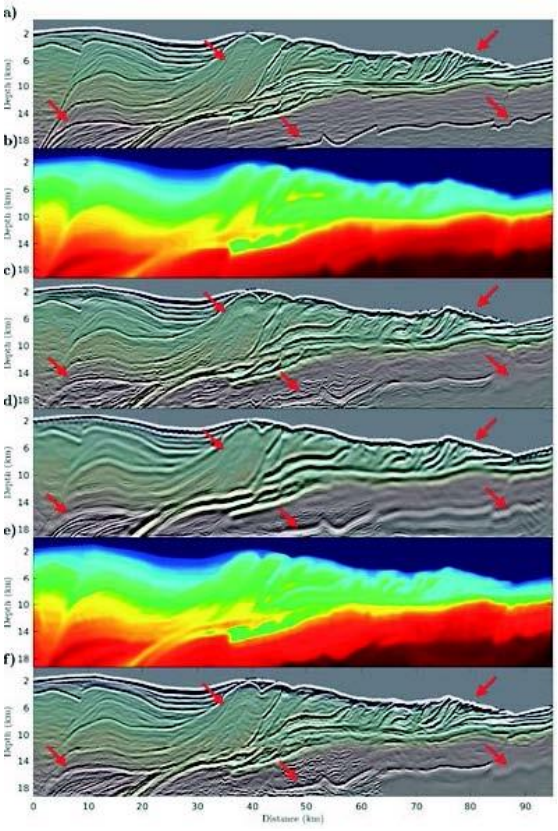


Fig. 1: a) True image, b) initial velocity model, c) image resulted by STV-LSRTM of MCS data, d) image resulted by STV-LSRTM of OBN data, e) updated initial velocity model using the OBN image, f) image resulted by STV-LSRTM of MCS data after updating the initial velocity model.

References

Górszczyk, A., and S. Operto (2021), GO_3D_OBS: the multi-parameter benchmark geomodel for seismic imaging method assessment and next-generation 3D survey design (version 1.0), *Geosci. Model Dev*. **14**, 3, 1773–1799, DOI: 10.5194/gmd-14-1773-2021.

Zand, T., A. Górszczyk, A. Gholami, H. Ghasemzadeh, and A. Malcolm (2022), Least-squares RTM with shifted total variation regularization for depth imaging of sparse short-offset seismic data, *Image* **22**, 2714–2718, DOI: 10.1190/image2022-3751356.1.

COMPLEX ORIGIN OF THE PALAEOMAGNETIC RECORD IN NEOPROTEROZOIC ROCKS OF NE SVALBARD

K. Michalski, G. Manby, K. Nejbert, J. Domańska-Siuda, M. Burzyński

One of the most complete Neoproterozoic sections on Earth crops out in NE Svalbard. Palaeomagnetic investigations of the area around Hinlopenstretet conducted by IG PAS scientific team are critical to verify the Neoproterozoic True Polar Wander hypothesis. New demagnetization results of 286 palaeomagnetic specimens from 15 sites in Neoproterozoic–Lower Paleozoic sequences of Ny Friesland–Nordaustlandet (the Caledonian Eastern Svalbard Terrane) were published in *Journal of the Geological Society of London* (Michalski et al. 2023*)*. New in situ 40Ar/39Ar ultraviolet mass spectrometry (Uv-MS) age determinations on amphibolites and mylonites from the Ny Friesland cluster in the 340–460 Ma interval correspond broadly to the Caledonian thermal event (Fig. 1a). No pre-Caledonian palaeomagnetic record was identified in investigated amphibolites and metacarbonates of Ny Friesland. Pre-folding pre-Caledonian, potentially Neoproterozoic (primary?) magnetization was recognized only in non-metamorphosed Murchisonfjorden (Nordaustlandet) carbonates. However, selective palaeomagnetic palaeopoles from Murchisonfjorden also fall into Caledonian sensu lato and Mesozoic sectors of the Laurussia reference path (Fig. 1b). This also indicates that regions east of Hinlopenstretet and east of the Caledonian front could be partially subjected to Caledonian remagnetization. Mesozoic palaeomagnetic overprints are potentially related to the injection of Mesozoic dolerites in eastern Svalbard.

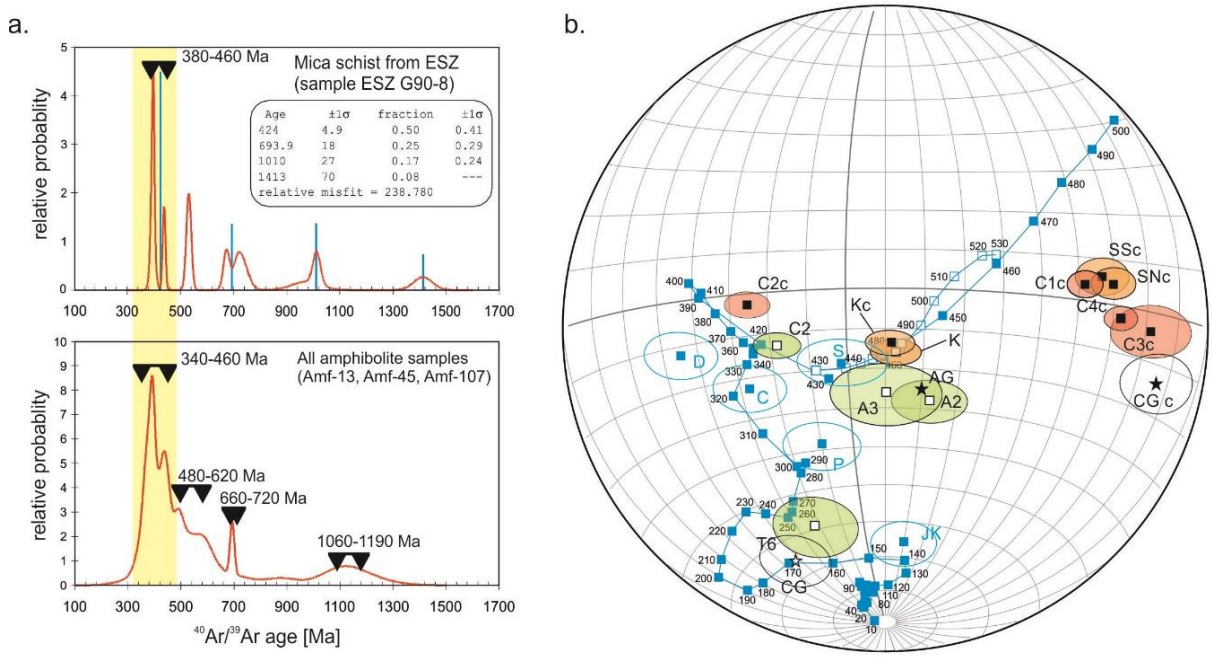


Fig. 1: a) Spectra of in situ 40Ar/39Ar Uv-MS ages obtained from Ny Friesland (Eastern Terrane of Svalbard); b) Palaeopoles calculated for components identified in amphibolites and metacarbonates of north Ny Friesland and carbonates and tillites of Murchisonfjord–west Nordaustlandet with their ellipses of the confidence limit α95 against Phanerozoic APWPs of Laurussia, Baltica and Laurentia as well as against reference palaeopoles from Svalbard (after Michalski et al. 2023).

Reference

Michalski, K., G.M. Manby, K. Nejbert, J. Domańska-Siuda, and M. Burzyński (2023), Palaeomagnetic investigations across Hinlopenstretet border zone: from Caledonian metamorphosed rocks of Ny Friesland to foreland facies of Nordaustlandet (NE Svalbard), *J. Geol. Soc*. **180**, 1; DOI: 10.1144/jgs2021-167.

2.4 Climate change and polar research

LAKES, RIVERS AND SNOW RESEARCH IN THE CONTEXT OF GLOBAL ENVIRONMENTAL CHANGE

M. Bartosiewicz, P. Głowacki, D. Kępski, B. Luks, A. Nawrot, M. Osuch, T. Wawrzyniak

We study a broad range of hydrosphere components in the Arctic and mountain environment, including lakes, glaciated catchments, and snow data. "Detritus-hosted methanogenesis sustains the methane paradox in an alpine lake" by Bartosiewicz et al. (2023) investigates the mechanism behind methane paradox formation in alpine lakes fueled by plankton detritus retained on the density gradient (thermocline) during exceptionally hot years (Fig. 1). "Changes in the flow regime of High Arctic catchments with different stages of glaciation, SW Spitsbergen" by Osuch et al. (2022) presents the influence of climate change on highly sensitive hydrological regimes in High Arctic catchments with differing stages of glaciation. We observed an earlier occurrence of snowmelt-driven floods, large increases in autumn flows, prolongation of the hydrologically active season (which starts earlier and lasts longer), and a decrease in runoff in the second part of June and the first part of August. The results indicate differences in the magnitude of hydrological response depending on the percentage of glacial coverage in the catchments. "Hansbreen Snowpit Dataset – over 30-year of detailed snow research on an Arctic glacier" by Laska et al. (2022) presents data on snowpack studies from Hansbreen. A unique dataset of snow measurements on Hansbreen, an Arctic glacier in Svalbard, has been compiled from 1989 to 2021, including 79 archived snow profiles. The dataset has been standardized and unified with current protocols.

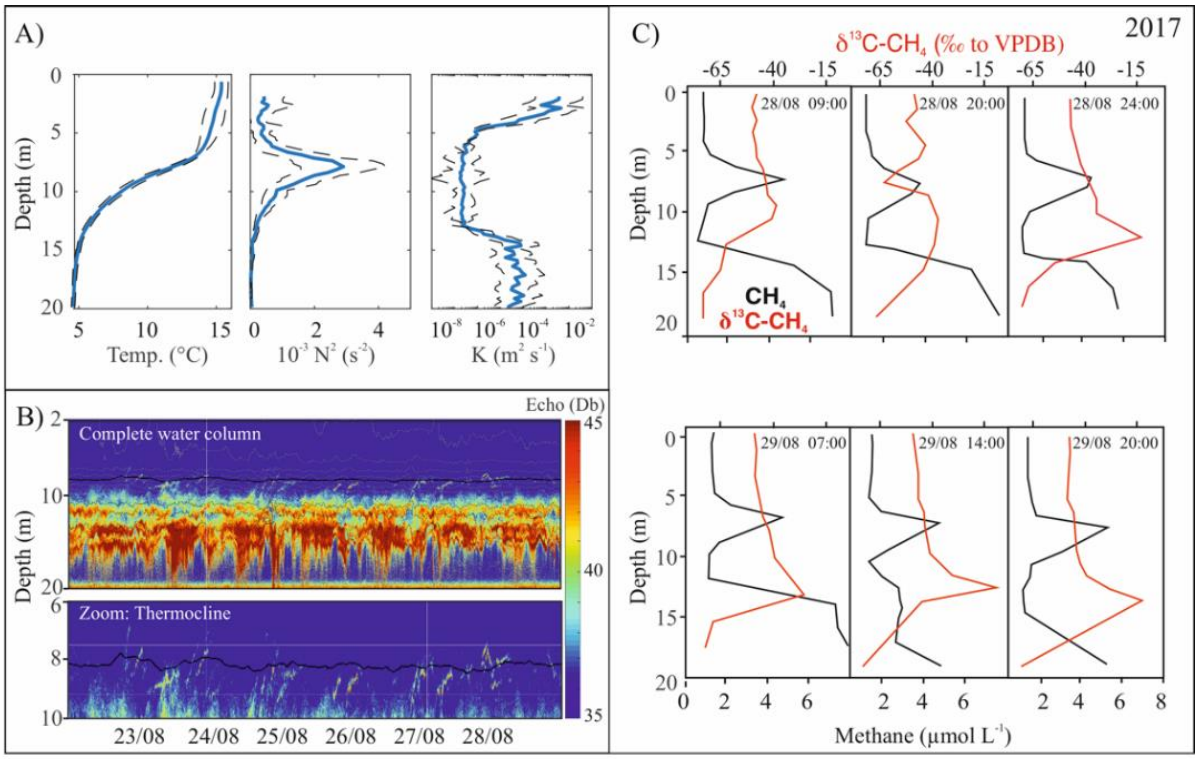


Fig. 1: (A) Mean temperatures, buoyancy frequencies – N2, diapycnal Osborn–Cox diffusivities – K; (B) Temporal evolution of echo-sounding from the signature 1000 MHz ADCP showing a relative peak in backscattering in the vicinity of the thermocline (black line). Dashed gray lines represent 1°C isotherms (between 9°C and 17°C); (C) Diurnal evolution of CH_4 concentrations and its $\delta^{13}C$ signatures in Lake Cadagno between 28 and 29 August 2017 (after Bartosiewicz et al. 2023).

References

Bartosiewicz, M., J. Venetz, S. Läubli, O. Sepúlveda Steiner, D. Bouffard, J. Zopfi, and M.F. Lehmann (2023), Detritus-hosted methanogenesis sustains the methane paradox in an alpine lake, *Limnol. Oceanogr*. **68**, 1, 248–264, DOI: 10.1002/lno.12263.

Laska, M., B. Luks, D. Kępski, B. Gądek, P. Głowacki, D. Puczko, K. Migała, A. Nawrot, and M. Pętlicki (2022), Hansbreen Snowpit Dataset – over 30-year of detailed snow research on an Arctic glacier, *Sci. Data* **9**, 656, DOI: 10.1038/s41597-022-01767-8.

Osuch, M., T. Wawrzyniak, and E. Łepkowska (2022), Changes in the flow regime of High Arctic catchments with different stages of glaciation, SW Spitsbergen, *Sci. Total Environ*. **817**, 152924, DOI: 10.1016/j.scitotenv.2022.152924.

TRENDS IN SHORT-TERM VARIABILITY OF TOTAL COLUMN OZONE IN EUROPE FOR THE PERIOD 1980–2020

J.W. Krzyścin

Total column ozone (TCO_3) shows high day-to-day variability due to ozone anomalies passing through mid-latitudes, as shown, for example, in Fig. 1 for two consecutive days (20–21 March 2021). The corresponding change of TCO_3 of ~ 100 DU (i.e., ~30% of the mean value for these days) was calculated from the measurements by the Dobson spectrophotometer at the Central Geophysical Laboratory, IG PAS, Belsk. For this site, the mean temperature (from ERA5 Reanalysis) shows an increase of 1.1°C and a decrease of 0.9°C between the 1980–1990 and 2010–2020 period in the mid troposphere (500 hPa) and lower stratosphere (100 hPa), respectively. Such changes are in agreement with the well-known troposphere warming and stratosphere cooling due to an increase of the greenhouse gases concentration in the troposphere. Our working hypothesis is that the recent climate change has also influenced the pattern of the one-day TCO_3 changes over Europe. We expect the intensity and depth of ozone anomalies to increase in the period 1980–2020.

Using daily mean TCO_3 data (taken from World Ozone and Ultraviolet Radiation Data Centre, Toronto, Canada) for 12 stations in mid-latitude Europe, differences are calculated between TCO_3 on two consecutive days as a percentage of the average TCO_3 value for these days. Then the time series (1980–2020) of the normalized one-day differences are analysed separately for all considered stations. For example, Fig. 2 shows TCO_3 series and the corresponding normalized one-day TCO_3 changes in 2020 at Belsk. The range of the normalized one-day TCO_3 variability was ±30% in 2020 with the extremely low and high values in winter.

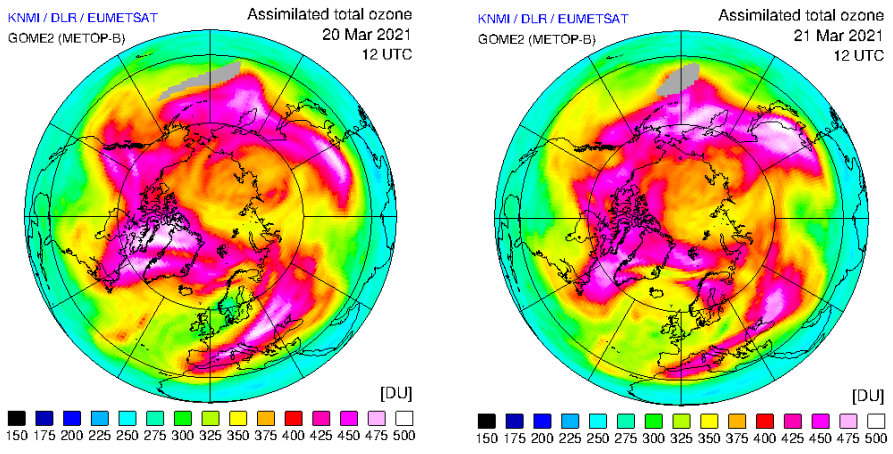


Fig. 1. Total column ozone over the Northern Hemisphere from satellite measurements GOME2 for 20 March (left) and 21 March 2021 (right).

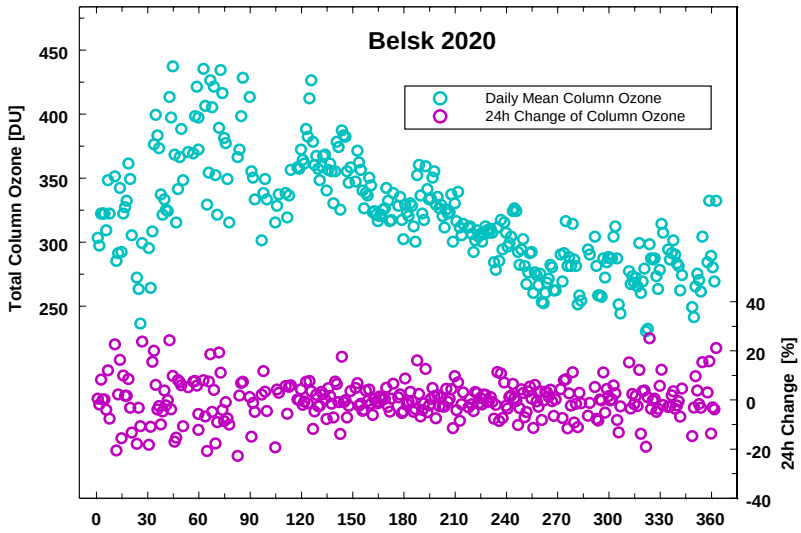


Fig. 2. Daily mean total column ozone and its normalized one-day change from the Dobson measurements at Belsk in 2020.

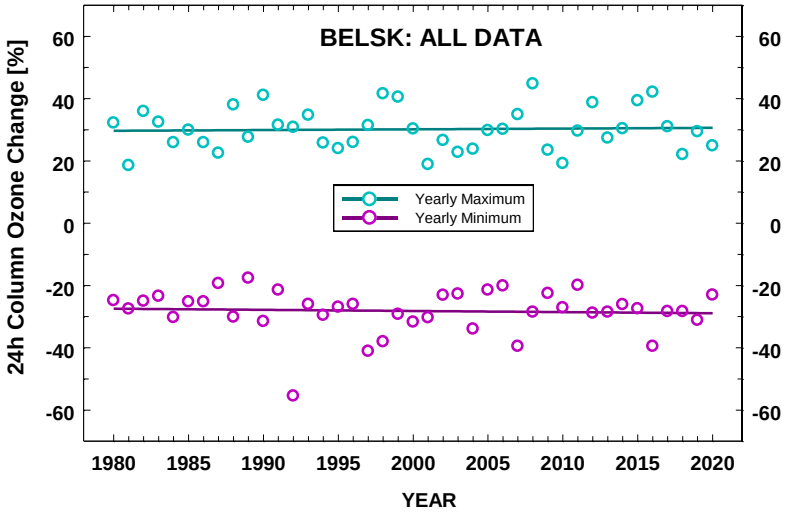


Fig. 3. Time series (1980–2020) of annual maxima and minima of the normalized one-day TCO_3 change at Belsk.

Several metrics of one-day TCO_3 change are proposed to search for long-term changes in the pattern of high/low TCO_3 area passing across Europe. The metrics are: standard deviation, the frequency of exceeding the threshold of 10% and 20% (for absolute value of normalized one-day change), and the minimum and maximum value. Linear trend (1980–2020) for each station, metric, and season was calculated, i.e., in total, 240 (12×5×4) time series were analysed. The trends were mostly statistically insignificant, see an example for the Belsk's maxima and minima (Fig. 3). Only in about 10% of cases, the trends were statistically significant, but also with a variable trend sign. In conclusion, the pattern of short-term TCO_3 changes in Europe has been stable during period of the troposphere warming and stratosphere cooling. For more details, see Krzyścin (2023).

Reference

Krzyścin, J.W. (2023), Trends in short-term variability of total column ozone over Europe for the period 1980–2020 from the ground-based observations and ERA5 reanalysis, *Atmos. Environ.* **295**, 119543, DOI: 10.1016/j.atmosenv.2022.119543.

UNCERTAINTY IN THE SPATIAL ASSESSMENT OF DROUGHT IN THE VISTULA CATCHMENT

E. Karamuz, I. Kuptel-Markiewicz, T.B. Senbeta, E. Bogdanowicz, J.J. Napiórkowski

The Standardized Precipitation Index (SPI) is one of the most widely used indicators in drought assessment studies due to its flexibility, spatial-temporal comparability, and quite simple calculation. Nevertheless, the SPI is a relative measure. Its calculation depends mainly on the probability density function (PDF) adopted as well as on the method used for parameter estimation and the reference period used in the estimation. The use of different types of distributions leads to different SPI values and may introduce inaccuracies in the assessment of the extent of the impact of the drought phenomenon. The study focuses on the uncertainty of meteorological drought extent determination in specific classes from a candidate probability distribution perspective and the cumulative time scale. The main goal of the study was to compare and highlight the discrepancies in determining the spatial extent of drought impacts resulting from using different candidate distributions to calculate SPI.

The WEI distribution tends to underestimate the number of droughts. It is particularly noticeable for the severe and extreme drought categories (Fig. 1b,c). The BS distribution under-

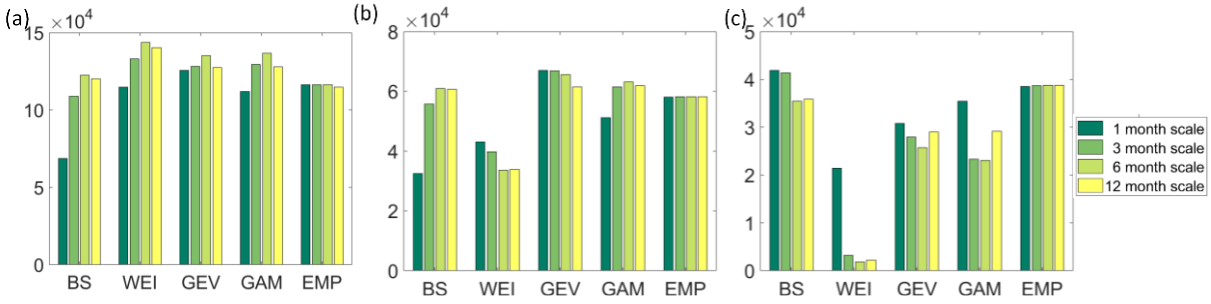


Fig. 1. Area in the Vistula catchment (number of grid cells) classified as: (a) moderate drought – SPI < –1, (b) severe drought – SPI < –1.5, and (c) extreme drought – SPI < –2 (BS – Birnbaum-Saunders distribution, WEI – Weibull distribution, GEV – Generalized Extreme Value distribution, GAM – Gamma distribution, EMP – empirical distribution) (modified from Karamuz et al. 2022).

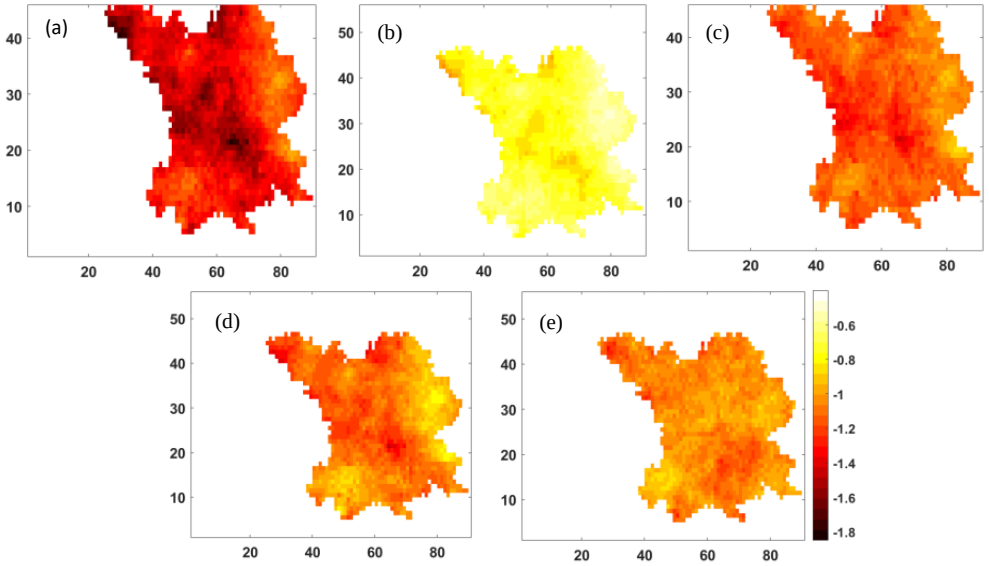


Fig. 2. Average drought severity in the Vistula catchment: (a) Birnbaum-Saunders distribution, (b) Weibull distribution, (c) Generalized Extreme Value distribution, (d) Gamma distribution, and (e) empirical distribution.

estimates the number of moderate and severe droughts for a 1-month accumulation period and overestimates extreme droughts (especially for the 1- and 3-month accumulation periods). Comparing the results with the EMP approach, they are generally consistent with those obtained using the GAM and GEV distributions (Fig. 1a,b). Significant differences occur only for extreme droughts (Fig. 1c). The EMP approach shows high stability of the results for individual accumulation periods, giving a similar number of drought events for each accumulation period. This regularity is observed for all drought categories.

Figure 2 shows the average drought severity in the Vistula catchment based on SPI values for 3-month accumulation period. The variation in drought severity depending on the distribution used is visible. The WEI and BS distribution stands out from other distributions underestimating and overestimating the magnitude of droughts, respectively. The obtained results indicate significant discrepancies in the spatial classification of individual drought categories, indicating high uncertainty in determining the area affected by severe and extreme droughts.

Reference

Karamuz, E., I. Kuptel-Markiewicz, T.B. Senbeta, E. Bogdanowicz, and J.J. Napiórkowski (2022), Discrepancies in the spatial assessment of drought – the Vistula catchment study, *Publs. Inst. Geophys. PAS* **443 (E-13)**, 59–63, DOI: 10.25171/InstGeoph_PAS_Publs-2022-044.

3. MANAGEMENT

The Board of Directors:

Beata Orlecka-Sikora
Director of the IG PAS

Mariusz Majdański
Deputy Director

Beata Fromeliusz
for Administration
and Finance

Krzysztof Otto
Deputy Director
for Polar and Technical
Issues

3.1 Employment structure

The structure of employment is illustrated by tables and graph below:

The number of employees

	Total	Researchers	PhD students
2016	175	69	29 (6 KNOW)
2017	178	67	26 (6 KNOW)
2018	187	74	22 (6 KNOW)
2019	184	78	18 (9 DS)
2020	179	77	15 (12 DS)
2021	176	75	9 (18 DS)
2022	181	78	6 (18 DS)
Change	+5	+3	+1

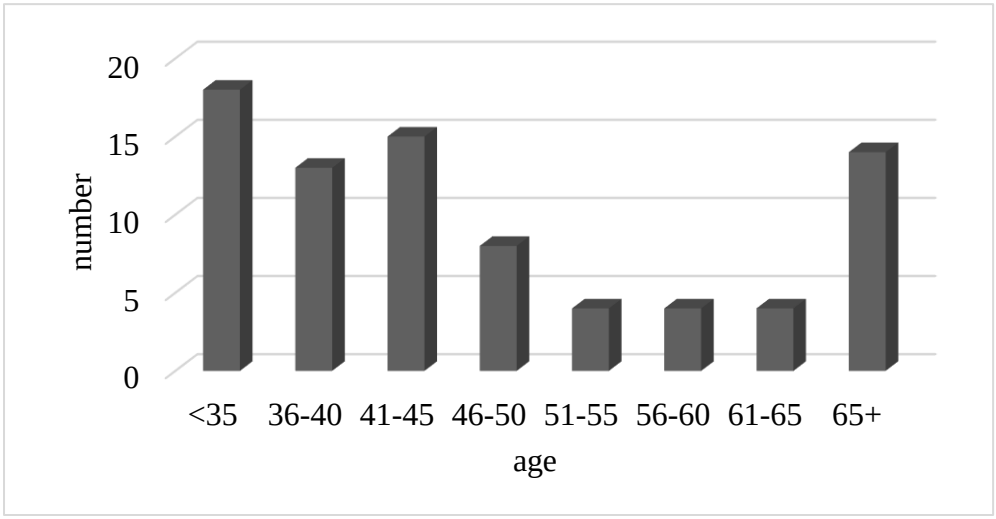
The employees by function

Function	Number
Polar expedition	9
Administration	49
Technicians	45
Researchers	78
Total	181

Researchers	Number
Research Assistant	7
Assistant Professor	31
Professor IG PAS	27
Professor	13

The employees by sex

	Female	Male
Researchers	24	54
Other	52	51
Total	76	105



Researchers' age structure

3.2 Activity of Scientific Information and Publishing Department

After the sad information about the death of Professor Roman Teisseyre, we want to emphasize the great role he has played in the history and present shape of all our publications. This renowned geophysicist was the Honorary Editor of the *Publications of the Institute of Geophysics PAS*, an active member of Editorial Boards of other journals and books, and a very fruitful author; articles to commemorate this distinguished scientist are in preparation.

In the year 2022, like in the previous years, the activity of the Scientific Information and Publishing Department concentrated on the three titles:

- *Acta Geophysica*,
- *Publications of the Institute of Geophysics, Polish Academy of Sciences*,
- *GeoPlanet: Earth and Planetary Sciences Book Series*.

Acta Geophysica

Acta Geophysica is a leading geophysical journal; it is edited at the Institute of Geophysics and in cooperation with Committee of Geophysics, Polish Academy of Sciences. It deals with all aspects of general and applied geophysics. This broad field is divided into five main categories: Solid Earth Sciences, Hydrology, Atmospheric and Space Sciences, Anthropogenic Geohazards, and Applied Geophysics.

Acta Geophysica publishes all kinds of high quality contributions: research and review articles, short communications as well as comments to published papers, and letters to the editor.

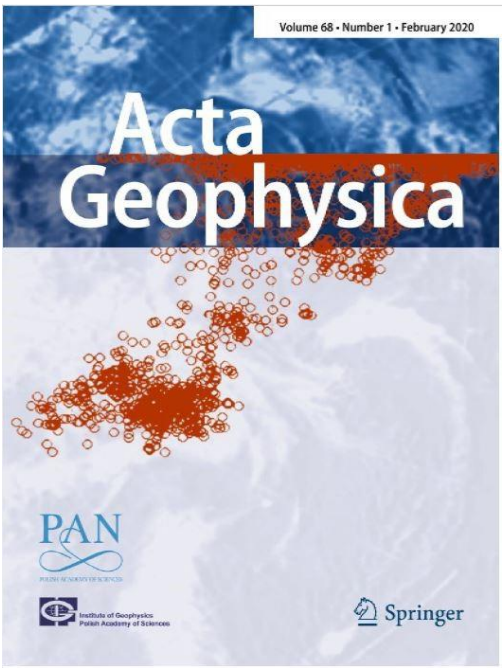
Proposals for special, topical issues are also welcome, for which careful assistance of the editorial team matches considerable independency granted to their Guest Editors.

The content-related supervision over the quality of *Acta Geophysica* is performed by the Editor-in-Chief (Prof. Eleftheria Papadimitriou from Greece), and her work is supported by the Co-Editors-in-Chief and Associate Editors – specialists in their fields, selected from among outstanding scientists. Help comes also from the Editorial Advisory Board which gathers prominent specialists to provide additional recommendations on the journal's policy and scope, try to attract high-quality manuscripts, and promote the journal.

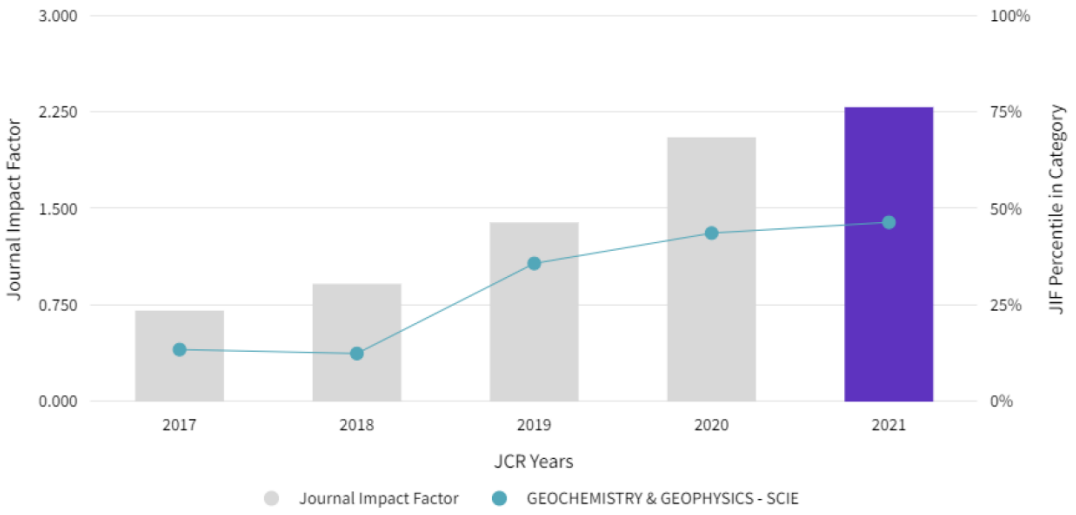
In the year 2022, six issues of *Acta Geophysica* were published, including two special issues (Experimental Methods and Instrumentation in Hydraulics and Trends; Perspectives and Prospects of Sensor Technologies in Hydrological Sciences). The total number of pages (B5) was 3021, and the number of articles was 194. The number of all papers submitted to *Acta Geophysica* in 2022 was 1033 – this was the first time that the threshold of 1 000 submitted articles was exceeded. *Acta Geophysica* has significantly increased its Impact Factor in the last three years (IF for 2019: 1.395; for 2020: 2.058; for 2021: 2.293 – the highest in the history of the journal). This is due to a large amount of work by an active international group of Editors and the publisher (Springer Nature).

According to the JCR ranking (JCI – Journal Citation Indicator) and Scimago, the journal is currently in the second quartile (Q2) of the most significant journals in the GEOCHEMISTRY & GEOPHYSICS group.

Publication website: https://www.springer.com/journal/11600/.



Front cover of *Acta Geophysica*

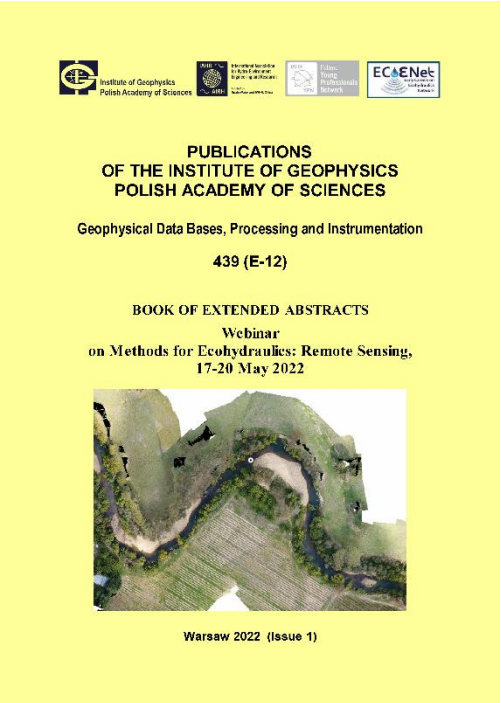


Impact Factor of *Acta Geophysica* (source: https://jcr.clarivate.com/)

Publications of the Institute of Geophysics, Polish Academy of Sciences

It is an electronic journal published by the Institute of Geophysics, Polish Academy of Sciences. It is available in Open Access form at https://pub.igf.edu.pl/. The Editor-in-Chief is Dr. Marek Kubicki. In the year 2022, six issues were published:

- Book of Extendent Abstracts. Webinar on Methods for Ecohydraulics: Remote Sensing, 17–20 May 2022;
- J. Reda, M. Neska, S. Wójcik, and P. Czubak – Results of Geomagnetic Observations: Belsk, Hel, Hornsund, 2020;
- J. Reda, M. Neska, S. Wójcik, and P. Czubak – Results of Geomagnetic Observations: Belsk, Hel, Hornsund, 2021;



Front cover of *Publications of the Institute of Geophysics, Polish Academy of Sciences*

- Atmospheric Electricity: Papers on Thunderstorm and Cloud Electricity;
- Book of Extended Abstracts. International Symposium on Drought and Climate Change, 24–25 November 2022;
- M. Grądzki – Application of the MATLAB bvp4c Solver in the Linear Stability Analysis of Some Magnetohydrodynamic Problems.

All the above-mentioned issues were published only in electronic form.

GeoPlanet: Earth and Planetary Sciences Book Series

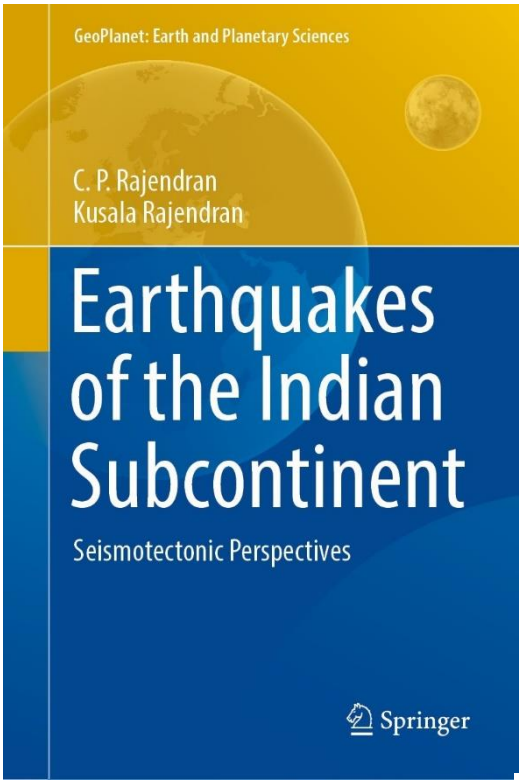
The *GeoPlanet* series is in part a continuation of Monographic Volumes of *Publications of the Institute of Geophysics, Polish Academy of Sciences*. Its Editors represent a consortium GeoPlanet (Earth and Planetary Research Centre), formed by five Institutes affiliated with the Polish Academy of Sciences: Institute of Geophysics, Space Research Centre, Institute of Geological Sciences, Nicolaus Copernicus Astronomical Centre, and Institute of Oceanology. The Editor-in-Chief is Prof. Paweł Rowiński.

This series is a forum for presenting the state-of-the-art and newest achievements in the Earth and space sciences. Its main objective is a multidisciplinary approach to link scientific activities in various Earth-related fields (geophysics, geology, oceanology) with the Solar System research.

The publications are produced in close cooperation between the GeoPlanet Series Editors and Springer Nature.

Just one issue bearing the copyright sign © 2022 was published, namely:

- C.P. Rajendran and Kusala Rajendran – Earthquakes of the Indian Subcontinent.



Front cover of *GeoPlanet: Earth and Planetary Sciences*

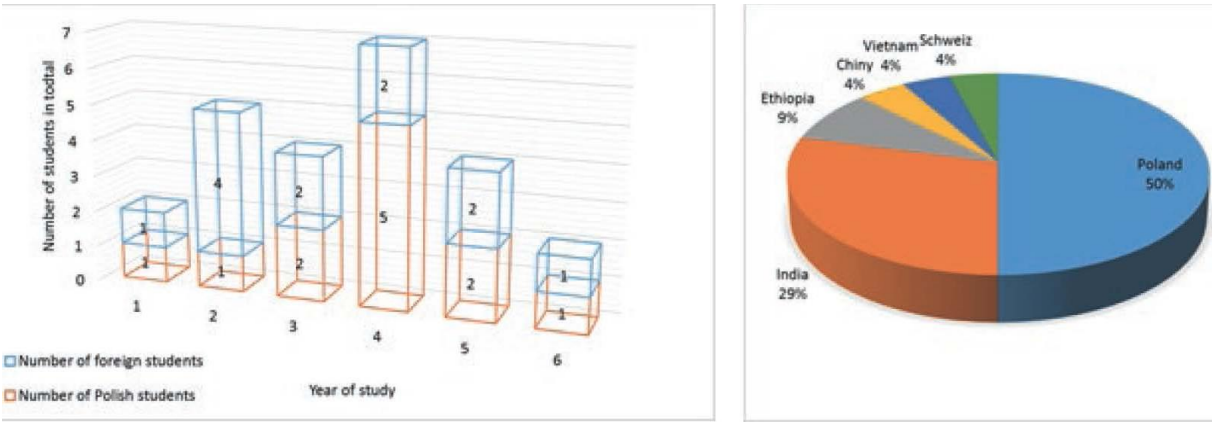
We were ready to publish the book Geoeconomy of the Future: Sustainable Agriculture and Alternative Energy, edited by Elena G. Popkova (from the Moscow State Institute of International Relations) and Bruno S. Sergi, but we decided, just after the invasion of Russia on Ukraine, to join the protest and halt the publication of this book in our series. It was published by Springer, but not in the GeoPlanet Series. Alongside, we rejected another proposal by those authors.

In the year 2022, we were also assisting Professor Subhasish Dey in editing the second, updated, and amended version of his monumental book Fluvial Hydrodynamics (nearly 1000 pages!). The first edition (2014) received enthusiastic reviews and was highly quoted. This second edition will be published jointly with a companion book Fluvial Hydrodynamics – Solutions Manual by Subhasish Dey and Zeeshan Ali; both will appear early this year.

Publication website:
https://www.springer.com/series/8821.

3.3 The activity of doctoral studies and doctoral schools at IG PAS in the Academic Year 2021/2022

Currently, there are 24 students studying at our institute, including 2 people who have been recruited to Doctoral Schools for the first year of study. One additional person has been just recruited and is expected at the beginning of 2023. Four people extended their studies for the 5th year. One person from the "6th year" has just defended his doctoral thesis at the beginning of 2023, and then 1 person has completed the exams and starts working on the doctoral thesis at the beginning of 2023. Twelve doctoral students come from abroad, representing different countries of the world (India, Ethiopia, China, Switzerland, and Vietnam), which proves a relatively good recognition of our educational offer abroad and contributes to an increase of the degree of "internationalization" of studies and the Institute (currently, this indicator is 50%).



Total number of students and foreign students by years of studies (left) and students by countries (right)

Mid-term evaluation

In 2022, 1 second-year student took part in the Assessment at the GeoPlanet School, and three doctoral students qualified for the assessment at IEDS. In both schools, all second-year students obtained a positive grade and thus were promoted to the third year of studies.

Commentary and prospects for the development of doctoral education at the IG PAS

In the next academic year, a further reduction in the number of IG PAS' PhD students is expected due to the defense of doctoral theses and we could not compensate the number of PhD students graduating with a similar number of new students. A positive trend is observed in decreasing average duration of studies because of earlier PhD defenses. It should also be mentioned that our studies are international and the results of recent recruitments indicate a growing trend of internationalization of studies. Interest in studies among Polish candidates is negligible. Unfortunately, there is also a noticeable drop in the level of candidates for our studies. Yet, the level of students admitted remains at a consistently high level. The activity of doctoral students in the field of science (number of published papers) and organizational activities, both in Poland and abroad, is satisfactory, despite the COVID pandemic, which had its (fortunately weakening) impact also in the last academic year. Students willingly look for courses outside the offer of the IGF and doctoral schools, organize trainings and workshops, and go on research trips themselves. Virtually every doctoral student has received a NAWA scholarship for the trip (some went twice).

In the 2021/2022 academic year, both schools changed the regulations and curricula, which hopefully will result in an improvement in teaching and in the students' assessment of studies, especially since we resign from online learning (unless it is absolutely necessary).

3.4 Data management portal

Proper management of scientific data is a key aspect of any reputable research organisation to ensure the authenticity of the collected data, improve its quality and maintain accuracy. In order to achieve the above-mentioned objectives, the data handling policies and procedures have been incorporated into the Institute's management policy and strategy.

The IG PAS Data Portal is an open data platform of Institute of Geophysics, Polish Academy of Sciences. This portal is used to collect, store, publish and share scientific data related to research activities, including access to data from external repositories. In line with national and international regulations and conventions such as FAIR principles, a metadata schema and data standards have been developed as the basis for interoperability. As the IG PAS Data Portal is still under development, it was rigorously monitored in search for technical and structural deficiencies. Based on the experiences of data steward and users, several new features have been proposed and metadata standards have been provided to enhance data management services and standardize databases. In addition, the view of the IG PAS Data Portal has been refreshed and links to Research Infrastructure Centers have been added.

The data of IG PAS are public and made available free of charge for non-commercial purposes on the basis of the applicable provisions of the law on sharing data financed from public funds. If the data is used by external entities, the data source should be provided in accordance with the guidelines contained in the metadata of the IG PAS Data Portal. The Data Portal stores 59 publicly available datasets and 25 projects (as of 3 February 2023). These numbers are constantly increasing as the process of adding new data is not complete.

The data steward provides researchers with consultations and support in managing, storing, and handling data and metadata throughout the entire data lifecycle. Additionally, he deals with the operation, monitoring, development, control and maintenance of IG PAS databases, including IG PAS Data Portal. The data steward is also involved in defining data management policies and standards in order to create more consistent, uniform and user-friendly databases according to commonly used data conventions and formats. The recent result of this task was the creation of a new internal database of measuring equipment of the IG PAS within the GLPI software, which is still under development. Its structure was obtained as a result of a deep discussion with the Representatives of Scientific Departments, who also enter the apparatus into the database. The data steward assists with the process of obtaining DOI numbers. Additionally, he designed and created logos of IG PAS Data Portal and IG PAS Equipment databases.

3.5 Projects / commercial agreements

Iceland Liechtenstein Norway grants	1 project
HORYZONT 2020	5 projects
European Commission	3 projects
Ministry of Science and Higher Education, Republic of Poland	14 projects
NAWA Narodowa Agencja Wymiany Akademickiej	2 projects
National Science Centre Poland	45 projects
Ośrodek Przetwarzania Informacji Państwowy Instytut Badawczy	2 projects
The Research Council of Norway	1 project
SIOS Svalbard Integrated Arctic Earth Observing System	4 projects
PASIFIC	1 project
Narodowe Centrum Badań i Rozwoju	3 projects
Commercial agreements	12 projects

3.6 Polish polar stations

Polish Polar Station Hornsund

The Polish Polar Station Hornsund, named after prof. Stanisław Siedlecki, is a modern interdisciplinary research platform located in the southern part of Spitsbergen, the largest island of the Svalbard archipelago. It was established in 1957 and has been in operation year-round since 1978. It is the only year-round Polish research observatory in the Arctic. The main objectives of the monitoring and research programmes carried out at the Station are related to the evolution of the High Arctic environment with respect to Climate Change.

The Station is managed by the Institute of Geophysics, Polish Academy of Sciences based in Warsaw, Poland. Well-equipped scientific laboratories, satellite communication and high standard accommodation and research facilities are available for over 20 visitors, in addition to the permanent staff of about 10 members of IG PAS Polar Expeditions. Every year, Polar Expedition to Hornsund Station is organized (photo by M. Moskalik).

Polish Antarctic Station A.B. Dobrowolski

Polish Antarctic Station A.B. Dobrowolski is a scientific station located in East Antarctica (Bunger Hills, Wilkes Land – 66°16′29″S, 100°45′00″E). Handed over to Poland by the Soviet Union in 1959, the Station currently belongs to the Polish Academy of Sciences and is managed by the Institute of Geophysics, Polish Academy of Sciences. The Station remained in hibernation, but thanks to the recent progress in the development of measuring instruments, scientific data acquisition, and telecommunication networks, IG PAS organized the 4th Polish Antarctic Research Expedition in the summer season 2021/2022 to revitalize the Station. The necessary funds were granted by the Ministry of Science and Higher Education. After 40 years, the 4th PARE reached Dobrowolski Station, in which Prof. Marek Lewandowski (IG PAS), Prof. Monika A. Kusiak (IG PAS), Dr. Adam Nawrot (IG PAS), and Prof. Wojciech Miloch (UiO) participated (photo by 4th PARE).

4. DEPARTMENT OF SEISMOLOGY

Łukasz Rudziński

4.1 About the Department

Department of Seismology is present in the three main scientific fields which are focused on Anthropogenic and Natural Geohazard, Geosystem Processes and, to a lesser extent, the Polar Regions. Main scientific interest of the Department fits in the Geohazards, which is clearly linked with anthropogenic seismicity. However, the Department's research activities extend also on natural seismic processes. The research activities of the Department can be divided into: seismicity induced by exploitation of geo-resources, seismicity triggered by water reservoirs (RTS) and hazards related with them, statistical properties of anthropogenic and natural seismic processes, engineering seismology and tectonic seismicity leading to large earthquakes.

The most interesting scientific topics last year dealt with the improvement in seismic hazard analysis by application of focal plane directions for estimation of ground motion models using machine learning and neural networks. The novel approach was applied, in which all previous measurements are included in the model, while the issue came down to the search for metric spaces of predictors. Since only functions determining distances for given features are important, it reduces the problem of creating Ground Motion Models to the study of different metric distances between parameters. This approach allows to examine a wide variety of predictors in various combinations of metric spaces. The method was tested on both local and global scale data sets.

The development of seismic process before strong earthquake was also investigated. Non-random, stochastic features of seismic series express the dynamics of seismic processes. Using these features can help to unravel earthquake predictability problems. Continuing the previous study of the clustering of seismicity before the *M*8.2 Tehuantepec, Mexico, 2017 earthquake, we analyzed the seismic process preceding the *M*8.3 Illapel, Chile, 2015 earthquake. Even though those two earthquakes resulted from quite different loading conditions, we obtained similar results. These results are important for seismic process modelling and seismic hazards analysis.

Similarly as in previous years, the Department of Seismology was active in EPOS Program. Particular activity was shown by the team involved in coordination of EPOS Thematic Core Service Anthropogenic Hazards (TCS AH). The consortium TCS AH, which is currently led by Prof. S. Lasocki, is a consortium of 13 European scientific, industrial, and private sector institutions and 1 associate partner from Brazil. TCS AH provides open data and services through the EPISODES Platform (former name: IS-EPOS platform) to foster research and training on induced seismicity and geo-hazards related to the exploration and exploitation of geo-resources. The development of the TCS AH infrastructure was supported within the following projects: EPOS SP (H2020), EPOS PL, and EPOS PL+, as well as DT-GEO A Digital Twin for GEOphysical extremes a Horizon Europe project.

4.2 Personnel

Head of the Department
Łukasz Rudziński (Associate Professor)

Professors
Stanisław Lasocki (Consortium EPOS TCS AH Director)
Beata Orlecka-Sikora (Director of the IG PAS)

Associate Professor
Grzegorz Lizurek

Assistant Professor
Taghi Shirzad (until July)

Research Assistants
Anastasios Kostoglou
Yaseen Mahmood
Monika Staszek

Technical Assistants
Mariusz Chmielewski
Izabela Dobrzycka
Jakub Kokowski
Kaj Michałowski
Janusz Mirek
Dorota Olszewska (until February)
Beata Plesiewicz
Mieczysław Rekowski
Leopold Stempowski
Francis Tong
Jan Wiszniowski

Technical Project Manager
Michał Lelonek (Consortium EPOS TCS AH)

Executive Office Manager
Anna Leśnodorska (Consortium EPOS TCS AH)

PhD Students
Alicja Caputa, Poland; Łukasz Rudziński – PhD supervisor
Jakub Kokowski, Poland; Łukasz Rudziński – PhD supervisor
Izabela Nowaczyńska, Poland; Grzegorz Lizurek – PhD supervisor
Anna Tymińska, Poland; Grzegorz Lizurek – PhD supervisor

4.3 Main research projects

- TCS AH EPOS ERIC For Governance and Coordination, S. Lasocki, EPOS ERIC, 2021–2023;
- TCS AH EPOS ERIC For Service Provision, S. Lasocki, EPOS ERIC, 2022–2023;
- TCS AH Thematic Core Services Anthropogenic Hazard, S. Lasocki, Ministry of Education and Science, 2021–2023;
- EPOS Sustainability Phase, B. Orlecka-Sikora, H2020, 2020–2023;
- DT-GEO A Digital Twin for GEOphysical Extremes, B. Orlecka-Sikora, Horizon Europe, 2022–2025;
- EPOS PL, D. Olszewska, POIR, OPI, 2016–2022;
- EPOS PL+ (Task 2), Ł. Rudziński, POIR, OPI, 2019–2023;

- Initialization and development of anthropogenic seismic processes induced by artificial surface reservoirs, G. Lizurek, NCN, 2018–2022;
- Application of machine learning and cluster identification for insight in the spatiotemporal changes of seismogenic processes triggered by water reservoirs, G. Lizurek, NCN, 2022–2026;
- Seismic monitoring of natural activity in Poland, Ł. Rudziński, M. Staszek, PIG-PIB, 2022–2024;
- Monitoring of the first possible Polish Nuclear Power Plant, Ł. Rudziński, PEJ/NDA, 2022–2023;
- Seismic activity analysis in the vicinity of Bogdanka mine, Ł. Rudziński, J. Mirek, LW Bogdanka/NDA, 2018–2023;
- Seismic hazard analisys in the vicinity of the Żelazny Most waste water impoundment, S. Lasocki, KGHM Polska Miedź SA/NDA, 2017–2022;
- Seismicity monitoring of the foreland and the base of the Żelazny Most waste water impoundment, S. Lasocki, KGHM Polska Miedź SA/NDA, 2017–2022;
- Influence of the natural and induced seismicity on the critical facilities in Poland, B. Orlecka-Sikora, NDA, 2022–2023.

4.4 Instruments and facilities

Equipment

- IG PAS Data e-NODE – which gathers episodes with their multidisciplinary data, manages them and provides access to AH data; Data Nodes linked to the EPISODES platform, which gather episodes with their multidisciplinary data, manage them and upon request, make them available to the platform. Presently two Data Nodes are in TCS AH: CIBIS, located in Institute of Geophysics PAS in Warsaw, Poland; CDGP Data Node located in EOST Strasbourg in France.
- Polish Seismological Network PLSN – the main regional seismological network in Poland. The network consists of 8 very broad-band Streckeisen STS2 seismometers: 7 in Poland and 1 in Hornsund. The network is a backbone system for seismological observation for both natural and induced seismicity. It also supports the IG PAS cooperation with local and regional authorities as well as governmental agencies and industrial partners. The data are open and available within EPOS seismological services;
- LUMINEOS – local monitoring of the mining-induced seismicity in Legnica–Głogów Copper District: 17 broadband (5s) seismometers and 10 strong motion instruments. Data are open and available within EPOS TCS AH EPISODES platform;
- BOIS – local monitoring of the seismicity induced by mining in Lubelski Węgiel Bogdanka colliery: 12 broadband (5s) seismometers, the network is directly connected with B+R project for Lubelski Węgiel Bogdanka S.A. Part of the data are already available within EPOS TCS AH EPISODES platform;
- SENTINELS – local monitoring of the induced seismicity around Czorsztyn–Niedzica artificial water reservoir: 10 broadband (5s) seismometers. Data are open and available within EPOS TCS AH EPISODES platform;
- Lai Chau – artificial water reservoir in Vietnam network cooperated with Institute of Geophysics, Vietnamese Academy of Science and Technology: 5 broadband seismometers (belonging to IG PAS) and 5 broadband seismometers (belonging to IG VAST). Data are available within EPOS TCS AH EPISODES platform;

- Geodynamic monitoring of Poland – the network for monitoring of the natural seismicity in Poland: 18 mobile stations supported by PLSN, the network is directly connected with B+R project for the Polish Geological Institute – National Research Institute (PGI-NRI);
- PEJ – the interdepartmental project involved in seismic monitoring of potential nuclear power plant (NPP) site in northern Poland in cooperation with Polskie Elektrownie Jądrowe Sp. z o.o. The project deals with local seismic activity as well as regional earthquakes. It is also supported by PLSN network.

Laboratory

EPISODES Platform (former name IS-EPOS Platform) provides access to the episodes' data, software, applications and computational resources for an advanced analysis and visualization.

The EPISODES Platform has been designed to serve as one of the main pillars of the Thematic Core Service Anthropogenic Hazards (TCS AH), belonging to the European Plate Observing System (EPOS) program – a long-term project aiming at integration of the European research infrastructure in solid Earth sciences. EPISODES Platform can be accessed by the website: https://tcs.ah-epos.eu/.

The EPISODES Platform integrates research infrastructure of EPOS TCS AH, giving access to: EPISODES – An Episode is a set of time-correlated geophysical, technological and other relevant geodata that relates comprehensively anthropogenic seismicity to its industrial cause; WORKSPACE – each affiliated user is provided with an own workspace where individual data processing and analyzing can be carried out; APPLICATIONS – Applications are software tools to process and analyze the data. They help to relate seismicity and technological factors for hazard assessment and other scientific targets; DOCUMENTS – the document repository is a comprehensive database of documents linked to the relevant episodes and applications.

Platform usage report for 2022

Status of user engagement:

- 1601 users of IS-EPOS platform from 59 countries
- 1063 users with institutional affiliation from 361 institutions
- 70 dedicated services
- 42 worldwide episodes
- 297203 data items
- 40063 displayed files
- 34617 file downloads from external repository
- 1286 file downloads from workspace
- 1689 files added to workspace
- 494 uploaded files
- 192 new users registered

4.5 Seminars and teaching

Seminars and lectures

M. Staszek, Earthquakes, Uniwersytet Trzeciego Wieku Politechniki Warszawskiej, Online, Lecture

G. Lizurek, Introduction to seismology, Międzynarodowa Środowiskowa Szkoła Doktorska, Warszawa, Lecture

B. Orlecka-Sikora, Anthropogenic seismicity, Międzynarodowa Środowiskowa Szkoła Doktorska, Warszawa, Lecture

Ł. Rudziński, Data processing in seismology, Międzynarodowa Środowiskowa Szkoła Doktorska, Warszawa, Lecture

M. Lelonek, EPISODES Platform presentation for AGH University of Science and Technology students of Geology, Kraków, Invited Lecture

S. Lasocki, The EPISODES open access platform for collaborative induced seismicity research, ARMA (American Rock Mechanics Association) TCIS, Online, Invited Lecture

Visiting scientists

Harsh Kumar Gupta, Indian National Science Academy, National Geophysical Research Institute, Hyderabad, India, 2–5.11.2022

Anne-Charlotte Joubert, European Spallation Source, Lund, Sweden, 15–16.11.2022

Savka Dineva, Luleå University of Technology, Lulea, Sweden, 15–16.11.2022

4.6 Meetings, workshops, conferences, and symposia

Presentations of the Department's members:

- M. Staszek, Ł. Rudziński, G. Kwiatek, G. Lizurek, B. Orlecka-Sikora, SSA Annual Meeting, Multiplet analysis for identification of fractures in areas of fluid migration: A comparative study of seismicity clusters from the geysers geothermal field, California and Song Tranh 2 water reservoir, Vietnam; Bellevue, Washington, USA, 20.04.2022, Oral, Conference;
- B. Orlecka-Sikora, S. Lasocki, Rockbursts and Seismicity in Mines 10, Interval estimation of seismic hazard parameters for mining induced seismicity; Tucson, Arizona, USA, 26–28.04.2022, Oral, Conference;
- S. Dineva, Ch. Dahnér, D. Malovichko, B. Lund, D. Gospodinov, N.P. Agostinetti, Ł. Rudziński, Rockbursts and Seismicity in Mines 10, Analysis of the magnitude 4.2 seismic event on 18 May 2020 in the Kiirunavaara mine, Sweden; Tucson, Arizona, USA, 26–28.04.2022, Oral, Conference;
- J. Kokowski, Ł. Rudziński, Rockbursts and Seismicity in Mines 10, Epicenter accuracy for seismic events recorded on the LUMINEOS network in Legnica-Głogów Copper District, Poland; Tucson, Arizona, USA, 26-28.04.2022, Oral, Conference;
- B. Orlecka-Sikora, M. Staszek, Ł. Rudziński, G. Lizurek, D. Olszewska, T. Shirzad, EGU 2022, Insight into the mechanics of seismic swarms triggered by water-reservoir impoundment; Vienna, Austria, 23.05.2022, Oral, Conference;
- S. Cesca, M. Sugan, Ł. Rudziński, S. Vajedian, P. Niemz, S. Plank, G. Petersen, Z. Deng, E. Rivalta, A. Vuan, M.P.P. Linares, S. Heimann, T. Dahm, EGU 2022, A massive earthquake swarm driven by magmatic intrusion at the Bransfield Strait, Antarctica; Vienna, Austria, 23.05.2022, Oral, Conference;
- G. Lizurek, K. Leptokaropoulos, M. Staszek, I. Nowaczyńska, A. Tymińska, EGU 2022, Reservoir triggered seismicity in tectonically stable and seismically active areas of Vietnam; Vienna, Austria, 23.05.2022, Oral, Conference;

- I. Nowaczyńska, G. Lizurek, EGU 2022, Seasonal stress inversion trends and Coulomb stress changes of RTS in Song Tranh2 reservoir, Vietnam; Vienna, Austria, 23.05.2022, Oral, Conference;
- Ł. Rudziński, S. Lasocki, B. Orlecka-Sikora, J. Kocot, A. Leśnodorska, M. Lelonek, 38th Czech-Polish-Slovak Symposium "On Mining and Environmental Geophysics", An open data infrastructure for the study of anthropogenic hazards related to the exploitation of georesources as part of the European Plate Observing System (EPOS); Stará Lesná, Vysoké Tatry, Slovakia, 1–3.06.2022, Oral, Symposium;
- G. Lizurek, TCS AH Workshop for scientists, EPISODES platform for scientists; online, 15.06.2022, Oral, Workshop;
- S. Lasocki, 56th Us Rock Mechanics / Geomechanics Symposium, EPOS Thematic Core Service Anthropogenic Hazards – open-access integrated infrastructures for research and innovation in the area of anthropogenic seismicity associated with the exploitation of georesources; Santa FE, USA, 26–29.06.2022, Oral, Symposium;
- S. Lasocki, 1st EPOS International Conference – EPOS Meets Africa and Latin America, Anthropogenic Hazards Thematic Core Service; Sal Island, Cape Verde, 11–13.07.2022, Oral, Conference;
- S. Lasocki, Latin American and Caribbean Seismological Commission IV ASSEMBLY, EPOS Thematic Core Service Anthropogenic Hazards – open-access integrated infrastructures for research and innovation in the area of anthropogenic seismicity associated with the exploitation of georesources; Quito, Ecuador, 04.08.2022, Oral – online participation, Symposium;
- Ł. Rudziński, S. Lasocki, B. Orlecka-Sikora, 3rd European Conference on Earthquake Engineering and Seismology, 17th European Conference on Earthquake Engineering and 38th General Assembly of the European Seismological Commission, Probabilistic seismic hazard analysis in the Pilot "Time-Dependent Anthropogenic Seismic Hazard Assessment"; Bucharest, Romania, 04–09.09.2022, Oral, Conference;
- A. Tymińska, 3rd European Conference on Earthquake Engineering and Seismology, 17th European Conference on Earthquake Engineering and 38th General Assembly of the European Seismological Commission, Noise influence on moment tensor inversion with the use of first P-wave amplitude based on VERIS and LUMINEOS networks; Bucharest, Romania, 4–9.09.2022, Poster, Conference;
- S. Lasocki, B. Orlecka-Sikora, A. Leśnodorska, M. Lelonek, 2022 Annual Meeting, Consortium Board and Platform Workshops, Annual reporting and future plans of TCS AH Consortium; Prague, Czech Republic, 25–26.10.2022, Oral, Meeting;
- M. Lelonek, 2022 EPOS TCS AH Consortium Board Annual Meeting EPISODES Platform Workshop; Praha, Czech Republic, 25.10.2022, Oral, Workshop;
- A. Leśnodorska, EPOS ERIC 11th Service Coordination Committee Meeting, TCS AH representation; Rome, Italy, 20–22.11.2022, Oral, Meeting;
- B. Orlecka-Sikora, ACK-UST Cyfronet Open Day, EPISODES platform – innovative support for seismic research of anthropogenic threats; Kraków, Poland, 21.11.2022, Oral, Conference;
- G. Lizurek, EPISODES Platform Workshop, EPISODES platform training for students; online, 02.12.2022, Oral, Workshop.

4.7 Publications

ARTICLES

Lasocki, S., **B. Orlecka-Sikora**, J. Kocot, **K. Chodzińska**, and **A. Leśnodorska** (2022), EPOS Thematic Core Service Anthropogenic Hazards in the operational phase, *Ann. Geophys*. **65**, 3, DOI: 10.4401/ag-8743.

Lasocki, S., Ł. Rudziński, et al., **B. Orlecka-Sikora** (2022), A hydrofracturing-triggered earthquake occurred three years after the stimulation, *Energies* **15**, 1, 336, DOI: 10. 3390/en15010336.

Atakan, K., et al., **B. Orlecka-Sikora**, **D. Olszewska**, B. Górka-Kostrubiec (2022), National EPOS initiatives and participation to the EPOS integration plan, *Ann. Geophys*. **65**, 2, DOI: 10.4401/ag-8758.

Cielesta, S., **B. Orlecka-Sikora**, and M.A. Idri (2022), Rotation of the stress tensor in a westerly granite sample during the triaxial compression test, *Geotech. Geol. Eng.* **40**, 2455–2474, DOI: 10.1007/s10706-021-02038-w.

Cesca, S., et al., **Ł. Rudziński** (2022), Massive earthquake swarm driven by magmatic intrusion at the Bransfield Strait, Antarctica, *Commun. Earth Environ*. **3**, 89, DOI: 10.1038/s43247-022-00418-5

Rahimi-Majd, M., **T. Shirzad**, et al. (2022), A self-organized critical model and multifractal analysis for earthquakes in Central Alborz, Iran, *Sci. Rep*. **12**, 8364, DOI: 10.1038/s41598-022-12362-7.

Shirzad, T., et al. (2022), Analysis of the shallow crustal structure of the Bam Fault Zone, Iran, using the surface wave and first-arrival P-wave tomography approaches, *Phys. Earth Planet. In.* **324**, 106852, DOI: 10.1016/j.pepi.2022.106852.

Wiszniowski, J. (2022), Application of focal plane directions for estimating ground motion models with general regression neural networks, *Pure Appl. Geophys*. **179**, 1197–1207, DOI: 10.1007/s00024-022-02975-4.

PUBLICATIONS IN PEER-REVIEWED CONFERENCE PROCEEDINGS

Kokowski, J., and **Ł. Rudziński** (2022), Epicenter accuracy for seismic events recorded on the LUMINEOS network in Legnica-Głogów Copper District, Poland. **In:** *Proc. 10th Conf. on Rockbursts and Seismicity in Mines (RaSiM)10, 24–29 April 2022, Tucson, Arizona, USA,* Society for Mining, Metallurgy & Exploration (SME), Colorado, USA.

Lasocki, S., **B. Orlecka–Sikora**, and **Ł. Rudziński** (2022), Probabilistic seismic hazard analysis in the Pilot "Time-Dependent Anthropogenic Seismic Hazard Assessment". **In:** C. Arion, A. Scupin, and A. Tiganescu (eds.), *Proceedings of the Third European Conference on Earthquake Engineering and Seismology – 3ECEES, 5–9 September 2022, Bucharest, Romania*, Conspress, Bucharest.

Lasocki, S., **B. Orlecka-Sikora**, **Ł. Rudziński**, **M. Lelonek**, et al. (2022), EPOS Thematic Core Service Anthropogenic Hazards – open-access integrated infrastructures for research and innovation in the area of anthropogenic seismicity associated with the exploitation of georesources. **In:** *Proc. 56th U.S. Rock Mechanics/Geomechanics Symposium, Santa Fe, New Mexico, USA, June 2022*, paper no. ARMA-2022-0708, DOI: 10.56952/ARMA-2022-0708.

Orlecka-Sikora, B., and **S. Lasocki** (2022), Interval estimation of seismic hazard parameters for mining induced seismicity. **In:** *Proc. 10th Conf. on Rockbursts and Seismicity in*

Mines (RaSiM)10, 24–29 April 2022, Tucson, Arizona, USA, Society for Mining, Metallurgy & Exploration (SME), Colorado, USA.

Dineva, S., et al., **Ł. Rudziński** (2022), Analysis of the magnitude 4.2 seismic event on 18 May 2020 in the Kiirunavaara mine, Sweden. **In:** *Proc. 10th Conf. on Rockbursts and Seismicity in Mines (RaSiM)10, 24–29 April 2022, Tucson, Arizona, USA*, Society for Mining, Metallurgy & Exploration (SME), Colorado, USA.

Tymińska, A., and **G. Lizurek** (2022), Noise influence on moment tensor inversion with the use of first P-wave amplitude based on VERIS and LUMINEOS networks. **In:** C. Arion, A. Scupin, and A. Tiganescu (eds.), *Proceedings of the Third European Conference on Earthquake Engineering and Seismology – 3ECEES, 5–9 September 2022, Bucharest, Romania*, Conspress, Bucharest.

5. DEPARTMENT OF ATMOSPHERIC PHYSICS

Aleksander Pietruczuk

5.1 About the Department

The Department's activities are focused on monitoring and investigating a wide range of physical atmospheric parameters including the columnar amount of ozone and its vertical distribution, atmospheric electricity and lightning activity, concentration and characteristics of airborne aerosols, UV spectra, trace gases concentrations, and thermodynamical processes in the tropics. These studies focus on different parts of the atmosphere: the surface layer, troposphere, stratosphere, and ionosphere. The common aim of these activities is to determine and predict the variability of atmospheric parameters and identify the sources of this variability on different time scales (from days up to decades). The Department contains four internal groups: Atmospheric Aerosols, Atmospheric Electricity, Ozone and UV, and Tropical Dynamics. The groups focus on the following topics in 2022:

- Examination of the vertical structure of aerosols with different techniques, complementing the remote technique with UAV measurements. Study of the influence of aerosol layering in the free troposphere on surface UV radiation and photolysis rates;
- Investigation of weather changes in the pattern of short-lived anomalies of high and low total ozone passing through Europe that is forced by climate change (troposphere warming and stratospheric cooling). A set of metrics characterizing the intensity of such TCO3 events has been proposed. The expected increase in the intensity of ozone concentration anomalies cannot be supported by the present analysis. This means that previously developed models of 24h TCO3 forecast will be valid for the next decades;
- Identification of sub-seasonal predictors of extreme precipitation events in the Maritime Continent using observations, ground-based and satellite remote sensing, and modeling (weather forecasts, atmospheric and oceanic reanalyses) resources;
- Detection of cloud-to-ground flashes by the measuring stations of the Local Lightning Detection Network (LLDN) in the Warsaw region and the Lightning Research Station (LOR) of the Rzeszów Technical University to identify different lightning development stages in the time and spectral domain.

New research projects funded by the NCN:

- Local and global Earth's atmospheric electric circuit signals in atmospheric electricity data from the observatory in Świder;
- Spatial representativeness of aerosol profiles, holistic multi-instrument approach;
- Modeling personal UV doses and their application to a pregnancy pattern prediction based on a large University College London Hospital (UK) database;
- Representation and predictability of Makassar (Sulawesi, Indonesia) flood of 2019 in MetOffice weather models (NAWA PROM).

5.2 Personnel

Head of the Department
Aleksander Pietruczuk
Associate Professor

Professor
Janusz Krzyścin

Associate Professors
Janusz Jarosławski

Assistant Professors
Dariusz Baranowski
Agnieszka Czerwińska
Jakub Guzikowski
Daniel Kępski
Magdalena Kossakowska
Marek Kubicki
Anna Odzimek
Izabela Pawlak
Michał Posyniak
Artur Szkop
Jose Tacza

Research and Technical Assistants
Piotr Barański
Anna Głowacka
Magdalena Morawska
Alicja Piłacik
Dorota Sawicka
Piotr Sobolewski
Jakub Wink

PhD Students
Alnilam Fernandez, India; Aleksander Pietruczuk – PhD supervisor
Beata Latos, Poland; Aleksander Pietruczuk, Dariusz Baranowski – PhD supervisors
Anahita Sattari, Iran; Jacek Kamiński – PhD supervisor
Wojciech Szkółka, Poland; Krzysztof Mizerski, Dariusz Baranowski – PhD supervisors

5.3 Main research projects

- Local and global Earth's atmospheric electric circuit signals in atmospheric electricity data from the observatory in Świder, A. Odzimek, D. Kępski, J. Tacza, I. Pawlak, National Science Centre, Poland, 2022–2024;
- Impact of absorbing aerosols on the planetary boundary layer height, M. Posyniak, National Science Centre, Poland, 2017–2022;
- Spatial representativeness of aerosol profiles, holistic multi-instrument approach, A. Pietruczuk, A. Szkop, D. Kępski, National Science Centre, Poland, 2022–2024;
- Multi-station analysis of solar effects in the ground-level atmospheric electric field, J. Tacza, A. Odzimek, National Agency for Academic Exchange, Ulam Program, Poland, 2020–2022;
- Wpływ procesów wieloskalowych na powstawanie ekstremalnych opadów w tropikach, D. Baranowski, B. Latos, W. Szkółka, National Science Centre "Opus", Poland, 2020–2023;
- Ekstrema pogodowe: powodzie i susze. W jaki sposób wielkoskalowa cyrkulacja atmosferyczna oraz para wodna nad Wschodnim Oceanem Indyjskim ze soba oddziałują?, B. Latos, D. Baranowski, National Science Centre "Preludium", Poland, 2021–2024;

- Monitoring of total ozone amount in the atmosphere and UV-B radiation at Belsk Observatory in 2021–2022, J. Jarosławski, Chief Inspectorate of Environment Protection, 2021–2022;
- Technologia wytwarzania innowacyjnych samoczyszczacych się prefabrykowanych elementów elewacyjnych i nawierzchniowych poprawiających jakość powietrza, J. Jarosławski, National Centre for Research and Development, Poland, 2021–2023;
- Modelowanie personalnych dawek promieniowania UV i ich zastosowanie w modelu prognozy przebiegu ciąży na podstawie rozbudowanej bazy danych University College London Hospital (UK), A. Czerwińska, National Science Centre "Miniatura 6", Poland, 2022–2023.

5.4 Instruments and facilities

Equipment

- Two "heavy" UAV with around 2 kg of payload, equipped with SparvIO dataloggers and a set of lightweight detectors, including dual-redundant pHT sensors;
- Two "small" UAV with lightweight data loggers (iMet-XQ2) and sea temperature sampling capability (RBR SoloT, SBE 56);
- Three automated weather stations;
- Polar nephelometer.

Laboratory

ACTRIS aerosol in-situ station at Racibórz. The joint laboratory of IG PAS and IEE PAS as a part of ACTRIS-PL Research Infrastructure. The station is equipped with:

- Polar nephelometer;
- Scanning Mobility Particle Sizer, to be delivered in January 2023;
- Aethalometer (owned by IEE PAS).

5.5 Seminars and teaching

Seminar and lectures

M. Posyniak, The use of cableways and ski lifts for smog profiling, Institute of Environmental Protection PAS, Warsaw, Poland, 26.01.2022, Seminar;

B. Latos, The role of tropical waves in the genesis of tropical cyclone Seroja, School of Environmental Sciences, University of East Anglia, Norwich, UK, 25.02.2022, Seminar;

B. Latos, The role of tropical waves in the genesis of tropical cyclone Seroja, Faculty of Physics, University of Warsaw, Warsaw, Poland, 25.03.2022, Seminar;

W. Szkółka, Tropospheric winds over Sumatra – the diurnal evolution and its variability in response to large-scale phenomena, Faculty of Physics, University of Warsaw, Warsaw, Poland, 03.06.2022, Seminar.

Thesis

D. Baranowski, M. Ciuryło, Atmospheric Boundary Layer Measurements with an uncrewed aerial vehicle (Bachelor thesis), University of Warsaw, Warsaw, Poland.

PhD

J. Kamiński, A. Sattari, Sensitivity of the GEM model to different descriptions of city surface parameters over Warsaw, IG PAS, Warsaw, Poland.

Visiting scientists

Jose Tacza, NAWA Polish National Agency for Academic Exchange, Peru, 06.07.2020–05.07.2022;

Marina Azaneu, University of East Anglia, Norwich, UK, 3–8.10.2022;

Adrian Matthews, Natasha Senior, University of East Anglia, Norwich, UK, 20–27.08.2022.

5.6 Meetings, workshops, conferences, and symposia

Presentations of the Department's members:

- G. Karnas, P. Barański, G. Maslowski, A. Odzimek, XVII International Conference on Atmospheric Electricity, Identification in the time and spectral domain of reflective processes involved in intra-cloud discharges recorded by the lightning detection station in Rzeszów in 2019; Tel Aviv, Israel, 19–24 June 2022, Poster, Conference;
- A. Odzimek, J. Tacza, D. Kępski, XVII International Conference on Atmospheric Electricity, Review of results of Global Circuit modelling by the EGATEC model compared with observational data; Tel Aviv, Israel, 19–24 June 2022, Poster, Conference;
- J. Tacza, A. Odzimek, J.-P. Raulin, M. Kubicki, XVII International Conference on Atmospheric Electricity, Effects of short-term solar disturbances on the potential gradient measurements recorded in two different stations; Tel Aviv, Israel, 19–24 June 2022, Poster, Conference;
- M. Posyniak, A. Szkop, K.M. Markowicz, 7th European Conference on Structural Control, Small sensors in atmospheric aerosols profiling; Poland, 10–13 July 2022, Poster, Conference;
- P. Sobolewski, M. Kubicki, 36th International Conference on Lightning Protection (ICLP), Simulation of the atmospheric electric field and current structure for sensors with different geometry in relation to the electric current measured in the external circuit; South Africa, Cape Town, 2–7 October 2022, Poster, Conference;
- J. Krzyścin, Workshop on Changes of the Polar Ecosystems, Is the polar ozone recovering?; Desne, Czech Republic, 9–11 November 2023, Oral, Workshop;
- P. Sobolewski, Workshop on Changes of the Polar Ecosystems, UV observations in the polar region; Desne, Czech Republic, 9–11 November 2023, Oral, Workshop;
- B. Latos, D. Baranowski, 35th Conference on Hurricanes and Tropical Meteorology, The role of tropical waves in the genesis of tropical cyclone Seroja – the first tropical cyclone to have a significant impact on Indonesian Land; New Orleans, USA, 9–13 May 2022, Oral, Conference;
- W. Szkółka, D. Baranowski, 35th Conference on Hurricanes and Tropical Meteorology, The diurnal evolution of tropospheric winds over Sumatra and its variability in response to large-scale phenomena; New Orleans, USA, 9–13 May 2022, Oral, Conference;
- D. Baranowski, 35th Conference on Hurricanes and Tropical Meteorology, Rainfall and Twitter. Spatio-Temporal Varability of Extreme Precipitation and Floods in Indonesia Assessed Using Satellite Observations and Twitter Activity, New Orleans, USA, 9–13 May 2022, Poster, Conference;

- B. Latos, D. Baranowski, European Geosciences Union (EGU) General Assembly 2022, The role of tropical waves in the genesis of tropical cyclone Seroja; Vienna, Austria, 23–27 May 2022, Oral, Conference;
- A. Czerwińska, J. Krzyścin, International Radiation Symposium 2022, Climatological aspects of Melanoma incidence increase in Europe; Thesalloniki, Greece, 04–08 July 2022, Oral, Syposium;
- A. Czerwińska, J. Krzyścin, International Radiation Symposium 2022, Patterns of teenagers' outdoor exposure in Spring–Autumn period during and after the first COVID-19 lockdown in 2020, Poland; Thesalloniki, Greece, 4–8 July 2022, Poster, Syposium;
- A. Czerwińska, J. Krzyścin, European Conference on Solar UV Monitoring and Personal UV Exposure, Patterns of teenagers' outdoor exposure in Spring–Autumn period during and after the first COVID-19 lockdown in 2020, Poland; Vienna, Austria, 14–16 September 2022, Oral, Conference;
- A. Czerwińska, J. Krzyścin, 1st MeteoXchange ECS Conference, Exposure to solar UV radiation of Polish children (preschoolers and teenagers) during Spring–Autumn period in 2018 and 2020; online, 17–18 March 2022, Oral, Conference.

5.7 Publications

ARTICLES

Karnas, G., **P. Barański**, et al. (2022), A new method for modeling and parameter identification of positively charged downward lightning leader based on remote lightning electric field signatures recorded in the ELF/MF range and 3D Doppler radar scanning data, *Energies* **15**, 22, 8566, DOI: 10.3390/en15228566.

Czerwińska, A., and **J. Krzyścin** (2022), Exposure to solar UV radiation of Polish teenagers after the first COVID-19 lockdown in March–April 2020, *Int. J. Biometeorol*. **66**, 10, 2021–2032, DOI: 10.1007/s00484-022-02337-8.

Jarosławski, J., **I. Pawlak**, **J. Guzikowski**, and **A. Pietruczuk** (2022), Impact of shale gas exploration and exploitation activities on the quality of ambient air—the case study of Wysin, Poland, *Atmosphere* **13**, 8, 1228, DOI: 10.3390/atmos13081228.

Witkowski, H., et al., **J. Jarosławski**, **A. Szkop** (2022), Ozone formation during photocatalytic oxidation of nitric oxides under UV irradiation with the use of commercial TiO_2 photocatalytic powders, *Materials* **15**, 17, 5905, DOI: 10.3390/ma15175905.

Kępski, D., and **M. Kubicki** (2022), Thunderstorm activity at high latitudes observed at manned WMO weather stations, *Int. J. Climatol*. **42**, 15, 7794–7816, DOI: 10.1002/joc.7678.

Laska, M., B. Luks, **D. Kępski**, et al., P. Głowacki, A. Nawrot (2022), Hansbreen Snowpit Dataset – over 30-year of detailed snow research on an Arctic glacier, *Sci. Data* **9**, 656, DOI: 10.1038/s41597-022-01767-8.

Sanchez-Cid, C., et al., **D. Kępski**, B. Luks, A. Nawrot (2022), Environmental and anthropogenic factors shape the snow microbiome and antibiotic resistome, *Front. Microbiol*. **13**, 918622, DOI: 10.3389/fmicb.2022.918622.

Zhang, W., et al., **M. Kubicki** (2022), Evaluation of ^{137}Cs, ^{133}Xe and ^{3}H activity concentrations monitored in the Arctic atmosphere, *J. Environ. Radioactiv*. **253–254**, 107013, DOI: 10.1016/j.jenvrad.2022.107013.

Pietruczuk, A., **A. Fernandes**, **A. Szkop**, and **J. Krzyścin** (2022), Impact of vertical profiles of aerosols on the photolysis rates in the lower troposphere from the synergy of photometer and ceilometer measurements in Raciborz, Poland, for the Period 2015–2020, *Remote Sens.* **14**, 5, 1057, DOI: 10.3390/rs14051057.

Szkop, A., **A. Fernandes**, and **A. Pietruczuk** (2022), Towards a multi-instrumental approach to closing aerosol optical extinction profiles, *Atmosphere* **13**, 9, 1443, DOI: 10.3390/atmos13091443.

Tacza, J., **A. Odzimek**, et al., **M. Kubicki** (2022), Investigating effects of solar proton events and Forbush decreases on ground-level potential gradient recorded at middle and low latitudes and different altitudes, *Space Weather* **20**, 3, e2021SW002944, DOI: 10.1029/2021SW002944.

CHAPTERS

Barański, P., and **J. Guzikowski** (2022), Dynamic and electric charge structure of thunderclouds obtained from the WRF and WRF_ELEC models and related to the charge sources of multiple CG flashes detected by the LLDN in the Warsaw region during thunderstorm season in 2009, *Publs. Inst. Geoph. PAS* **442 (D-77)**, 5–17, DOI: 10.25171/InstGeoph_PAS_Publs-2022-022.

Parfiniewicz, J., **P. Barański**, et al. (2022), A novel application of the virtual Fujita scale (VFS) number approach as a useful tool for assessment of lightning discharges development and severity for the derecho episode in Poland on 11 August 2017 together with its synoptic context, *Publs. Inst. Geoph. PAS* **442 (D-77)**, 85–119, DOI: 10.25171/InstGeoph_PAS_Publs-2022-027.

Odzimek, A., and **P. Barański** (2022), Atmospheric electricity: Papers on thunderstorm and cloud electricity. Preface, *Publs. Inst. Geoph. PAS* **442 (D-77)**, 3–3, DOI: 10.25171/InstGeoph_PAS_Publs-2022-021.

Odzimek, A., **P. Barański**, **M. Kubicki**, et al. (2022), Nimbostratus and Stratus cloud atmospheric electricity database and analysis methods for the Project "Research studies on the Electricity of Low-Level Layer Clouds for the purpose of developments in global atmospheric circuit modelling (ELLEC)", *Publs. Inst. Geoph. PAS* **442 (D-77)**, 19–40, DOI: 10.25171/InstGeoph_PAS_Publs-2022-023.

Odzimek, A., et al. (2022), Red sprites over thunderstorms in Czech Republic, Germany and Poland observed from Gliwice in 2011–2013, *Publs. Inst. Geoph. PAS* **442 (D-77)**, 41–54, DOI: 10.25171/InstGeoph_PAS_Publs-2022-024.

Odzimek, A., et al., **M. Kubicki** (2022), Red sprites over northwest Poland and the southern Baltic coast observed from Świder Geophysical Observatory, *Publs. Inst. Geoph. PAS* **442 (D-77)**, 55–70, DOI: 10.25171/InstGeoph_PAS_Publs-2022-025.

Odzimek, A., et al. (2022), Methodology of estimating time accuracy in TV recordings of sprite lightning observed from Gliwice and Świder 2011–2015, *Publs. Inst. Geoph. PAS* **442 (D-77)**, 71–83, DOI: 10.25171/InstGeoph_PAS_Publs-2022-026.

6. DEPARTMENT OF LITHOSPHERIC RESEARCH

Tomasz Janik and Working Group[1]

6.1 About the Department

NSL1. Structure and evolution of Central Europe's lithosphere with particular emphasis on the area of Poland

The main task of the work carried out under the topic is to identify the structure and evolution of the lithosphere of Central Europe by experimental seismic methods. Large projects of deep seismic soundings are carried out in multiannual cycles, usually in broad international cooperation. In 2022, the work of the Department of Lithospheric Research focused on the continuation of the interpretation of materials collected in previous seismic experiments, both active and passive, such as: **AniMaLS** – Sudetes, **SHIELD'21** – the East European craton (Ukrainian shield), and final presentation of the interpretation of materials from the **TTZ-South**, **BalTec** and **SOFIC** profiles were published.

In July 2022, we have finished measurement phase of the passive seismic project **PACASE** and started measurements for the **AdriaArray** seismic project (Carpathian Mountains, Pannonian Basin), both carried out in broad international cooperation.

Located in Central and Southeastern Europe, all the projects allow for determination of the structure of the Earth's crust, and, partly, also of the lower lithosphere along profile lines (two-dimensional) or spatial (three-dimensional) models. The data obtained along new generation of seismic profiles are of fundamental importance for understanding the geodynamics of the European continent. They are the base of reference for other disciplines of Earth sciences. Numerous citations testify to this. Our studies are also relevant for exploration seismic.

NSL2. Structure and evolution of the northern Atlantic lithosphere in the contact zone of the Eurasian and North American plate in the Arctic

The purpose of the work under the **NSL2** theme is geodynamic research in the North Atlantic in the Svalbard Archipelago area in the Arctic using seismic methods. This region, with oblique ultra-slow mid-oceanic Knipovich Ridge, is of fundamental importance in the study of tectonic evolution of the Earth.

6.2 Personnel

Head of the Department
Tomasz Janik
Professor

Professor
Aleksander Guterch (2/5)

Associate Professor
Piotr Środa

Assistant Professors
Somayeh Abdollahi
Wojciech Czuba
Monika Bociarska (maternity leave)

[1]Working Group of the Department of Lithospheric Research: Somayeh Abdollahi, Monika Bociarska, Wojciech Czuba, Tomasz Janik, Weronika Materkowska, Julia Rewers, Piotr Środa, Dariusz Wójcik, Aleksander Guterch.

Research Assistant
Weronika Materkowska (until February)
Dariusz Wójcik (until February)

Technical Assistant
Erwin Szypuła (since June)

PhD Student
Julia Rewers, Poland; Piotr Środa – PhD supervisor

6.3 Main research projects

- Structure of the Knipovich Ridge based on seismic investigations – KNIPSEIS, W. Czuba, National Science Centre "Opus", 2018–2023;
- Passive seismic studies of the lithosphere and asthenosphere of the Southern Poland (Carpathian area), W. Czuba, National Science Centre "Opus", 2020–2024;
- Deep Seismic Soundings Profile TTZ-South, T. Janik, National Science Centre "Harmonia", 2017–2022;
- Determination of the seismic anisotropy of the lithosphere in the Lower Silesia area, P. Środa, National Science Centre "Opus", 2017–2022;
- EPOS – European Plate Observing System (EPOS-PL), Task 7, W. Czuba, Operational Programme Smart Growth, 2014–2020, Co-financing from European Regional Development Fund, 2017–2022.

6.4 Instruments and facilities

Equipment
- 80 × TEXAN portable seismic recorders with 1C 4.5 Hz geophones,
- 60 × CUBE portable seismic recorders with 40×1C and 20×3C 4.5 Hz geophones,
- 100 × CUBE portable seismic recorders with 3C 4.5 Hz geophones,
- 11 × Güralp CMG-DM24S3EAM broadband seismic stations with CMG-6T 30 s seismometers,
- 1 × Ocean Bottom Seismometers, semi-broadband (Güralp),
- 20 × L-4C-3D 1 Hz seismometers,
- 6 × timing system devices (for measuring times at shooting points).

6.5 Meetings, workshops, conferences, and symposia

Presentations of the Department's members:
- T. Janik, D. Wójcik, EGU General Assembly 2022, Two-dimensional gravity and magnetic model along a new WARR profile in the transition zone from the Precambrian to Palaeozoic platform in the southern Baltic; Vienna, Austria, 23–27 May 2022, Oral/Poster, Conference;
- T. Janik, W. Czuba, P. Środa, D. Wójcik, 19th Symposium Tectonic, Structural Geology and Geology of Crystalline Rocks (TSK19), Deep structure of the East European Craton at the transition from Sarmatia to Fennoscandia as interpreted from the TTZ-South seismic profile (SE Poland to Ukraine); Halle, Germany, 9–11 March 2022, Oral, Symposium;
- D. Wójcik, T. Janik, BalTec grant final meeting, Deep structure of the Teisseyre–Tornquist Zone from modelling of the OBS data, BalTec grant final meeting; Warsaw, Poland, 25–26 October 2022, Oral, Meeting;

- W. Czuba, P. Środa, T. Janik, M. Mendecki, S.P. Malinowski, J. Rewers, S. Abdollahi, ORFEUS Annual Observatory Meeting and Workshop, Adria Array Project in Poland; Potsdam, Germany, 6–7 October 2022, Poster, Meeting.

6.6 Publications

ARTICLES

Abdollahi, S., et al. (2022), Integrated analysis of surface wave velocity and gravity data for the development of new density-velocity models of the crust and upper mantle in SE Iran, *J. Asian Earth Sci.: X* **7**, 100101, DOI: 10.1016/j.jaesx.2022.100101.

Janik, T., et al., **W. Czuba**, **P. Środa**, **D. Wójcik** (2022), Lithospheric structure of the East European craton at the transition from Sarmatia to Fennoscandia interpreted from the TTZ-South seismic profile (SE Poland to Ukraine), *Minerals* **12**, 2, 112, DOI: 10.3390/min12020112.

Janik, T., **D. Wójcik**, et al., M. Malinowski (2022), Crustal structure across the Teisseyre–Tornquist Zone offshore Poland based on a new refraction/wide-angle reflection profile and potential field modelling, *Tectonophysics* **828**, 229271, DOI: 10.1016/j.tecto.2022.229271.

Tiira, T., **T. Janik**, et al. (2022), Implications on crustal structure from the South Finland Coastal (SOFIC) deep seismic sounding profile, *Bull. Geol. Soc. Finland* **94**, 2, 165–180, DOI: 10.17741/bgsf/94.2.004.

7. DEPARTMENT OF THEORETICAL GEOPHYSICS

Zbigniew Czechowski

7.1 About the Department

Scientific activity of Department of Theoretical Geophysics was concentrated on the following issues: seismic models and forecast, fracture processes described by DEM, fluid flows, time series analysis, stochastic models, and monitoring of rotational effects.

New analytical tools have been proposed to study seismicity patterns in subduction and collision zones. For the seismic data, such as earthquake magnitudes and locations in time and space, the concepts of forerunning and afterrunning earthquakes have been defined, which enabled us to create the rooted forest graphs representing hierarchical earthquake structure ready for further analyses. Then, a variety of graph characteristics and measures have been applied to the processed data, to reveal how the seismicity structure changes both in time and in space, among different subduction zones. In this way we can reveal seismicity patterns related to the largest earthquake occurrences, which can lead to their forecasting.

Discrete Element Method (DEM) was used to study the so-called "scale problem" formulated in the context of seismic (earthquake) source physics. It is related to the fact that the earthquake processes involve two distinct time (and so energy) scales. One of them (long-term scale) is related to the slow loading of faults system with a typical orders of tens-to-thousands years. The second one comprises time scales typical for dynamic phase of fault failure and ranges from mili-seconds to minutes. The task which has been analyzed was a question whether the rupturing process is time scale invariant.

Supervised machine learning was applied to predict the stick-slip phenomena in Discrete Element Method numerical fault model. Algorithms were trained using only current measurements of the numerical model state (changes in energy, rotation of particles, and other physical quantities). Important part of that approach is an attempt to predict movements within the numerical fault not in regards to the history of previous movements, but only on the basis of the signals recorded in the model.

The Brinkman flow model was studied to describe flows through an overgrown canal. The theoretical results of this work are consistent with the laboratory results presented in the literature in foreign and domestic reports. The model describes the flow of a two-phase liquid: the Stokes equation was used above the plants and the flow through the porous medium (channel bottom) was modeled with the Brinkman equation.

Systematic analyzes of the multiscale behavior of irreversibility, irregularity, and non-stationarity of time series versus the degree of nonlinearity and persistence of the stochastic model were performed. As a time series generator, the modified nonlinear Langevin equation with build-in persistence is adopted. The modes of nonlinearity are determined by one parameter and do not change the Gaussian form of the distribution function. The expected direct dependencies (sometimes non-trivial) were found and explained profiting from the simplicity of the model. The multiscale patterns can be treated as fingerprints, which characterize the type of correlations and nonlinearities hidden in time series.

7.2 Personnel

Head of the Department
Zbigniew Czechowski
Professor

Professor
Wojciech Dębski

Associate Professors
Włodzimierz Bielski
Piotr Senatorski

Assistant Professor
Piotr Klejment

Technical Assistant
Krzysztof Teisseyre

PhD Student
Venkata Gangadhara Rao Kambala, India; Piotr Senatorski – PhD supervisor

7.3 Main research project

- Prediction of numerically modeled earthquakes using supervised machine learning, P. Klejment, National Science Centre, 2022–2023.

7.4 Seminars and teaching

Seminars and lectures

P. Klejment, „Numerical Methods with Python", Lecture for PhD students from Geoplanet School; Warsaw, Poland, April–May 2022, Lecture (PhD students), 12h;

P. Klejment, „Introduction to Machine Learning with Python", Lecture for PhD students from: Geoplanet School; Warsaw, Poland, November 2022 – January 2023, Lecture (PhD students), 20 h;

W. Dębski, Short story on how loading scenario influences the failure of solid material under stretching, IG PAS, Warsaw, Poland, 28.10.2022, Seminar.

7.5 Meetings, workshops, conferences, and symposia

Presentation of the Department's member:

- P. Klejment, International Sopot Youth Conference 2022, Predicting a pattern of DEM modelled stick-slip events in faults using Machine Learning; Sopot, Poland, 10 June 2022, Oral, Conference.

7.6 Publications

ARTICLES

Bielski, W., and R. Wojnar (2022), Laminar flow past the bottom with obstacles – a porous medium approximation, *J. Theor. Appl. Mech.* **60**, 3, 509–520, DOI: 10.15632/jtam-pl/151947.

Czechowski, Z. (2022), Sławomir Maj (1933–2021), *Prz. Geof.* **67**, 1–2, 55–57.

Dębski, W. (2022), Symulacje pękania materiałów o ziarnistej strukturze mikroskopowej: pierwsze uwagi, *Prz. Geof.* **67**, 1–2, 39–54, DOI: 10.32045/PG-2022-030.

8. DEPARTMENT OF HYDROLOGY AND HYDRODYNAMICS

Jarosław Napiórkowski

8.1 About the Department

Under the framework of NHH02, the following activities were performed in 2022:

- **Modelling hydrological extremes:** Hydrological extremes (floods and droughts) are a major concern, as they are forecasted to further impact Central Europe. The Department focused on both aspects, thanks to externally funded projects and statutory activities.

  In terms of droughts, recent studies show that the Vistula Basin is nowadays more prone to droughts than it was a few decades ago. This trend is also confirmed by the statistical analysis of the extremes in the basin, which pointed out a relationship between the longest sequences of days with no precipitation and periods of drought.

  In terms of floods, both statistical analyses of precipitation and modelling approach showed an increment of extreme events across Europe, characterised by shorter durations but increased magnitude. Further research was focused on considering not only water in flood risk management, but also other phenomena like ice, vegetation growth, and sediment transport.
- **Experimental studies:** Flume experiments focused on the transport of non-natural materials. Studies on microplastics incipient motion were carried out in the Hydrodynamic Models Laboratory, while macroplastic transport was investigated in collaboration with IBW-PAN. These experiments aim to characterise the effect of different flow conditions, bed morphology/morphotype and vegetation density on the uptake and transport of an emerging pollutant, eventually leading to improved modelling approaches to depicting plastic transport and fate in rivers. Laboratory studies were conducted to explain the non-Newtonian effects of biologically modified seawater on the hydrodynamics of microplastics. Moreover, the sinking of microplastic aggregates in the salinity-stratified water column was investigated to evaluate their settling behaviour and stability. In addition to laboratory experiments, field investigations were performed in a small agricultural ditch to investigate the effects of vegetation on flow and mixing processes.
- **Thermal regime of freshwater systems:** Arctic rivers are highly affected by climate change, and understanding and predicting their behaviour can provide more insights into a solution to address global warming. In Hornsund, Spitsbergen, field works were performed via tracer experiments, thermal imagery and water temperature measurements to infer the variability of the thermal regime of three arctic rivers. Such data will then be used for modelling to reconstruct past water temperatures, and project future conditions. Two new variants of the air2water model have been proposed for surface water temperature modelling in lakes that are based only on the air temperature data. In the first variant, parameters associated with lake stratification of cold waters differ from those associated with lake stratification of warm waters. In the second variant, the so-called normalized depth of the well-mixed surface layer is not fixed but advantageously optimized.

8.2 Personnel

Head of the Department
Jarosław Napiórkowski
Professor

Professors
Paweł Rowiński

Associate Professors
Ewa Bogdanowicz
Monika Kalinowska
Krzysztof Kochanek
Magdalena Mrokowska
Michael Nones
Marzena Osuch
Adam Piotrowski

Assistant Professors
Emilia Karamuz
Iwona Kuptel-Markiewicz
Anna Łoboda
Łukasz Przyborowski
Muhammad Jehanzaib

Research Assistants
Arianna Varrani, PhD candidate; Paweł Rowiński, Magdalena Mrokowska – PhD supervisors
Marta Majerska, PhD candidate; Marzena Osuch, Tomasz Wawrzyniak – PhD supervisors

Technical Assistant
Andrzej Skrzyński

PhD Students
Abhishek Bamby Alphonse, India; Marzena Osuch and Tomasz Wawrzyniak – PhD supervisors
Nicole Hanselmann, Switzerland; Marzena Osuch and Tomasz Wawrzyniak – PhD supervisors
Tesfaye Senbeta, Etiopia; Krzysztof Kochanek, Emilia Karamuz – PhD supervisors
Geetika Harish Chauhan, India; Krzysztof Kochanek, Iwona Kuptel-Markiewicz – PhD supervisors
Motuma Regasa, Etiopia; Michael Nones – PhD supervisor
Yiwei Guo, China; Michael Nones – PhD supervisor

8.3 Main research projects

- Skutki zmian w łączności ekosystemów na procesy metaboliczne i emisje gazów cieplarnianych z ocieplających się jezior Arktycznych i Alpejskich, M. Osuch, National Science Centre, Poland, 2021–2024;
- Visualization of methane fluxes along coastal boundaries of Arctic permafrost and glaciers, M. Osuch, PASIFIC, 2021–2024;
- Application of machine learning and cluster identification for insight in the spatio-temporal changes of seismogenic processes triggered by water reservoirs, K. Kochanek, National Science Centre, Poland, 2021–2024;
- FORecasting hydrological response, Carbon balance and Emissions from natural mires in arctic-to-temperate zone transect in abrupt climatic change, K. Kochanek, NORWAY GRANTS, 2021–2023;
- Geosphere INfrastructures for QUestions into Integrated Research, K. Kochanek, Horizon Europe, 2022–2026;

- Understanding and modeling compound climate and weather events, I. Kuptel-Markiewicz, COST Action CA17109, 2018–2023;
- Variability of arctic river thermal regimes in a changing climate (VariaT), M. Majerska, M. Osuch, A. Łoboda, NCBiR SMALL GRANT SCHEME, 2022–2023;
- Experimental studies on the effects of exopolymers on the settling dynamics and interactions between solid particles in density-stratified aquatic systems, M. Mrokowska, National Science Centre, Poland, 2020–2024;
- Assessing Catchment Sediment Yield and Siltation Impacts on Reservoir Capacity under Land Cover/Use Changes: the Case Study of the Fincha Dam, Ethiopia; M. Nones, National Science Centre, Poland, 2020–2024;
- Satellite imagery to support flood risk modelling in large European rivers, M. Nones, National Science Centre, Poland, 2022-2026;
- NEXUSNET: Network on Water-Energy-Food Nexus for a low-carbon economy in Europe and beyond, M. Nones, COST, 2021–2025;
- Plastics monitoRIng detectiOn RemedIaTion recoverY (PRIORITY), A. Varrani, A. Łoboda, Ł. Przyborowski, COST, 2021–2025;
- Applied remote sensing and geophysical imaging in recognition of the changes of the water balance in High Arctic catchments, M. Osuch (PI), National Science Centre, Poland, 2021–2025;
- Technika śledzenia ruchu cząstek w badaniu transportu makroplastiku w kanałach z roślinnością – konsultacja naukowa, Ł. Przyborowski, National Science Centre, Poland, 2021–2023;
- Human and climate impacts on drought dynamics and vulnerability Polish-Chinese SHENG1 Project HUMDROUGHT, J. Napiórkowski (PI), E. Bogdanowicz, E. Karamuz, M. Nones, I. Kuptel-Markiewicz, National Science Centre, Poland, 2019–2023;
- Laboratory experiments on microplastics transport in open channel flow, A. Varrani, National Science Centre, Poland, 2021–2024.

8.4 Instruments and facilities

Equipment

- Parrot SEQUOIA+ (multispectral camera)
- Drone DJI Matrice 300 RTK with two cameras DJI Zenmuse H20T and Micasense RedEdge-MX
- Zenmuse P1 RGB camera
- GPSMap 66i z PL TOPO 2020.4
- FLIR T530 Thermal Camera
- Time-lapse camera Cyclopse Pro Glacier (×2)
- Logger CR1000X
- Sonda Drill & Drop (×3)
- Ewapometer EWP-1010 (×6)
- GPS Garmin Montana 610

Laboratories

Hydraulic Laboratory:

- two tilting flumes with flow recirculation system for open channel flow and gravity currents studies (dimensions: 5 m long × 0.25 m wide; 5 m long × 0.15 m wide)

- two ultrasonic flowmeters (range: 0.6–150 L/min; 1–250 L/min)
- high-precision inclinometer: 2 directional slope measurement
- two cameras GoPro HERO9 BLACK (acquired in 2021)

Laboratoryof Hydrodynamic Micromodels:

- high-resolution macro image acquisition system (two monochrome 60 fps CMOS cameras, macrolenses, computer)
- density meter (range: 0–3 g/cm^3, accuracy: 0.0001 g/cm^3) (acquired in 2021)
- refractometer
- precision balance (readability: 0.01 g, max capacity: 6100 g) (acquired in 2021)
- analytical balance (readability: 0.1 mg, max capacity: 220 g) (acquired in 2021)

Hornsund

- Meteorological stations Gill GMX 400 with logger metstream100 (×6)
- C-FLUOR sensor+data logger (×2)
- TD-Diver (×3) +BaroDiver

8.5 Seminars and teaching

Seminars and lectures

P. Rowiński, Towarzystwo Naukowe Warszawskie, wykład staszicowski, Woda, wielki problem Polski i świata, Warsaw Scientific Society, Warsaw, Poland, 30.11.2022, Invited lecture;

M. Nones, Flood risk management is not only water management: insights from Europe, University of Thrace, Xanthi, Greece, 12.10.2022, Invited lecture;

M.S. Regasa, Applied Hydrology, Wollega University, Nekemte, Ethiopia, 1 February 2022 – 1 August 2022, Invited lecture;

A. Varrani, Introduction to river engineering, BTU Cottbus-Senftenberg & WUT, Cottbus (DE), Warsaw (PL), 7–10.11.2022, Online Seminar;

I. Kuptel-Markiewicz, Statistical methods in hydrology, Warsaw University of Technology, Warsaw, Poland, May–June 2022, Lectures;

I. Kuptel-Markiewicz, Statistical methods for modeling hydro-climatological extremes with application to Poland, Institut National de la Recherche Scientifique (INRS), Québec, Canada, 05.12.2022, Lecture;

K. Kochanek, Statistical methods in hydrology, Warsaw University of Technology, Warsaw, Poland, May–June 2022, Lectures;

M. Kalinowska, et al., Ogólnopolska Szkoła Hydrauliki, Badania rzek i kanałów z wykorzystaniem nauki obywatelskiej, Cracow, Poland, May 2022, Oral;

M. Osuch, Przysposobienie sieciowe, WSISiZ, Warsaw, Poland, Winter semester 2022/2023, Lectures;

M. Osuch, Geomarketing, WSISiZ, Warsaw, Poland, Winter semester 2022/2023, Lectures and laboratories;

A.B. Alphonse, N. Hanselmann, Geomarketing, WSISiZ, Warsaw, Poland, Winter semester 2022/2023, Lectures and laboratories;

A.B. Alphonse, N. Hanselmann, GIS, WSISiZ, Warsaw, Poland, Winter semester 2022/2023, Lectures and laboratories.

Teaching

A. Krztoń-Maziopa, M. Mrokowska, M. Pękalska, Badania wpływu agregacji makrocząsteczek wybranych egzopolimerów w wodnych roztworach z dodatkiem elektrolitów na dynamikę opadania cząstek stałych, Warsaw University of Technology, Warsaw, Poland.

Visiting scientists

Koen Berends, Deltares, Delft, The Netherlands, 15–18.11.2022

8.6 Meetings, workshops, conferences, and symposia

Presentations of the Department's members:

- E. Karamuz, I. Kuptel-Markiewicz, E. Bogdanowicz, J. Napiórkowski, XXIV Computational Methods in Water Resources, Long term changes in groundwater dynamics in the Vistula Catchment; Gdańsk, Poland, 19–23.06.2022, Poster, Conference;
- J. Napiórkowski, A. Piotrowski, E. Karamuz, T. Senbeta, XXIV Computational Methods in Water Resources, The impact of the choice of the optimizer on the performance of catchment runoff models; Gdańsk, Poland, 19–23.06.2022, Conference;
- M. Nones, M.S. Regasa, 1st International Electronic Conference on Land, Past trends and future changes in land use/land cover in the Fincha basin, Ethiopia; online, 17–19.05.2022, Oral, Online conference;
- M. Nones, et al., Webinar on Remote Sensing in Ecohydraulics, Deep Learning Approach for river hydro-morphodynamics monitoring using SAR data; online, 17–20.05.2022, Oral, Webinar;
- M.S. Regasa, M. Nones, Sopot Youth Conference, Past and future land use/land cover changes in the Ethiopian Fincha sub basin; online, 10.06.2022, Oral, Online conference;
- M. Majerska, M. Osuch, et al., Sopot Youth Conference, Variability of hydrological regimes of non-glaciated polar catchment in a changing climate; online, 10.06.2022, Oral, Online conference;
- M.S. Regasa, M. Nones, 39th IAHR World Conference, Land use land cover changes in the Fincha basin, Ethiopia; Granada, Spain, 19–24.06.2022, Poster, Conference;
- M. Nones, et al., 4th Int. Conference I.S. Rivers, Exploitation of satellite data for the monitoring river morphological evolution: study case of the Po River (Italy); Lyon, France, 4–8.07.2022, Oral, Conference;
- M.S. Regasa, M. Nones, 4th Euro-Mediterranean Conference for Environmental Integration, Trends of historical land use land cover changes and future predictions for Ethiopia's Fincha watershed; online, 01–04.11.2022, Oral, Hybrid conference;
- M. Nones, et al., Symposium on Drought and Climate Change, Remote sensing as a tool to monitor drought at the watershed scale; online, 24–25.11.2022, Oral, Online symposium;
- E. Karamuz, I. Kuptel-Markiewicz, T. Senbeta, E. Bogdanowicz, J. Napiórkowski, Symposium on Drought and Climate Change, Discrepancies in the spatial assessment of drought – the Vistula catchment stud; online, 24–25.11.2022, Oral, Online symposium;
- E. Bogdanowicz, E. Karamuz, I. Kuptel-Markiewicz, K. Kochanek, Symposium on Drought and Climate Change, The dynamics of low flows characteristics and exposure to hydrological drought along the River Vistula and in its; online, 24–25.11.2022, Oral, Online symposium;

- T. Senbeta, E. Karamuz, K. Kochanek, J. Napiórkowski, Symposium on Drought and Climate Change, Understanding socio-hydrological vulnerability to drought over time and space in the context of climate change, Vistula River; online, 24–25.11.2022, Ora, Online symposium;
- Ł. Przyborowski, A. Łoboda, Online Youth Water Congress on "Emerging water challenges since COVID-19", Local water monitoring activities as inclusive, modern ecological education – Poland perspective and proposal; online, 06–08.04.2022, Oral, Online conference;
- Ł. Przyborowski, A. Łoboda, et al., 7th IAHR Europe Congress, Athens, Experiments on macroplastic storage in rivers with spur dikes; Athens, Greece, 7–9.09.2022, Oral, Conference;
- A. Varrani, Ł. Przyborowski, M. Mrokowska, P. Rowiński, et al., 7th IAHR Europe Congress, Athens, Measuring near-bed flow field in shallow quasi-uniform flow conditions with the use of an Ultrasonic Velocity Profiler; Athens, Greece, 7–9.09.2022, Oral, Conference;
- A. Varrani, EU TalentOn, Working group on EU Mission Restore our Oceans and Waters; Leiden, The Netherlands, 14–17.9.2022, Oral, Hackathon-Workshop on entrepreneurial skills;
- A. Varrani, M. Mrokowska, P. Rowiński, et al., MICRO 2022, Threshold surface concentration of microplastics triggering higher mobility on gravel bed; online, 14–18.11.2022, Poster, Online conference;
- E. Karamuz, I. Kuptel-Markiewicz, E. Bogdanowicz, J. Napiórkowski, XXIV International Conference on Computational Methods in Water Resources, Analysis of long term baseflow changes in the Vistula catchment; Gdańsk, Poland, 19–23.06.2022, Poster, Conference;
- I. Kuptel-Markiewicz, DAMOCLES Compound Events Final Conference "Perspectives and ways forward in Compound Event research", Variability and depth–duration–frequency relationship of maximum rainfall as the factor of flood risk in the Upper Vistula Basin; Lisbon, Portugal,
  6–8.09.2022, Poster, Conference;
- I. Kuptel-Markiewicz, STAHY2022 – 12th International Workshop on Statistical Hydrology, A new approach to the determination of depth-duration-frequency (DDF) curves for maximum rainfall; Chia, Italy, 17–20.09.2022, Poster, Conference;
- E. Karamuz, I. Kuptel-Markiewicz, T. Senbeta, E. Bogdanowicz, STAHY2022 – 12th International Workshop on Statistical Hydrology, Uncertainty in spatio-temporal drought assessment; Chia, Italy, 17–20.09.2022, Poster, Conference;
- K. Kochanek, I. Kuptel-Markiewicz, et al., STAHY2022 – 12th International Workshop on Statistical Hydrology, Flood peaks theoretically derived distribution based on the variable contributing area with annual maximum rainfall GEV distributed; Chia, Italy, 17–20.09. 2022, Poster, Conference;
- K. Kochanek, et al., STAHY2022 – 12th International Workshop on Statistical Hydrology, De-evolution of the ice phenomena in Southern Poland; Chia, Italy, 17–20.09.2022, Poster, Conference;
- K. Kochanek, et al., IV Krajowy Kongres Hydrologiczny, Zanik zjawisk lodowych w południowej Polsce; Warsaw, Poland, 21–23.09.2022, Oral, Conference;
- K. Kochanek, et al., 11th IAHS Assembly, Analysis of long-term changes in inundation characteristics of near-natural temperate riparian habitats in the Lower Basin of the Biebrza Valley, Poland; Montpellier, France, 29.05–3.06.2022, Poster, Conference;

- T. Sanbeta, K. Kochanek, E. Karamuz, et al., 11th IAHS Assembly, Rainfall-runoff modelling approaches for investigating the role of human factors in influencing hydrological drought; Montpellier, France, 29.05–3.06.2022, Poster, Conference;
- E. Bogdanowicz, IV Krajowy Kongres Hydrologiczny, Potrzeby, możliwości i ograniczenia wyznaczania charakterystyk projektowych przepływów maksymalnych; Warsaw, Poland, 21–23.09.2022, Oral (keynote lecture), Conference;
- E. Bogdanowicz, K. Kochanek, I. Kuptel-Markiewicz, Chauhan, IV Krajowy Kongres Hydrologiczny, Some aspects of trend detection in time-series of hydrological data, Warsaw, Poland, 21–23.09.2022, Oral, Conference;
- I. Kuptel-Markiewicz, IV Krajowy Kongres Hydrologiczny, Statystyczny model zależności wielkość-czas trwania-częstotliwość ekstremalnych opadów w dorzeczu górnej Wisły; Warsaw, Poland, 21–23.09.2022, Oral, Conference;
- M. Osuch, et al., EGU2022, Assessment of streamflow trends in snow and glacier melt dominated catchments of SW Spitsbergen, Vienna, Austria, 23–27.05.2022, Oral, Conference;
- M. Osuch, et al., EGU2022, Climatic and anthropogenic drivers of river intermittence in Poland; Vienna, Austria, 23–27.05.2022, Oral, Conference;
- M. Osuch, et al., EGU2022, The effect of subsurface freezing-thawing in the SW Svalbard on the newly deglaciated areas; Vienna, Austria, 23–27.05.2022, Oral, Conference;
- A.B. Alphonse, M. Osuch, et al., SIOS Online Conference on "Earth Observation (EO) and Remote Sensing (RS) applications in Svalbard", UAV-based remote sensing observation products in High Arctic Catchments in SW Spitsbergen; online, 12–14 October 2022, Oral, Online conference;
- P. Rowiński, Symposium "Anthropocene and the mission of transformation", Why water? Why rivers?; Paris, France, 13.04.2022, Invited keynote lecture, Conference;
- P. Rowiński, Falling Walls Summit, How to restart science in Ukraine after the Russian aggression?; Berlin, Germany, 8.11.2022, Invited plenary panellist, Conference;
- P. Rowiński, Kujawsko-Pomorskie Forum of Innovation, Science, Business and Local Government, Modern research challenges of environmental hydraulics; Toruń, Poland, 6.11.2022, Invited keynote lecture, Conference;
- M. Mrokowska, et al., The 14th Symposium on Ecohydraulics, Laboratory experiments on rheological effects of exopolymers on particle sinking in seawater, China; online, 10–14.10. 2022, Oral, Conference;
- M. Mrokowska, IUTAM Symposium on "Particles, Drops and Bubbles in Stratified Environments", Dynamics of disk settling in two-layered liquid with non-linear density transition; France, online, 4–7.07.2022, Oral, Conference;
- M. Mrokowska, et al., Ocean Sciences Meeting, Effects of dispersed exopolymer gels on the rheology of water column and settling dynamics of solid particles: a laboratory perspective; USA, online, 24.02–4.03.2022, Oral, Conference;
- M. Mrokowska, et al., MICRO 2022, Effects of biologically modified seawater on settling behaviour of microplastics; online, 14–18.11.2022, Oral, Conference;
- M. Mrokowska, et al., MICRO 2022, Homoaggregation of environmentally realistic polystyrene; online, 14–18.11.2022, Oral, Conference;
- E. Karamuz, A. Łoboda, Webinar on Remote Sensing in Ecohydraulics, How to avoid difficulties in a proper acquisition of remote sensing data? Measurements of sand waves movement in the Świder River, Poland; online, 17–20.05.2022, Oral, Webinar.

8.7 Publications

ARTICLES

Kalinowska, M.B., and **A. Goździk** (2022), Research investigations on rivers and channels using citizen science, *AURA* **2022**, 3, 13–15, DOI: 10.15199/2.2022.3.1 (in Polish).

Kochanek, K., et al. (2022), Gradual disappearance of ice phenomena in rivers of southern Poland, *Monogr. Kom. Gosp. Wodnej PAN* **45**, 19–31 (in Polish).

Kochanek, K., and **I. Markiewicz** (2022), Statistical approach to hydrological analysis, *Water* **14**, 7, 1094, DOI: 10.3390/w14071094.

Mrokowska, M.M., et al. (2022), Effect of exopolymer gels on the viscoelasticity of mucus-rich saltwater and settling dynamics of particles, *Mar. Chem.* **246**, 104163, DOI: 10.1016/j.marchem.2022.104163.

Ghorbani, M.K., et al., **M. Nones** (2022), Concept-based integration of project management and strategic management of rubber dam projects using the SWOT–AHP method, *Sustainability* **14**, 5, 2541, DOI: 10.3390/su14052541.

Liro, M., **M. Nones**, et al. (2022), Modelling the effects of dam reservoir backwater fluctuations on the hydrodynamics of a small mountain stream, *Water* **14**, 19, 3166, DOI: 10.3390/w14193166.

Przyborowski, Ł., **M. Nones**, **M. Mrokowska**, et al. (2022), Preliminary evidence on laboratory experiments to detect the impact of transient flow on bedload transport, *Acta Geophys.* **70**, 2311–2324, DOI: 10.1007/s11600-022-00743-5.

Quang, N.H., et al., **M. Nones** (2022), Assessment of human-induced effects on sea/brackish water chlorophyll-a concentration in Ha Long Bay of Vietnam with Google Earth Engine, *Remote Sens.* **14**, 19, 4822, DOI: 10.3390/rs14194822.

Osuch, M., T. Wawrzyniak, and **M. Majerska** (2022), Changes in hydrological regime in High Arctic non-glaciated catchment in 1979–2020 using a multimodel approach, *Adv. Clim. Change Res.* **13**, 4, 517–530, DOI: 10.1016/j.accre.2022.05.001.

Osuch, M., T. Wawrzyniak, et al. (2022), Changes in the flow regime of High Arctic catchments with different stages of glaciation, SW Spitsbergen, *Sci. Total Environ.* **817**, 152924, DOI: 10.1016/j.scitotenv.2022.152924.

Araźny, A., et al., T. Wawrzyniak, **M. Osuch** (2022), Climate change in the Arctic and Antarctic ecosystems, *Kosmos* **70**, 4, 579–595, DOI: 10.36921/kos.2022_2836 (in Polish).

Blauhut, V., et al., **M. Osuch** (2022), Lessons from the 2018–2019 European droughts: A collective need for unifying drought risk management, *Nat. Hazards Earth Sys. Sci.* **22**, 6, 2201–2217, DOI: 10.5194/nhess-22-2201-2022.

Majdański, M., et al., A. Marciniak, B. Owoc, **M. Osuch**, T. Wawrzyniak (2022), Variations of permafrost under freezing and thawing conditions in the coastal catchment Fuglebekken (Hornsund, Spitsbergen, Svalbard), *Permafrost Periglac. Process.* **33**, 3, 264–276, DOI: 10.1002/ppp.2147.

Marciniak, A., **M. Osuch**, T. Wawrzyniak, B. Owoc, et al., M. Majdański (2022), Multi-method geophysical mapping of ground properties and periglacial geomorphology in Hans Glacier forefield, SW Spitsbergen, *Pol. Polar Res.* **43**, 2, 101–123, DOI: 10.24425/ppr.2022.140363.

Piotrowski, A.P., et al., **J.J. Napiórkowski** (2022), Air2water model with nine parameters for lake surface temperature assessment, *Limnologica* **94**, 125967, DOI: 10.1016/j.limno.2022.125967.

Piotrowski, A.P., et al. (2022), Differential evolution and particle swarm optimization against COVID-19, *Artif. Intell. Rev*. **55**, 2149–2219, DOI: 10.1007/s10462-021-10052-w.

Xu, Y., et al., **Ł. Przyborowski** (2022), Assessing riverbed surface destabilization risk downstream isolated vegetation elements, *Water* **14**, 18, 2880, DOI: 10.3390/w14182880.

Regasa, M.S., and **M. Nones** (2022), Past and future land use/land cover changes in the Ethiopian Fincha Sub-basin, *Land* **11**, 8, 1239, DOI: 10.3390/land11081239.

Leta, M.K., et al., **M.S. Regasa** (2022), Parameter uncertainty analysis for streamflow simulation using SWAT model in Nashe watershed, Blue Nile River Basin, Ethiopia, *Appl. Environ. Soil Sci*. **2022**, 1826942, DOI: 10.1155/2022/1826942.

Merga, D.D., et al., **M.S. Regasa** (2022), Evaluation of surface water resource availability under the impact of climate change in the Dhidhessa Sub-basin, Ethiopia, *Atmosphere* **13**, 8, 1296, DOI: 10.3390/atmos13081296.

Rowiński, P.M., et al. (2022), Environmental hydraulics research for river health: recent advances and challenges, *Ecohydrol. Hydrobiol*. **22**, 2, 213–225, DOI: 10.1016/j.ecohyd. 2021.12.003.

Hamidifar, H., et al., **P.M. Rowiński** (2022), Assessment of environmental water requirement allocation in anthropogenic rivers with a hydropower dam using hydrologically based methods—case study, *Water* **14**, 6, 893, DOI: 10.3390/w14060893.

Jóźwiak, W., and **P. Rowiński** (2022), Jerzy Jankowski (1933–2020), *Prz. Geof.* **67**, 1–2, 58–63.

Waldschläger, K., **A. Varrani**, et al. (2022), Learning from natural sediments to tackle microplastics challenges: A multidisciplinary perspective, *Earth-Sci. Rev*. **228**, 104021, DOI: 10.1016/j.earscirev.2022.104021.

9. DEPARTMENT OF MAGNETISM

Rafał Junosza-Szaniawski

9.1 About the Department

The activities of the Department of Magnetism include the studies of lithospheric structures and dynamic processes inside the Earth, environmental magnetism, and the study of magnetohydrodynamics with applications to the dynamics of the Earth's interior.

Problems of environmental pollution (outdoor and indoor air, soil and water sediments) and their wide range of impacts on human life are contained within the NM1 task. In 2022, the work was focused on the application of combined magnetic and non-magnetic methods to study the quality of outdoor and indoor air, transformations of Fe-bearing magnetic minerals in technogenic soils, pollution around former and active mining areas and to identify which of Fe-bearing phases bind heavy metals in road dust. The multidisciplinary national and international level collaboration allowed to study sources of urban air pollution and to evaluate adverse health effects related to exposure pathway of heavy metals. The monitoring service of the concentration of particulate matter (PM10 and PM2.5) and its magnetic susceptibility to trace the trends in the ground-level air pollution variability was also continued.

The research group working on the NM2 task conducted research on paleogeographic and tectonic issues. In 2022, research work was carried out in the Carpathian Mountains (Slovakia, Poland, and Romania), on Svalbard (Ny Friesland – Nordaustlandet), on the Popocatépetl volcano in Mexico, and in the East European Craton area. The main topics of this research work were the paleoposition of lithospheric plates and tectonic deformation associated with the collision of lithospheric plates as well as the characterization of pyroclastic sequences. Paleomagnetic studies of the E section of Svalbard were aimed at verifying the Neoproterozoic True Polar Wander hypothesis. The problem of magnetic field stability in the Proterozoic was also investigated. In addition, organic-rich shales were studied in the context of environmental changes, particularly changing geochemical conditions on the sea floor. Studies of pyroclastic materials have shown that magnetic properties can be used to separate different types of pyroclastic materials associated with different magma compositions.

Within the NM3 task, the construction of regional models of the geoelectric structure as well as research on source effects in the magnetotelluric method were continued. A detailed, 3-D model of the resistivity distribution in the lithosphere in the Grójec Fault area was developed. Pilot preliminary studies were carried out to identify peat beds and geoarchaeological studies of mass graves were also conducted in the Treblinka and Kulmhof extermination camps. The magnetic dynamo team within the NM3 has conducted research on non-equilibrium effects in generation of the turbulent electromotive force (EMF), identifying a strong dependence of the EMF on the coexistence of the cross- and kinetic helicities in the magnetohydrodynamic turbulence. The joint action of the magnetic buoyancy, the magnetorotational and the centrifugal instabilities in the Solar tachocline was also investigated. Throughout 2022 there were continued the Earth's magnetic field observations within NO 1.2 task, including the absolute measurements and continuous recording of geomagnetic field in Belsk, Hel, and Hornsund (Spitsbergen) observatories, a continuous recording of geomagnetic field changes with real-time data access at four permanent stations and Schumann Resonance observations in Hornsund and Suwałki. Our magnetic observatories and permanent stations participated in the INTERMAGNET, IAGA, IMAGE, and EMMA networks. We are also continuously providing geomagnetic data for SWARM missions.

9.2 Personnel

Head of the Department
Rafał Junosza-Szaniawski
Associate Professor

Professors
Volodymyr Bakhmutov
Marek Lewandowski
Maria Teisseyre-Jeleńska

Associate Professors
Tomasz Ernst
Beata Górka-Kostrubiec
Waldemar Jóźwiak
Krzysztof Michalski
Krzysztof Mizerski
Anne Neska
Krzysztof Nowożyński

Assistant Professors
Katarzyna Dudzisz
Sylwia Dytłow
Marek Grądzki
Dominika Niezabitowska-Śliwka
Szymon Oryński

Laboratory Technician
Grzegorz Karasiński

Technicians
Paweł Czubak
Krzysztof Kucharski
Mariusz Neska
Anna Wójcik
Stanisław Wójcik

Head of Laboratory for Paleomagnetism and Environmental Studies
Tomasz Werner

Head of Laboratory for Geoelectromagnetism
Jan Reda

PhD Students
Szczepan Bal, Poland; Krzysztof Michalski – PhD supervisor
Agata Bury, Poland; Anne Neska – PhD supervisor
Paweł Jujeczko, Poland; Krzysztof Mizerski – PhD supervisor
Sarasija Sanaka, India; Anne Neska – PhD supervisor
Dorota Staneczek, Poland; Rafał Szaniawski – PhD supervisor
Wojciech Szkółka, Poland; Krzysztof Mizerski – PhD supervisor

9.3 Main research projects

- EPOS–PL European Plate Observing System; Task 4 – CIBAL – Centre of Research Infrastructure of Analytical Laboratories, T. Werner, B. Górka-Kostrubiec, European Union, European Regional Development Fund, Operational Program Smart Growth 2014–2020, 2017–2022;
- EPOS–PL + European Plate Observing System; Task 4 – CIBAL – Centre of Research Infrastructure of Analytical Laboratories, T. Werner, S. Dytłow, European Union, European Regional Development Fund, Operational Program Smart Growth 2014–2020, 2020–2023;
- EPOS–PL European Plate Observing System; Task 3 – CIBOGM – Geomagnetic and Magnetotelluric Observations Research Infrastructure Center, W. Jóźwiak, European Union, European Regional Development Fund, Operational Program Smart Growth 2014–2020, 2017–2022;
- EPOS–PL + European Plate Observing System; Task 3 – CIBOGM – Geomagnetic and Magnetotelluric Observations Research Infrastructure Center, W. Jóźwiak, European Union, European Regional Development Fund, Operational Program Smart Growth 2014–2020, 2020–2023;
- The role of lithospheric memory in the spatial and temporal localization of the intraplate deformation – investigating a deep structure of the Grójec Fault Zone based on potential field anomalies and seismic data, W. Jóźwiak, National Science Centre "Opus 13", Poland, 2018–2022;
- Buoyancy driven magnetic dynamo, K. Mizerski, National Science Centre "Sonata Bis", Poland, 2018–2022;
- Svalbox 2.0 – FAIR geoscientific data from Svalbard, K. Michalski, Research Council of Norway, 2021–2023;
- Geo-INQUIRE, Access to observations, data products and services in the geosciences. Task. 09, S. Dytłow, R. Junosza-Szaniawski,EC Horizon Europe Programme, Project Number: 101058518, 2022–2025;
- The Timanian Orogeny in NorthernSvalbard (TONeS), K. Michalski, The Research Council of Norway, 2022–2025;
- Szybkość przemieszczania się płyt litosferycznych w neoproterozoiku – weryfikacja hipotez prawdziwej wędrówki bieguna w neoproterozoiku (akronim: NEOMAGRATE), K. Michalski, National Science Centre, 2022–2025;
- Pleistocene rock magnetic and magnetostratigraphic records of loess-palaeosol sequences in Poland and Ukraine, V. Bakhmutov, National Science Centre, 2022–2023;
- Opracowanie nowego zastosowania parametrów magnetycznych do oceny stężenia zanieczyszczeń wielopierścieniowymi węglowodorami aromatycznymi we frakcjach granulometrycznych pyłów drogowych, S. Dytłow, National Science Centre, 2022–2025;
- Badania ultradrobnych cząstek zanieczyszczeń powietrza w środowisku miejskim. Charakterystyka ich własności fizyko-chemicznych, źródeł emisji i mechanizmów rozprzestrzeniania, S. Dytłow, Narodowa Agencja Wymiany Akademickiej (NAWA) – Program im. Mieczysława Bekkera, 2022–2023;
- The Baltic Sea evolution before human existence – a key to understanding a future of the sedimentary basin, D. Niezabitowska, Narodowa Agencja Wymiany Akademickiej (NAWA) – Program im. Mieczysława Bekkera, 2022–2024.

9.4 Instruments and facilities

Equipment

Equipment for field laboratory for paleomagnetism and environmental magnetism

- MS2 susceptibility meter (Bartington, Great Britain) with sensors
- MS3 susceptibility meter (Bartington, Great Britain) with sensors

Financed by EPOS-PL+

- DJI MATRICE 600 PRO drone with AIR DRON/ AD – SH 24 unit for PM measurements
- PM meter/sampler (DustTrak 8533DRX, TSI, USA) – 2 pcs
- Black carbon meter – aethalometr (AE-51, Aeth-Labs, USA)
- MS3 susceptibility meter (Bartington, Great Britain) with new sensors
- Portable rock drills (RSD, Germany) – 2 pcs
- Nonmagnetic sample containers (Magnetic Measurements, Great Britain) – 4 pcs

Equipment for PM dust collection (environmental magnetism studies)

- PNS15C/ PM dust samplers (Atmoservice, Poland) – 3 units
- PNS18T/ PM dust samplers (Atmoservice, Poland and Comde Derenda) – 3 units

Equipment for magnetotelluric survey and magnetic observations

- 2 magnetotelluric broad-band stations Phoenix
- 8 magnetotelluric low-frequency stations Geomag
- 6 low-frequency magnetometers LEMI
- 4 PMP proton magnetometers
- 4 proton Overhauser magnetometers
- 2 torsion photoelectric magnetometers PSM
- 4 DIFLUX magnetometers for absolute measurements
- 4 induction coil magnetometers
- 1 GEM GSM-19T gradiometer
- 1 electromagnetic conductivity meters CMD MiniExplorer 6L (2021)
- 13 NDL digital recorders
- 18 LB-480 digital recorders
- 1 Electrical Resistivity Tomography Set – ABEM Terrameter LS2 with four 21 take-outs cables with 5 m spacing

Laboratory

Laboratory for paleomagnetism and environmental studies – list of the laboratory equipment:

Equipment for measurements of magnetic remanence with step-wise AF/TH demagnetization

- 755–1.65 2G Enterprises cryogenic magnetometer DC SQUID with AF degausser, 2021 – the upgrade of cooling system (financed by EPOS-PL)
- JR6a automated dual speed spinner magnetometer (Agico, Czech Republic)
- MMTDSC – Nonmagnetic furnace for thermal demagnetization Magnetic Measurements, Great Britain

- MMTD-80 Nonmagnetic furnace for thermal demagnetization by Magnetic Measurements, Great Britain
- MMTD1 Nonmagnetic furnace for thermal demagnetization by Magnetic Measurements, Great Britain

Equipment for acquisition of magnetic remanence

- LDA5/PAM1 Alternating Field Demagnetizer/Anhysteretic and Pulse Magnetizer, Agico, Czech Republic
- LDA3a/AMU1a, Alternating Field Demagnetizer/Anhysteretic Magnetizer, Agico, Czech Republic
- Two MMPM10 pulse magnetisers, Magnetic Measurements, Great Britain
- SI6 – Pulse magnetizer, Sapphire Instruments, Canada

Equipment for magnetic susceptibility measurements

- KLY-5A/CS-4/CS-L – Susceptibility bridge Agico, Czech Republic
- MFK1-FA – Susceptibility bridge, Agico, Czech Republic
- KLY-3/CS-3/CS-L – Susceptibility bridge, Agico, Czech Republic
- KLY2 – Susceptibility bridge, Geofyzika Brno, Czech Republic

Equipment for studies of magnetic hysteresis and Curie temperatures

- Micromag AGFM 2900-02 Alternating gradient force magnetometer, Princeton Measurements Corp., USA
- VSM Nuvo Vibrating Sample Magnetometer, Molspin Ltd, Great Britain
- AVFTB (Advanced Variable Field Translation Balance) Petersen Instruments, Magnetic Measurements, Great Britain) upgrade of the cooler unit (EPOS–PL)
- STEPS III apparatus for SIRM (T) experiments (TUS Electronics, Poland) – upgrade of the new electronics (EPOS–PL)

Mass balances

- The microbalance MYA 5.4.Y F (RADWAG, Poland) for mass determination of PM collected on filters used in dust samplers (EPOS–PL)

9.5 Seminars and teaching

Seminars and lectures

K. Dudzisz, Expert's tutoring (Tutoring ekspercki); University of Silesia, Katowice, Poland, September–December 2022, Tutoring of PhD students;

K. Mizerski, Nonlinear turbulent dynamo induced by fluctuations of the Lorentz force; NORDITA, Nordic Institute for Theoretical Physics, Stockholm, Sweden, 20 December 2022, Seminar;

M. Lewandowski, History of global glaciations; Akademickie Liceum w Gdyni, Gdynia, Poland, 19.12.2022, Invited lecture;

Sz. Bal, Barwny świat skał i minerałów – warsztaty, Geologia i obszary arktyczne – wykład; Szkoły podstawowe i średnie powiatu myślenickiego (woj. małopolskie), Poland, 12–16 December 2022, Invited lecture (summary – 32 h).

Teaching

K. Mizerski, M. Grądzki, Hydromagnetic dynamo theory in geo- and astrophysics; Physics Faculty, University of Warsaw, Lecture;

M. Lewandowski, Bumpy road from Big Bang to geosystem; Doctoral School, Poland, 26.04.2022, Lecture;

S. Oryński, Internships in applied geophysics for students of the first and second year of Master's studies; Faculty of Geology of the University of Warsaw, 5–9.09.2022, Chęciny, Lecture.

PhD

A. Bury, Badanie zmian sezonowych w wektorach indukcyjnych pochodzących z danych obserwacyjnych geomagnetycznych w celu oceny efektów źródłowych istotnych dla badań magnetotellurycznych; Supervisor: A. Neska.

Visiting scientists

Dorota Staneczek, University of Silesia, Katowice, Poland, 24–28.01.2022, 9–15.05.2022, 16–29.11.2022, 8–9.12.2022, 17–19.12.2022;

Bruno Mendes, Karlsruhe Institute of Technology, Karsruhe, 13–15.09.2022.

9.6 Meetings, workshops, conferences, and symposia

Presentations of the Department's members:

- Ł. Uzarowicz, B. Górka-Kostrubiec, K. Dudzisz, 17th Castle Meeting New Trends on Paleo-, Rock-, and Environmental Magnetism, Iron oxide transformations in Technosols developed from thermal power station ash; Trakoščan, Croatia, 28.08–3.09.2022, Poster, Conference;
- K. Dudzisz, A. Kontny, L. Alva-Valdivia, 17th Castle Meeting New Trends on Paleo-, Rock-, and Environmental Magnetism, Temperature dependent in and out of phase magnetic susceptibility as an indicator of thermal histories of different pyroclastic deposits; Trakoščan, Croatia, 28.08–3.09.2022, Oral, Conference;
- D.K. Niezabitowska, R. Szaniawski, 17th Castle Meeting New Trends on Paleo-, Rock-, and Environmental Magnetism, Terranes paleoposition and chemical evolution of sedimentary basin materials, and the effects on measurable magnetic properties – the Holy Cross Mountains case; Trakoščan, Croatia, 28.08–3.09.2022, Oral, Conference;
- T. Magiera, B. Górka-Kostrubiec, M. Rachwał, T. Szumiata, 17th Castle Meeting New Trends on Paleo-, Rock-, and Environmentyal Magnetism, Identification of technogenic magnetic particles from different pollution sources by magnetic proxies; Trakoščan, Croatia, 28.08–3.09.2022, Oral, Conference;
- D. Hlavatskyi, V. Bakhmutov, B. Górka-Kostrubiec, R. Szaniawski, T. Werner, AGU Fall meeting, Updated stratigraphy and magnetic mineralogy of the Pleistocene reference loess-palaeosol sequence at Roksolany in southern Ukraine; Chicago, USA, 12–16.12.2022, Oral, Conference;
- D. Staneczek, R. Szaniawski, L. Marynowski, 27th Meeting of the Petrology Group of the Mineralogical Society of Poland, Oligocene burial effects on the magnetic fabric of the Huty Fm in the Orava-Podhale Paleogene Basins; Poland, 20–23.10.2022, Poster, Conference;
- S. Oryński, M. Majdański, A. Marciniak, Konferencja "Hydrogeologia w Praktyce – Praktyka w Hydrogeologii". Chęciny, Metody geofizyczne stosowane w utworach przypowierzchniowych i ich wykorzystanie w badaniach hydrogeologicznych; Poland, 23–25.05. 2022, Oral, Conference;
- M. Lewandowski, M.A. Kusiak, W. Miloch, A. Nawrot, Scientific Committee for Antarctic Research, Polish Antarctic Station Dobrowolski: history, present and future perspective in brief; India online, 1.08.22, Oral, Conference;
- K. Dudzisz, Geology of the Northeastern Oman; Muscat, Oman, 07–18.10.2022, Workshop;

- M.Yu. Smirnov, J. Hübert, O. Ritter, A. Neska, T.M. Rasmussen, P. Hejda, S. Flower, A. Chambodut, J.J. Curto, J. Matzka, A. Thomson, A. Viljanen, 25th Electromagnetic Induction Workshop, Making geoelectromagnetic (magnetotelluric) data accessible via EPOS portal; Cesme, Turkey, 11–18 September 2022, Oral, Conference;
- S. Sanaka, 25th Electromagnetic Induction Workshop, Distribution of source effects in the high latitude magnetotelluric data; Cesme, Turkey, 11–18 September 2022, Poster, Conference;
- A. Neska, J. Reda, IMAGE 40th Anniversary, 1. IG PAS magnetometers state of September 2022, 2. Experiences with the magnetotelluric remote reference method applied to IMAGE data; Helsinki, Finland (remote), 5–6 October 2022, Oral, Meeting;
- A. Neska, EPOS TCS Geomagnetic Observation Board Meeting; Tortosa, Spain, 8–10 November 2022, Meeting;
- V. Bakhmutov, D. Hlavatskyi, XXI Terenowe Seminarium "Metodyka Rekonstrukcji Zmian Klimatu i Środowiska Zapisanych w Pokrywach Lessowych", Rock magnetism, magnetostratigraphy and the problems of correlation of Pleistocene loess-palaeosol sections in the western Black Sea region of Ukraine; Jarosław, Poland, 6–8 October 2022, Oral, Meeting;
- V. Bakhmutov, I. Poliachenko, S. Cherkes, D. Hlavatskyi, V. Shpyra, XVI International Scientific Conference "Monitoring of Geological Processes and Ecological Condition of the Environment", Palaeomagnetism of the Volyn traps, southwestern margin of the East European Platform: new data about Ediacaran geomagnetic field; Kyiv, Ukraine, 15–18 November 2022, Oral, Meeting;
- N. Gerasimenko, D. Hlavatskyi, V. Bakhmutov, W.A.P. Wimbledon, I. Poliachenko, O. Bonchkovskyi, XVI International Scientific Conference "Monitoring of Geological Processes and Ecological Condition of the Environment", Enviromagnetic study of the reference Ukrainian loess-palaeosol sequence at Stari Kaydaky; Kyiv, Ukraine, 15–18 November 2022, Oral, Meeting;
- V. Bakhmutov, D. Hlavatskyi, G. Melnyk, S. Mychak, S. Cherkes, International Conference of Young Professionals "GeoTerrace-2022", Pleistocene climate fluctuations recorded in the magnetic susceptibility of the longest LPSs of Ukraine; Lviv, Ukraine, 3–5 October 2022, Oral, Meeting;
- D. Hlavatskyi, V. Bakhmutov, Yu. Veklych, V. Shpyra, I. Poliachenko, International Conference of Young Professionals "GeoTerrace-2022", Danube loess magnetostratigraphy: a perspective from Ukraine; Lviv, Ukraine, 3–5 October 2022, Oral, Meeting;
- G. Melnyk, D. Hlavatskyi, I. Poliachenko, V. Bakhmutov, O. Shenderovska, V. Yakukhno, XVI International Scientific Conference, Monitoring of Geological Processes and Ecological Condition of the Environment, Current state of knowledge of the Brunhes chron geomagnetic excursions; Kyiv, Ukraine,15–18 November 2022, Oral, Meeting;
- D. Hlavatskyi, N. Gerasimenko, V. Bakhmutov, I. Poliachenko, AGU Fall Meeting, Rock magnetic record from the Late Middle–Upper Pleistocene deposits of the Neporotove 7 loess-soil section (western Ukraine); Chicago, USA, 12–16 December 2022, Oral, Meeting;
- T. Bozóki, G., Satori P. Ernő, E. Williams, A. Guha, Y. Liu, J. Bór, A. Buzás, K. Szabóné-André, M. Atkinson, C. Beggan, A. Koloskov, A. Kulak, J. LaPierre, D. Milling, J. Młynarczyk, A. Neska, M. Neska, A. Potapov, T. Raita, R. Rawat, R. Said, A.K. Sinha, M. Stock, Y. Yampolski, 17th International Conference on Atmospheric Electricity,19 days of global lightning activity as seen by ground-based global lightning detection networks and inferred from Schumann resonance observations; Tel Aviv, Israel, 19–24 June 2022, Oral;

- T. Bozóki, E. Williams, G. Satori, C.D. Beggan, C. Price, P. Steinbach, A. Guha, Y. Liu, A. Neska, R. Boldi, M. Atkinson, 17th International Conference on Atmospheric Electricity, Predicting the occurrence of extreme El Nino events based on Schumann resonance measurements, Tel Aviv, Israel, 19–24 June 2022, Poster.

9.7 Publications

ARTICLES

Bakhmutov, V., et al. (2022), On the reliability of a stratigraphic interpretation that overlooks geophysical techniques and results when determining the age of loess-soil deposits – Comment on Łanczont et al. (2022) "A remarkable last glacial loess sedimentation at Roxolany in the Dniester Liman (Southern Ukraine)", *Quaternary Sci. Rev.* **297**, 107668, DOI: 10.1016/j.quascirev.2022.107668.

Bakhmutov, V., et al. (2022), Palaeomagnetism of the Vendian traps of Volyn, southwestern margin of the East European platform. P. 1: palaeomagnetic directions and poles, *Geophys. J*. **43**, 6, DOI: 10.24028/gzh.v43i6.251555.

Dudzisz, K., et al. (2022), Curie temperatures and emplacement conditions of pyroclastic deposits from Popocatépetl volcano, Mexico, *Geochem. Geophys. Geosyst*. **23**, 8, e2022GC010340, DOI: 10.1029/2022GC010340.

Dudzisz, K., et al. (2022), Effect of cyclic loading at elevated temperatures on the magnetic susceptibility of a magnetite-bearing ore, *Geophys. J. Int*. **228**, 2, 1346–1360, DOI: 10.1093/gji/ggab400.

Ernst, T., **K. Nowożyński**, **W. Jóźwiak** (2022), Source effect impact on the magnetotelluric transfer functions, *Ann. Geophys*. **65**, 1, GM104, DOI: 10.4401/ag-8751.

Górka-Kostrubiec, B., et al., **S. Dytłow** (2023), Integration of chemical fractionation, Mössbauer spectrometry, and magnetic methods for identification of Fe phases bonding heavy metals in street dust, *J. Environ. Sci.* **124**, 875–891, DOI: 10.1016/j.jes.2022.02.015.

Atakan, K., et al., B. Orlecka-Sikora, D. Olszewska, **B. Górka-Kostrubiec** (2022), National EPOS initiatives and participation to the EPOS integration plan, *Ann. Geophys*. **65**, 2, DM211, DOI: 10.4401/ag-8758.

Jeleńska, M., **T. Werner**, **M. Kądziałko-Hofmokl**, and **G. Karasiński** (2022), Evaluation of indoor/outdoor urban air pollution by magnetic parameters; preliminary study, *J. Appl. Geophys*. **206**, 104804, DOI: 10.1016/j.jappgeo.2022.104804.

Jóźwiak, W., and P. Rowiński (2022), Jerzy Jankowski (1933–2020), *Prz. Geof.* **67**, 1–2, 58–63.

Jóźwiak, W., **K. Nowożyński**, et al. (2022), Deep electrical resistivity structure of the European lithosphere in Poland derived from 3-D inversion of magnetotelluric data, *Surv. Geophys*. **43**, 1563–1586, DOI: 10.1007/s10712-022-09716-1.

Meinander, O., et al., M.A. Kusiak, **M. Lewandowski**, B. Luks, A. Nawrot, **T. Werner** (2022), Newly identified climatically and environmentally significant high-latitude dust sources, *Atmos. Chem. Phys*. **22**, 17, 11889–11930, DOI: 10.5194/acp-22-11889-2022.

Mizerski, K.A. (2022), Anisotropic turbulent viscosity and large-scale motive force in thermally driven turbulence at low Prandtl number, *Arch. Mech*. **74**, 5, DOI: 10.48550/arXiv.2206.01539.

Mizerski, K.A. (2022), Dynamo effect caused by non-stationary turbulence in strongly magnetized, hot, low-density plasma, *Astron. Astrophys*. **660**, A110, DOI: 10.1051/0004-6361/202142488.

Oryński, Sz., **W Jóźwiak**, **K. Nowożyński**, et al. (2022), Comparison of 3D, 2D, and 1d magnetotelluric inversion results on the example of data from Fore-Sudetic Monocline, *Int. J. Geophys*., ID 3400950, DOI: 10.1155/2022/3400950.

Del Corpo, A., et al., **J. Reda** (2022), Study of the average ion mass of the dayside magnetospheric plasma, *J. Geophys. Res.: Space Phys*. **127**, 10, e2022JA030605, DOI: 10.1029/2022JA030605.

Staneczek, D., **R. Szaniawski**, et al. (2022), Transpression-driven deformations of the Chočské vrchy Mountains (Western Carpathians): Insights from magnetic fabric, *Geol. Carpath*. **73**, 5, 451–471, DOI: 10.31577/GeolCarp.73.5.4.

MONOGRAPHS

Reda, J., **M. Neska**, **S. Wójcik**, and **P. Czubak** (2022), Results of Geomagnetic Observations: Belsk, Hel, Hornsund, 2020, *Publs. Inst. Geoph. PAS* **440 (C-115)**, DOI: 10.25171/InstGeoph_PAS_Publs-2022-018.

Reda, J., **M. Neska**, **S. Wójcik**, and **P. Czubak** (2022), Results of Geomagnetic Observations: Belsk, Hel, Hornsund, 2021, *Publs. Inst. Geoph. PAS* **441 (C-116)**, DOI: 10.25171/InstGeoph_PAS_Publs-2022-019.

10. DEPARTMENT OF GEOPHYSICAL IMAGING

Michał Malinowski and Mariusz Białecki

10.1 About the Department

The Department's activities in 2022 were traditionally focused on the two research topics. The first one deals with geophysical imaging of geological structures at various scales; the second one – with the mathematical analysis of complex systems in geophysics and the dynamics of porous media. We contribute to all four research areas of the Institute of Geophysics.

The year 2022 – like the previous one – was a period of changes. During the summer holidays there was a change of the head of the Department – Michał Malinowski handed over his duties to Mariusz Białecki. The research team has been significantly strengthened – we have recruited one professor of the institute – Ali Gholami, and two assistant professors – Toktam Zand and Qamar Yasin. All doctoral students are finalizing their work on doctoral dissertations.

The Department's activities were mostly related to research projects. We continued five NCN projects and acquired two new projects: Mariusz Majdański's project within Horizon Europe program and Andrzej Górszczyk's project financed by NCBiR.

The most remarkable achievements made by the Department include:

- Multi-method geophysical mapping of ground properties and periglacial geomorphology in Hans Glacier forefield, SW Spitsbergen (Mariusz Majdański, Artur Marciniak)
- Imaging the effects of seamount subduction: evidence from the Tokai area, Nankai Trough, Japan (Andrzej Górszczyk)
- An evaluation of depth imaging methodologies for deep mineral targeting tested on complex Kylylahti deposit, Finland (Brij Singh, Michał Malinowski)
- Advancements in seismic depth imaging for mineral exploration using data from Ludvika, Sweden (Brij Singh, Michał Malinowski, Andrzej Górszczyk)
- Investigation of patterns in glacial microseismicity for Hansbreen terminus, Spitsbergen, Norway (Wojciech Gajek)
- Shallow gas expression of the petroleum system offshore western Poland — Pomeranian Bight (Quang Nguyen, Michał Malinowski)
- Fault and fracture network characterization using seismic data: a study based on neural network models assessment (Qamar Yasin, Mariusz Majdański)
- High resolution imaging of subduction zone using Ocean Bottom Nodes and Streamer Data (Toktam Zand, Andrzej Górszczyk, Ali Gholami)
- Improved full waveform inversion by the method of multipliers (Ali Gholami)
- •Methods for qualitative and quantitative assessment of the transformation of pore geometry of a rock as a result of karstification illustrated on Smerdyna's samples (Mariusz Białecki)

10.2 Personnel

Head of the Department
Michał Malinowski (until July)
Professor
Mariusz Białecki (since August)
Associate Professor

Professor
Michał Malinowski

Associate Professors
Mariusz Białecki
Ali Gholami
Mariusz Majdański

Assistant Professors
Wojciech Gajek
Andrzej Górszczyk
Qamar Yasin
Toktam Zand

PhD Students
Artur Marciniak, Poland; Mariusz Majdański – PhD supervisor
Quang Nguyen, Vietnam; Michał Malinowski – PhD supervisor
Rishabh Prakash Sharma (UW), India; Mariusz Białecki – PhD supervisor
Brij Singh, India; Michał Malinowski – PhD supervisor

10.3 Main research projects

- Three-dimensional imaging of subduction zones with full waveform inversion of two-dimensional seismic data, A. Górszczyk (PI), T. Zand, W. Gajek, National Science Centre "Opus", Poland, 2020–2023;
- Mechanistic explanation of a generation of (and deviations from) the universal curve of the Earthquake Recurrence Time Distribution by means of constructions of solvable stochastic cellular automata and their analytical description, M. Białecki (PI), National Science Centre "Opus", Poland, 2018–2023;
- Active and passive source multiscale subsurface imaging and monitoring based on the full seismic waveform, M. Malinowski (PI), A. Górszczyk, National Science Centre "Sheng", Poland, 2019–2022;
- Linking deep and shallow geological processes in the transition from Precambrian to Palaeozoic platform in the southern Baltic Sea using new geophysical data, M. Malinowski (PI), Q. Nguyen, National Science Centre "Opus", Poland, 2018–2022;
- Anthropogenic triggering of landslides in the environment modified due to climate change – geophysical investigation, A. Marciniak (PI), M. Majdański, National Science Centre "Preludium", Poland, 2021–2023;
- Seismic and electromagnetic methods for deep mineral exploration, A. Górszczyk (PI), B. Singh, NCBiR, 2022–2025;
- Geo-INQUIRE, M. Majdański, Horizon Europa, 2022–2026;
- Extension of seismic monitoring network in Hornsund, M. Majdański, SIOS, 2019–2022.

10.4 Instruments and facilities

Equipment
- Department equipment was not updated in 2022.

Laboratory
- Geophysical data analysis performed at the Department is supported by the local cluster composed of blade servers.

10.5 Seminars and teaching

Seminars and lectures

M. Majdański, Seismology and active seismic, Warsaw University (Physics), Warsaw, October 2021 – February 2022, Lecture (30 h);

M. Majdański, Seismology and structure of the Earth, Warsaw University (Physics), Warsaw, October 2021 – February 2022, Lecture (30 h);

B. Singh, Seismic imaging in the hardrock environment, EAGE Local Chapter Czech Republic, Prague, Czech Republic, 23 May 2022, Invited lecture (online);

W. Gajek, Sejsmologia lodowców, AGH University of Krakow, Cracov, 4 April 2022, Invited lecture.

Teaching

W. Gajek, Four weeks bachelor student internship supervision (AGH University of Krakow), Ongoing supervision of bachelor thesis.

Thesis

Mariusz Majdański, Julia Chachulska (ongoing), Sejsmika przypowierzchniowa w badaniach środowiskowych na przykładzie aktywnego osuwiska, Warsaw University (Physics), Warsaw.

Visiting scientist

Luciano Telesca, Institute of Metodologies for Environmental Analysis, National Research Council, Tito, Potenza, Italy, 31 October – 5 November 2022.

10.6 Meetings, workshops, conferences, and symposia

Presentations of the Department's members:

- M. Białecki, R.P. Sharma, M.P. Cooper, P. Szymczak, EGU 2022, Comparative study of undissolved and karstified limestone based on microtomography; Vienna, Austria, 23–27.05.2022, Oral, Conference;
- M. Białecki, Summer Solstice Conference on Discrete Models of Complex Systems, On a certain model of earthquake statistics in the form of probabilistic cellular automaton and its connections with various domains of mathematics; Gdańsk, Poland, 28.05.2022, Oral (invited), Conference;
- M. Białecki, R.P. Sharma, M.P. Cooper, P. Szymczak, Computational Methods in Water Resources, Comparative study of undissolved and karstified limestone based on microtomography; Gdańsk, Poland, 19–23.06.2022, Oral, Conference;
- M. Białecki, International Conference on Difference Equations and Applications, Discrete probabilistic aggregative dynamics related to integer sequences; Paris, France, 18–22.07. 2022, Oral, Conference;
- A. Górszczyk, AGU 2022, On the reliability of 2D regional-scale velocity model building in complex geological setting; Chicago, USA, 12.12.2022, Poster, Conference;
- A. Górszczyk, IMAGE/SEG 2022, Structure of the Tokai segment from the integrated high-resolution seismic imaging: A case study from the eastern Nankai Trough; Houston, USA, 29.08.2022, Oral, Conference;
- A. Górszczyk, EAGE 2022, Mitigating the cycle-skipping problem with Graph Space Optimal Transport misfit function – practical considerations for regional-scale FWI from sparse OBN data; Madrid, Spain, 05.06.2022, Oral, Conference;
- A. Górszczyk, SEISCOPE Annual Meeting, On the reliability of regional-scale velocity model building from 2D OBS data; Grenoble, France, 12.04.2022, Oral, Workshop;

- M. Majdański, Jubileusz 50-lat Wrocławskiej Stacji Polarnej, Zmienność permafrostu w warunkach zamarzania i tajania w zlewni przybrzeżnej Fuglebekken, Hornsund; Wrocław, Poland, April 2022, Oral, Conference;
- M. Majdański, W. Dobiński, A. Marciniak, M. Osuch, T. Wawrzyniak, B. Owoc, M. Glazer, EGU 2022, The effect of subsurface freezing-thawing in the SW Svalbard on the newly deglaciated areas; Vienna, Austria, 23-27.05.2022, Oral, Conference;
- A. Marciniak, I. Stan-Kłeczek, M. Wróbel, M. Majdański, S. Kowalczyk, EAGE NSG 2022, Integrated geophysical imaging in the landslide studies – a case study from Outer Carpathians, Poland; Belgrade, Serbia, September 2022, Oral, Conference;
- Q. Nguyen, M. Malinowski, R. Kramarska, D. Kaulbarsz, C. Huebscher, EGU 22, Linking shallow gas occurrences and deeper structure offshore western Poland (Pomeranian Bight); Vienna, Austria, 23–27 May 2022, Oral, Conference;
- Q. Nguyen, Cretaceous Symposium 2022, The Late Cretaceous inversion of the Polish Basin and surrounding area – a current perspective based on seismic data. In book: Cretaceous of Poland and of adjacent areas; Warsaw, Poland, 21–26 August 2022, Symposium;
- Q. Nguyen, IMAGE 2022, Shallow gas expression of the petroleum system offshore western Poland – Pomeranian Bight; Houston, USA, 28–1 September 2022, Poster, Conference;
- B. Singh, Seems Deep Kick-off Meeting; Oulu, Finland, 15–18.08.2022, Meeting;
- B. Singh, M. Malinowski, EAGE NSG Conference 2022, Depth imaging of crooked seismic profiles in hardrock environment: Is 2D enough?; Belgrade, Serbia, 18–22.09.2022, Oral, Conference;
- T. Zand, A. Górszczyk, A. Gholami, H. Ghasemzadeh, A. Malcolm, IMAGE22, Least-squares RTM with shifted total variation regularization for depth imaging of sparse short-offset seismic data; Houston, USA, 30.08.2022, Oral, Conference;
- M. Malinowski, EGU22, Multicomponent seismic acquisition for the characterization of the groundwater system at Kurikka, western Finland; Vienna, Austria, 23–27.05.2022, Oral, Conference;
- M. Malinowski, EAGE NSG Conference 2022, Multicomponent seismic acquisition for the characterization of the complex multiaquifer system at Kurikka, Western Finland; Belgrade, 18–22.09.22, Oral, Conference;
- M. Malinowski, Lithosphere 2022 Symposium, Exploring East European Craton crust in Poland using state-of-the-art deep reflection seismic profiling; Turku, Finland, 15–17.11. 2022, Oral (invited), Conference;
- M. Malinowski, Lithosphere 2022 Symposium, Distributed acoustic sensing walkaway vertical seismic profiling in Koillismaa deep drillhole; Turku, Finland, 15–17.11.2022, Poster, Conference;
- W. Gajek, EGU, Hansbreen's calving-driven ice loss derived from seismic data supported by millimetre-wave radar scans and neural networks; Vienna, Austria, 23–27 April 2023, Oral, Conference;
- Harcourt (coauthored by W. Gajek), EGU, Millimetre-wave radar observations of glacier calving at Hansbreen (Svalbard) correlated with TLS, time-lapse camera images and seismic records; Vienna, Austria, 23–27 April 2023, Oral, Conference;
- A. Marciniak (coauthored by W. Gajek), EGU, Integrated time-lapse geophysical imaging and remote-sensing study of the antropoghenic triggering of the landslides; Vienna, Austria, 23–27 April 2023, Oral, Conference.

10.7 Publications

ARTICLES

Gholami, A., et al. (2022), Automatic balancing parameter selection for Tikhonov-TV regularization, *BIT Numer. Math*. **62**, 1873–1898, DOI: 10.1007/s10543-022-00934-y.

Cao, J., et al., **A. Górszczyk** (2022), 3-D multiparameter full-waveform inversion for ocean-bottom seismic data using an efficient fluid–solid coupled spectral-element solver, *Geophys. J. Int*. **229**, 1, 671–703, DOI: 10.1093/gji/ggab484.

Majdański, M., et al., **A. Marciniak**, B. Owoc, M. Osuch, T. Wawrzyniak (2022), Variations of permafrost under freezing and thawing conditions in the coastal catchment Fuglebekken (Hornsund, Spitsbergen, Svalbard), *Permafrost Periglac. Process*. **33**, 3, 264–276, DOI: 10.1002/ppp.2147.

Chamarczuk, M., **M. Malinowski**, et al. (2022), Reflection imaging of complex geology in a crystalline environment using virtual-source seismology: case study from the Kylylahti polymetallic mine, Finland, *Solid Earth* **13**, 3, 705–723, DOI: 10.5194/se-13-705-2022.

Chamarczuk, M., et al., **M. Malinowski** (2022), Towards adapting reverse vertical seismic profiling for ambient-noise imaging with transient sources: Automatic estimation of stationary-phase receivers for improved retrieval of the interferometric Green's function, *Geophysics* **87**, 6, 1ND-V570, DOI: 10.1190/geo2021-0293.1

Hloušek, F., **M. Malinowski**, et al. (2022), Three-dimensional reflection seismic imaging of the iron oxide deposits in the Ludvika mining area, Sweden, using Fresnel volume migration, *Solid Earth* **13**, 5, 917–934, DOI: 10.5194/se-13-917-2022.

Janik, T., D. Wójcik, et al., **M. Malinowski** (2022), Crustal structure across the Teisseyre-Tornquist Zone offshore Poland based on a new refraction/wide-angle reflection profile and potential field modelling, *Tectonophysics* **828**, 229271, DOI: 10.1016/j.tecto.2022.229271.

Qian, J., et al., **M. Malinowski** (2022), First observation of paired microseismic signals during solution salt mining, *Front. Earth Sci*. **10**, 952314, DOI: 10.3389/feart.2022.952314.

Marciniak, A., M. Osuch, T. Wawrzyniak, B. Owoc, et al., **M. Majdański** (2022), Multimethod geophysical mapping of ground properties and periglacial geomorphology in Hans Glacier forefield, SW Spitsbergen, *Pol. Polar Res*. **43**, 2, 101–123, DOI: 10.24425/ppr.2022.140363.

Singh, B., **M. Malinowski**, **A. Górszczyk**, et al. (2022), 3D high-resolution seismic imaging of the iron oxide deposits in Ludvika (Sweden) using full-waveform inversion and reverse time migration, *Solid Earth* **13**, 6, 1065–1085, DOI: 10.5194/se-13-1065-2022.

Yasin, Q., et al. (2022), Evaluation of Neoproterozoic source rock potential in SE Pakistan and adjacent Bikaner–Nagaur Basin India, *Sci. Rep.* **12**, 11102, DOI: 10.1038/s41598-022-14831-5.

Yasin, Q., **M. Majdański**, et al. (2022), An analytical hierarchy-based method for quantifying hydraulic fracturing stimulation to improve geothermal well productivity, *Energies* **15**, 19, 7368, DOI: 10.3390/en15197368.

Yasin, Q., **M. Majdański**, et al. (2022), Fault and fracture network characterization using seismic data: a study based on neural network models assessment, *Geomech. Geophys. Geoenerg. Georesour*. **8**, 41, DOI: 10.1007/s40948-022-00352-y.

Zand, T., **A. Górszczyk**, et al. (2022), Least-squares RTM with shifted total variation regularization for depth imaging of sparse short-offset seismic data, *Image* **22**, 2714–2718, DOI: 10.1190/image2022-3751356.1.

11. DEPARTMENT OF POLAR AND MARINE RESEARCH

Marek Lewandowski and Mateusz Moskalik

11.1 About the Department

In 2022 our polar team contributed to studies of a wide spectrum of Arctic environmental processes. In fiords and marine-terminating glaciers subject, we published papers concerning acoustic measurements of glacier mass loss, secure external funding including the National Science Centre of Poland, and participate in business meetings and conferences. We continue collaborating with partners from the U.S. and Singapore within the International Partnership for the AcOustic Monitoring of Glaciers (IPA OMG) and during the realization of the Polish-Norwegian research project related to ecology and biogeochemical processes in Arctic fiords. Apart from glaciers and fiords, researchers from the Department worked to gather comprehensive information on the climate change impacts and hydrodynamic state of the rivers and lakes. We further expanded the existing measurement networks into new locations, starting new monitoring techniques and methodologies, that will be continued in 2023. Most importantly, we have, for the first time, used a drone equipped with thermal, multispectral, and orthophoto cameras for the acquisition of detailed photographs of Arctic catchments. This novel approach will allow us to link the dataset from continuous monitoring at Hornsund to real-time hydrological observations and will create an opportunity for valuable comparison with other Arctic regions. This year, for the first time in the history of PSP Hornsund, we have completed a detailed survey of biogeochemical conditions in lakes and ponds of SW Spitsbergen. We have also continued to closely monitor physicochemical conditions in Lake Revvatnet using autonomous O_2, T, pH, and conductivity sensors. Interestingly, we have found unexpectedly high methane concentrations in ground waters and ponds in the vicinity of Hans Glacier; this may indicate that, at least, part of the underground outflow from beneath this glacier is CH_4-enriched.

Beneath glaciers, rivers and lakes, extensive research work has been done in early Earth rock formations in Arctic (Greenland and Labrador) and in Antarctica (the Napier Complex). External funding from the National Science Centre of Poland has been secured. In the 2022 field investigation of the polar-geology research team aimed to decipher the nature of these oldest Earth rocks. During the 2022 season, we visited areas near Kangerlussuaq region and, based on helicopter and boat logistics, we were able to collect rock specimens from places where there is a lack of geological information. Samples were prepared for the whole-rock, petrography, and geochronology.

At the beginning of the year, the 4th Polish Antarctic Research Expedition (PARE) to the A.B. Dobrowolski Polish Antarctic Station, organized by the Department, reached the Bunger Oasis located in East Antarctica. This was the first official visit after 42 years of absence of Polish researcher in the area. For five weeks, a plan to revitalize the station was implemented and scientific research was conducted.

11.2 Personnel

Head of the Department
Marek Lewandowski (until July)
Professor
Mateusz Moskalik (since August)
Associate Professor

Professors
Piotr Głowacki
Monika A. Kusiak
Marek Lewandowski (until July)

Associate Professors
Daniel J. Dunkley
Mateusz Moskalik

Assistant Professors
Maciej Bartosiewicz
Oskar Głowacki
Vineet Jain (since June)
Piotr Król (since December)
Bartłomiej Luks
Adam Nawrot
Zuzanna Świrad
Tomasz Wawrzyniak

Research Assistants
Meri Korhonen (since April)
Piotr Król (until November)

Technical Assistants
Jerzy Giżejewski (since July)
Radosław Kiraga (since October)
Ekaterina Rets (since July)

PhD Students
Nathan Darellis, France, March–August 2022; Mateusz Moskalik and Maciej Bartosiewicz – PhD supervisors
Tanmay Keluskar, Indie; Monika A. Kusiak– PhD supervisor
Dhruv Maniktala, India, since December 2022; Mateusz Moskalik and Oskar Głowacki – PhD supervisors
Marcin Mieszczak, Poland; Monika A. Kusiak– PhD supervisor
Julian Podgórski, Poland; Michał Pętlicki (UJ) and Piotr Głowacki – PhD supervisors

11.3 Main research projects

- Visualization of methane fluxes along coastal boundaries of Arctic permafrost and glaciers, **M. Bartosiewicz – Project leader**, M. Moskalik, COFUND – Marie Curie Fellowship/PAS, 2022–2024;
- Archean crust in East Antarctica, **D. Dunkley – Project leader**, P. Król (PostDoc), M.A. Kusiak, National Science Centre "Opus", Poland, 2022–2025;
- Studying glacier calving fluxes and calving styles through a novel combination of acoustic and optical methods, **O. Głowacki – Project leader**, D. Maniktala (PhD student), M. Moskalik, National Science Centre "Sonata", Poland, 2022–2025;
- SIOS – Svalbard Integrated Arctic Earth Observing System (Zintegrowany Arktyczny System Obserwacyjny dla Svalbardu), **P. Głowacki – Project leader**, Polish Road Map of Research Infrastructure, Ministry of Science and Higher Education, 2018–2023;
- Poles together – missing link between Arctic and Antarctic early Earth record, **M.A. Kusiak – Project leader**, D.J. Dunkley, T. Keluskar (PhD student), R. Kiraga, P. Król, M. Mieszczak (PhD student), 75% Norwegian Financial Mechanism, 2014–2021, 25% National Science Centre "Grieg", Poland, 2020–2023;

- Polska Stacja Antarktyczna im. Antoniego A.B. Dobrowolskiego, Oaza Bungera, Antarktyda Wschodnia, **M. Lewandowski – Project leader**, M.A. Kusiak, A. Nawrot, Ministry of Education and Sciences, Poland, SPUB, 2022–2024;
- "RAW – Retreat And Wither" – What is the influence of glaciers recession from tidewater to land-based on the marine biological production and biogeochemistry in the Arctic?, **M. Moskalik – Project leader**, J. Giżejewski, O. Głowacki, V. Jain (PostDoc), M. Korhonen, B. Luks, E. Rets, 75% Norwegian Financial Mechanism, 2014–2021, 25% National Science Centre "Grieg", Poland, 2021–2024;
- Ecosystem connectivity effects on the metabolism and greenhouse gas flux in warming Arctic and Alpine lakes (ConGas), **M. Moskalik – Project leader since April 2022, M. Bartosiewicz – Project leader until March 2022**, N. Darellis (PhD student), B. Luks, T. Wawrzy-niak, National Science Centre "Opus Lap", Poland, 2021–2026;
- Wave energy delivery to the shores of Hornsund fjord, Svalbard, **Z. Świrad – Project leader**, M. Moskalik, National Science Centre "Sonatina", Poland, 2021–2024;
- CRIOS Cryosphere Integrated Observatory Network on Svalbard, **B. Luks – Project partner leader**, M. Bartosiewicz, Norwegian Financial Mechanism 2014–2021, National Science Centre, Poland, 2022–2024;
- FLOURISH – Consequences of glacier changes on downstream nutrient supply and carbon metabolism, **B. Luks – Project partner leader**, M. Bartosiewicz, M. Moskalik, National Science Centre "Sonata", Poland, 2022–2025;
- Fossil fuel contribution to Black Carbon deposition on Svalbard Glaciers (BC14), **B. Luks – Project partner leader**, A. Nawrot, Research Council of Norway (RCN), SSF Svalbard Strategic Grant, 2021–2023;
- Snow Pilot, **B. Luks – Project partner leader**, E. Rets, Svalbard Integrated Arctic Earth Observing System, 2022;
- Argo-Polska, **M. Moskalik – Project partner leader**, O. Głowacki, Ministry of Education and Sciences, Poland, 2022–2026;
- Quantification of heavy metal discharge with freshwater runoff to an Arctic fjord ecosystem (Hornsund, Spitsbergen), **M. Moskalik – Project partner leader**, O. Głowacki, M. Korhonen, National Science Centre "Opus", Poland, 2021–2024;
- Harmonising Environmental Research and Monitoring of Priority Pollutants in the Svalbard Atmosphere (HERMOSA), **A. Nawrot – Project partner leader**, B. Luks, Research Council of Norway (RCN) SSF Svalbard Strategic Grant, 2020–2022;
- Interact III – International Network for Terrestrial Research and Monitoring in the Arctic, P. Głowacki, European Union's Horizon 2020 Research and Innovation Programme, 2020–2023;
- INTAROS – Integrated Arctic observation system, P. Głowacki, European Union's Horizon 2020 Research and Innovation Programme, 2016–2022;
- Dust in Svalbard: local sources versus long-range transported dust (SVALDUST), M. Lewandowski, B. Luks, A. Nawrot, Svalbard Integrated Arctic Earth Observing System SESS call, 2022;
- 25 years of high-frequency ground penetrating radar measurements of snow studies in Svalbard (SnowGPR), B. Luks, Svalbard Integrated Arctic Earth Observing System SESS call, 2022;

- Anthropogenic triggering of landslides in the environment modified due to climate change – geophysical investigation, B. Luks, A. Nawrot, National Science Centre "Preludium", Poland, 2021–2023;
- Applied remote sensing and geophysical imaging in recognition of the changes of the water balance in High Arctic catchments, T. Wawrzyniak, National Science Centre "Sonata Bis", Poland, 2021–2025;
- Variability of arctic river thermal regimes in a changing climate (VariaT), T. Wawrzyniak, NCBiR, Small Grant Scheme, 2021–2023.

11.4 Instruments and facilities

Equipment

Geology:
EKO-LAB LAB-02-130 Rock crusher, fitted with a HEPA filter vacuum cleaner to extract dust (GeoBeLa); EKO-LAB Sieve and shaker to separate crushed samples (GeoBeLa); Air compressor and air gun for sample and surface cleaning (GeoBeLa); Zeiss Primotech petrographic microscope with PC for thin section examination (GeoBeLa); Zeiss Stemi 508 binocular microscope with PC for mineral separation (GeoBeLa); Tawo geochemical fume cupboard (digestorium) with carbon filter attachment for work with hazardous chemicals (GeoBeLa); WAMED drying oven for drying samples (GeoBeLa).

Geomorphology and cryosphere research:
GNSS Leica GR25 (2 sets), GS14, GS10, GNSS Leica GS14 Professional, GNSS Leica GS10 Professional (PolarPOL); Terrestrial Laser Scanner Riegl VZ6000 (PolarPOL); Ice core driller Kovacs Coring System Mark II (PolarPOL); Georadar MALÅ ProEx with antenas (2 sets, partly PolarPOL); Unmanned aerial vehicle (UAV) Phantom 4 Pro+ (3 sets; PolarPOL); MicroMap UAV (PolarPOL); snow density meter (3 sets).

Hydrology/Hydrochemistry/Meteorology/Climatology:
Flow meter NIVUS PCM-F with Active Doppler sensor (KDA-KP 10) (2 sets) – discharge measurements (PolarPOL); Autosampler ISCO 6712 (2 sets; PolarPOL); ISCO rain gauge meters (2 sets; PolarPOL); OnSet Hobo U20 (8 sets) – water level and temperature; OnSet Hobo U24 (4 sets) – water conductivity and temperature; OnSet Hobo pH (2 sets); OnSet Hobo O2 (2 sets); Sontek FlowTracker – Doppler method current meter (PolarPOL); Valeport 802 – Electromagnetic Current Meter; RF OLYMPUS VANTA M, advanced handheld X-ray uorescence (XRF) device (provides rapid, accurate element analysis and alloy identification to demand laboratory-quality results in the field); pH and conductivity meters (2 sets); Vaisala MAWS 301 – automatic weather station (3 sets; PolarPOL); FLIR CH4 Camera, Axetris CH4 sensor, Sonic 3D Anemometer Gill.

Marine:
Sub Sea Sonics AR-50 Acoustic Release (11 sets; partly PolarPOL) + ARI-50 Acoustic Release Interrogator (2 sets; partly PolarPOL); Sonardyne RT 6-1000 Acoustic Release (8 sets; partly PolarPOL); Star-Oddi Starmon Heading, pitch & roll, 3-D acceleration, pressure / depth and temperature logger; Wildlife Song Meter SM3M submersible acoustic buoy (2 sets) (PolarPOL); High Tech HTI-96-MIN hydrophone (4 sets); NTG-5 broadband microphone; Tascam DR-680 8-channel portable acoustic recorder (2 sets); Tascam, DR-40X 2-channel portable acoustic recorder; RBR CTD + O2 + chl-a; RBR pH; RBR CO2; RBR solo PAR (2 sets); RBR solo Tu (3 sets); RBR CTD (3 sets; partly PolarPOL); Hydro-Bios Multi Water Sampler Slime-

Line 6 with Sea & Sun CT (PolarPOL); Hydro-Bios Multi Sediment Trap 24 Bottles (PolarPOL); Plastic Water Samplers 1l and 3.5l; Sediment Traps Sets; Sequoia Laser In-Situ Scattering and Transmissometery LISST-100X 2.5-500 μm with Sea-Bird MicroCat CT, BIOBLOCK and 2 sets Large Battery Pack (PolarPOL); Small Gravitation Sediment Corer Sampler; Teledyne RDI ADCP WH300 (PolarPOL); Teledyne RDI ADCP Sentinel V20 with Battery Pack; SAIV A/S STD/CTD SD204 with Dissolved Oxygen and Turbidity Sensors (PolarPOL); RBRsolo T (5 sets; PolarPOL); RBRduet TD (2 sets; PolarPOL); RBRvirtuoso Tide & Wave (2 sets); Valeport miniCTD; Russell Technology XIR3000C Marine Radar System with Furuno antenna (PolarPOL); Digisnap Autonomous Photographic Systems (7 sets); Kongsberg Geoswath 4 Multibeam Echosounder 250 kHz (PolarPOL); EdgeTech Chirp Sub-Bottom 3100-P SB-216S 2–20 kHz (PolarPOL); SEABED Sub-Bottom Profiler 3010-MP 3–14 kHz; Seismo-acoustic Sparker and Boomer System; EdgeTech Side Scan Sonar 4125 400/ 900 kHz with Depressor Wing (PolarPOL); Tritech Side Scan Sonar StarFish 990F; Wesmar Side Scan Sonar SHD700SS; CODA DA 100 Acoustic Acquisition System; Lowrance Echosounder LMS 527C DF GPS 50/200 kHz; Lowrance Echosounder HDS-9 Gen 3 50/200 kHz with Structure Scan; Diving equipments; Buster Cabin E Boat (PolarPOL); SEARIS Multipurpose Unmanned Surface Explorer MUSE with Winch and Camera System (PolarPOL); Hydro-Bios Hand Winch with Motor (2 sets; PolarPOL); GoPro systems with Underwater Lights and Macro Converter.

Laboratory

GeoBeLa – Geoprocessing Belsk Laboratory:
After the completion and opening of GeoBeLa in 2021, the year of 2022 faced a major renovation program for the whole Geophysical Observatory in Belsk. Therefore, work in laboratory was limited and full operation began in October 2022. In the past year, 25 samples from Greenland and Labrador were processed. A new lab manager was employed, allowing smoother workflow and the ability to open the laboratory to scientists from external institutions. So far, four researchers from the AGH in Kraków have processed their samples in GeoBeLa.

Hornsund's unique Arctic Field Laboratory – part of the Polish Multidisciplinary Polar Research Laboratory (PolarPOL):
A goal of the PolarPOL is to combine technical and organizational ability for running interdisciplinary research and observations within natural phenomena taking place in the Arctic environment. The Laboratory to strengthen the Polish contribution to creating a worldwide network for research and monitoring of land and marine environments in polar zones which are crucial for understanding the dynamics of environmental changes all over the globe (global warming and raising sea levels especially). It also consolidates the dispersed scientific potential of Polish polar researchers. PolarPOL is going to secure participation in Poland in both international competition and collaboration by co-participation in the global research of polar areas, which is of fundamental importance for the position of Poland both in the scientific research of polar areas and in the field of the foreign policy of the State. A specific goal of the Laboratory is the facilitation of the use results of the basic research for the applicability including extraction of submarine mineral resources, use of biological marine resources, opening toward new navigation possibilities, and also tourism operations. A wide spectrum of scientific domains and areas provides also the opportunity to implement new industrial technologies by the Polish business entities.

11.5 Seminars and teaching

Seminars and lectures

M. Bartosiewicz, The evolving role of lakes in the global carbon cycle, Wrocław Geographical Dialogues, Wrocław, Poland, 8.04.2022, Invited lecture;

M. Bartosiewicz, Understanding the role of plankton in the biogeochemistry of lakes, Polish Hydrobiological Society Lecture Series, Warsaw, Poland, 15.12.2022, Invited lecture;

D. Dunkley, The use of stable and radioactive isotopes in environmental research, MŚSD University of Silesia in Katowice, Warsaw, Poland, 10.10.2022, Lecture;

D. Dunkley, Vestiges of the earliest continents: Eoarchean crustal growth in the North Atlantic Craton and the Poles Together Project, University of Niigata, Niigata, Japan, 30.11.2022, Invited lecture;

O. Głowacki, Oceanographical monitoring, International Environmental Doctoral School associated with the Centre for Polar Studies at the University of Silesia in Katowice (IEDS), Warsaw, Poland, 11.12.2022, Seminar/Lecture;

P. Głowacki, Tajemnicze wnętrza lodowców, Mediateka Grodzisk, Festiwal Nauki i Pasji, Grodzisk Mazowiecki, Poland, 02.09.2022, Open seminar/Invited lecture;

P. Głowacki, Praca i życie w bazie polarnej – biomedyczne aspekty polarne, Jagiellonian University, Medical College, Kraków, Poland, 19.02.2020, 27.11.2022, Invited lecture;

P. Głowacki, Polska obecność na Svalbardzie "Baranówka" – wspomnienie z łezką w oku, Wrocław University, Sesja naukowa – 50-lecie Baranówki, Wrocław, Poland, 23.04.2022, Open seminar/Invited lecture;

P. Głowacki, Polarna szkoła przeżycia –przystosowanie organizmu człowieka do zimna, Mazowieckie Centrum Polityki Społecznej, Warsaw, Poland, 19.07.2022, Invited lecture;

P. Głowacki, Zmiany klimatu – czy człowiek pyłkiem czy pępkiem w mechanizmie współczesnych zmian, Sierpcki Uniwersytet Trzeciego Wieku, Sierpc, Poland, 06.12.2022, Invited lecture;

P. Głowacki, Jak zalodzenie Oceanu Arktycznego może wpływać na pogodę w Polsce. (I. i II. część), Mazowieckie Centrum Polityki Społecznej, Warsaw, Poland, 15.11, 17.11.2022, Invited lecture;

M.A. Kusiak, Centrum Prasowe. Foksal, Dobrowolski. Reaktywacja. Antarktyczna misja (prawie) niemożliwa, Warsaw, Poland, 6.04.2022, Lecture;

M.A. Kusiak, Days of ice, Turanga Library, Bunger Oasis. Mission to reactivate Polish Antarctic Research Station, Christchurch, New Zealand, 1.10.2022, Lecture;

M.A. Kusiak, Uniwersytet III Wieku, Dobrowolski. Reaktywacja. Antarktyczna misja (prawie) niemożliwa, Milanówek, Poland, 10.10.2022, Lecture;

M.A. Kusiak, 90-ta rocznica Pierwszej Wyprawy Polarnej, Dobrowolski. Reaktywacja. Antarktyczna misja (prawie) niemożliwa, Legionowo, Poland, 16.10.2022, Lecture;

B. Luks, Winter fieldwork safety in mountains and polar regions, International Environmental Doctoral School associated with the Centre for Polar Studies at the University of Silesia in Katowice (IEDS), Poland, online, 01.03.2022, Lecture;

B. Luks, Field methods in the cryosphere research – detailed snowpit analyses, International Environmental Doctoral School associated with the Centre for Polar Studies at the University of Silesia in Katowice (IEDS), Zakopane, Poland, 03.03.2022, Other – Field classes;

B. Luks, Field methods in the cryosphere research – GPR, International Environmental Doctoral School associated with the Centre for Polar Studies at the University of Silesia in Katowice (IEDS), Zakopane, Poland, 04.03.2022, Other – Field classes;

B. Luks, Snow and glacier monitoring in Hornsund, International Environmental Doctoral School associated with the Centre for Polar Studies at the University of Silesia in Katowice (IEDS), Warsaw, Poland, 13.05.2022, Lecture;

B. Luks, Snow and glacier monitoring in Hornsund, International Environmental Doctoral School associated with the Centre for Polar Studies at the University of Silesia in Katowice (IEDS), Warsaw, Poland, 14.10.2022, Lecture;

M. Moskalik, RAW – glaciers Retreat And fiords Wither, ArcticSGD Meeting, Sopot, Poland, 07.12.2022, Open seminar;

M. Moskalik, Oceanographical monitoring, International Environmental Doctoral School associated with the Centre for Polar Studies at the University of Silesia in Katowice (IEDS), Warsaw, Poland, 11.12.2022, Seminar/Lecture;

A. Nawrot, Natural environment of the Bunger Oasis, or a few words about soil, snow and climate. Preliminary results of research carried out during the 4th Polish Antarctic Research Expedition (PARE) to the A.B. Dobrowolski Polish Antarctic Station, East Antarctica, IG PAS, Warsaw, Poland, online, 06.05.2022, Open seminar;

A. Nawrot, Behawioryzm niedźwiedzia polarnego, Lecture for Polish Polar Station Hornsund team, IG PAS, Warsaw, Poland, 10.05.2022, Lecture;

A. Nawrot, Misja Reaktywacja – wyprawa do Polskiej Stacji Antarktycznej im. Antoniego Bolesława Dobrowolskiego, Polar Festival, Warsaw, Poland, 04.06.2022, Lecture;

A. Nawrot, Nie tylko miarka, lupa i notes – o nowoczesnych pomiarach geomorfologicznych w rejonach polarnych, GeoGADKA, online, 07.09.2022, Open lecture;

A. Nawrot, Hydrochemical monitoring, led by the Polish Polar Station Hornsund, International Environmental Doctoral School associated with the Centre for Polar Studies at the University of Silesia in Katowice (IEDS), Warsaw, Poland, 13.05.2022, Lecture;

A. Nawrot, Hydrochemical monitoring, International Environmental Doctoral School associated with the Centre for Polar Studies at the University of Silesia in Katowice (IEDS), Warsaw, Poland, 14.10.2022, Lecture;

A. Nawrot, Polskie Prace badawcze w Oazie Bungera Antarktyda Wschodnia, Faculty of Earth Sciences and Spatial Management, Nicolaus Copernicus University, Toruń, Poland, 08.12.2022, Invited lecture; Faculty Scientific Meeting (Posiedzenie Naukowe);

T. Wawrzyniak, Polskie laboratorium naukowe w sercu Arktyki, Uniwersytet Trzeciego Wieku "Atena" w Obornikach Śląskich, Oborniki Śląskie, Poland, 05.05.2022, Invited lecture;

T. Wawrzyniak, Zmiany klimatyczne na przykładzie zlewni polarnych otoczenia fiordu Hornsund, Mediateka Grodzisk, Festiwal Nauki i Pasji, Grodzisk Mazowiecki, Poland, 02.09.2022, Open seminar;

T. Wawrzyniak, Hydrometeorologia stacji polarnej Hornsund, Szkoła im. Mateusza Chełmońskiego w Adamowiźnie, Adamowizna, Poland, 02.09.2022, Seminar and workshop;

T. Wawrzyniak, Arctic amplification – why is the Arctic a canary in a coal mine for global climate change, EXPO 2020 Science Week at the Polish Pavilion, Dubai, UAE, February 2022, Invited lecture;

T. Wawrzyniak, Arctic hydrology (Procesy hydrologiczne w Arktyce), EduArctic2, online, January 2022, Webinars.

PhD

M.A. Kusiak, P. Król, Ewolucja skorupy kontynentalnej w archaicznym Kompleksie Napier, Antarktyda Wschodnia, Institute of Geological Sciences PAS, Warsaw, Poland.

Visiting scientists

Simon Wilde, Curtin University, Perth, Australia, 14–24.08.2022;

Martin Whitehouse, Museum of Natural History, Stockholm, Sweden, 16–25.08.2022;

Julien Farlin, Ministry of Environmental, Climate and Sustainable Development, Water Administration, Groundwater and Drinking Water Division, Luxembourg, Luxembourg, 21–23.09.2022.

11.6 Meetings, workshops, conferences, and symposia

Presentations of the Department's members:

- D. Dunkley, M.A. Kusiak, SCAR Open Science Conference, New discoveries of Eoarchean rocks in Antarctica; India, online, 2.08.2022, Oral, Conference;
- O. Głowacki, Polish Scientific Networks – Climate Change: Science and Society, Listening to glaciers: Can we measure ice loss with passive cryoacoustics?; Wrocław, Poland, 28–30.09.2022, Oral (invited, keynote), Conference;
- P. Głowacki, Arctic Summit Week, FARO Annual Meeting, Polish research activity at Svalbard – Raport from 2021; Tromso, 26.03.2022, Oral;
- P. Głowacki, Arctic Summit Week, Svalbard Science Forum Meeting, Polish research activity plan in 2022 at Svalbard; Tromso, 31.03.2022, Oral;
- P. Głowacki, Międzynarodowy Kongres Morski, Czy doczekamy się zaniku lodu morskiego w Arktyce; Szczecin, Poland, 29–30.06.2022, Oral, Conference;
- T. Keluskar, M.A. Kusiak, D.J. Dunkley, International Youth Conference, Importance of 3.3 Ga magmatism in the Saglek Block, Labrador; Sopot, Poland, 10.06.2022, Oral, Meeting;
- T. Keluskar, M.A. Kusiak, D.J. Dunkley, 27th Meeting of the Petrology Group of the Mineralogical Society of Poland, A ca. 3.3 Ga magmatic event in the Saglek Block, Labrador; Rudy, Poland, 22.10.2022, Oral, Conference;
- P. Król, M.A. Kusiak, D.J. Dunkley, Goldschmidt Conference 2022, Low-$\delta^{18}O$ signatures in zircon – evidence for emergent land in the early Archean; Hawaii, USA, online, 13.07.2022, Oral, Conference;
- P. Król, M.A. Kusiak, D.J. Dunkley, 27th Meeting of the Petrology Group of the Mineralogical Society of Poland, Evidence for emergent land on the early Earth recorded in low-δ18O zircon signatures from the Napier Complex, East Antarctica; Rudy, Poland, 22.10.2022, Oral, Conference;
- M.A. Kusiak, 27th Meeting of the Petrology Group of the Mineralogical Society of Poland, Nano- and microstructures in lunar zircon from Apollo 15 and 16 impactites: implications for age interpretation; Rudy, Poland, 22.10.2022, Oral, Conference;

- M. Lewandowski, M.A. Kusiak, A. Nawrot, SCAR 2022 – Antarctica in a Changing World. 10th SCAR Open Science Conference, Polish Antarctic Station Dobrowolski: history, present and future perspective in brief; India; online, 01–10.08.2022, Oral, Conference;
- B. Luks, 2022 Arctic Circe Assembly, Polish Polar Station Hornsund – a Unique Platform for Polar Research; Reykjavik, Iceland, 13–16.10.2022, Oral, Conference;
- M. Mieszczak, M.A. Kusiak, D.J. Dunkley, International Youth Conference, Challenges of dating old cratons, an example of the Eoarchean Isukasia terrane, Itsaq gneiss, SW Greenland; Sopot, Poland, 10.06.2022, Oral, Meeting;
- M. Mieszczak, M.A. Kusiak, D.J. Dunkley, 27th Meeting of the Petrology Group of the Mineralogical Society of Poland, Diversity in zircon preservation in Eoarchean rocks of the Itsaq gneiss comples, SW Greenland; Rudy, Poland, 22.10.2022, Oral, Conference;
- A. Nawrot, M.A. Kusiak, M. Lewandowski, B. Luks, SCAR 2022 – Antarctica in a Changing World. 10th SCAR Open Science Conference, Chemical and physical characteristics of the seasonal snow layer in the Bunger Oasis; India, online, 01–10.08.2022, Oral, Conference;
- A. Nawrot, B. Luks, Harmonising Environmental Research and Monitoring of Priority Pollutants in the Svalbard Atmosphere (HERMOSA), Air and precipitation monitoring conducted by the Polish Polar Station Hornsund, Spitsbergen; Longyearbyen, Svalbard, 12–15.09.2022, Oral, Workshop (Adam Nawrot – co-organizer);
- E. Rets et al., INARCH – International Network for Alpine Research Catchment Hydrology Workshop, Studying scale effects in streamflow response in glacierized Baksan river catchment in the North Caucasus using natural stable isotopes; Baños de Panticosa, Spain, 18–20.10.2022, Oral, Workshop;
- T. Wawrzyniak et al., ITCH Workshop, Permafrost in Hornsund. The Cryogrid Hackathon; Potsdam, Germany, 23–27.10.2022, Oral, Workshop;
- K. Koziol et al., A. Nawrot, SESS Report 2022 – Finding connections, HERMOSA – Harmonising Environmental Research and Monitoring of Priority Pollutants in the Svalbard Atmosphere; Longyearbyen, online, 03.06.2022, Oral, Workshop;
- B. Di Mauro, et al., M. Lewandowski, B. Luks, A. Nawrot, SESS Report 2022 – Finding Connections, SVALDUST – Dust in Svalbard: local sources versus long-range transported dust; Longyearbyen, Svalbard; online, 03.06.2022, Oral, Workshop;
- C. Sanchez-Cid, et al., B. Luks, A. Nawrot, 9th International Conference on Polar and Alpine Microbiology (PAM), Environmental and anthropogenic factors shape the snow microbiome and Antibiotic resistome; Potsdam, Germany, 09–14.10.2022, Oral, Conference;
- M.A. Killie, et al., B. Luks, Cryosphere International Symposium on Ice, Snow and Water in a Warming World, Decadal trends in Svalbard snow cover and sea-ice area; Reykjavik, Iceland, 21–26.08.2022, Oral, Conference;
- C. Deschamps-Berger, et al., B. Luks, International Mountain Conference 2022, Watching mountain snowpacks from space: recent advances in snow depth mapping from satellite photogrammetry; Innsbruck, Austria, 11–15.09.2022, Oral, Conference;
- R. Mourot, et al., B. Luks, 9th International Conference on Polar and Alpine Microbiology (PAM), Biogeography of glacier microbial communities; Potsdam, Germany, 09–14.10.2022, Oral, Conference;
- M. Majerska, et al., T. Wawrzyniak, International Sopot Youth Conference entitled Where the World is Heading, Variability of hydrological regimes of non-glaciated polar catchment in a changing climate; Sopot, Poland, 10.06.2022, Oral, Conference;

- M. Majdański, et al., T. Wawrzyniak, EGU General Assembly 2022, The effect of subsurface freezing-thawing in the SW Svalbard on the newly deglaciated areas; Vienna, Austria, 23–27.05.2022, Oral, Conference;
- M. Osuch, et al., T. Wawrzyniak, EGU General Assembly 2022, Assessment of streamflow trends in snow and glacier melt dominated catchments; Vienna, Austria, 23–27.05.2022, Oral, Conference;
- A. Bamby, et al., T. Wawrzyniak, SIOS Online Conference "Earth Observation and Remote Sensing applications in Svalbard", UAV-based remote sensing observation products in High Arctic Catchments in SW; Spitsbergen online, 12.10.2022, Oral, Conference;
- V. Jain, International School on Integrated Environmental Studies in the Arctic, NA; Sopot, Poland, 26–30.09.2022, NA, Workshop;
- Z. Świrad, et al., M. Moskalik, American Geophysical Union (AGU) Fall Meeting, Recent wave conditions in Hornsund, Svalbard from in situ measurements; Chicago, Il, USA, online, 12–16.12.2022, Poster, Conference;
- M. Moskalik and working group (inc. J. Giżejewski, O. Głowacki, V. Jain, M. Korhonen, B. Luks), Polish Scientific Networks – Climate Change: Science and Society, "RAW – Retreat And Wither" – What is the influence of glaciers recession from tidewater to land-based on the marine biological production and biogeochemistry in the Arctic?; Wrocław, Poland, 28–30.09.2022, Poster, Conference;
- E. Malygin, et al., E. Rets, INARCH – International Network for Alpine Research Catchment Hydrology Workshop, Combined physically-based and machine learning approach for operational estimation of snow water equivalent across the Western U.S.: Snowcast Showdown competition; Baños de Panticosa, Spain, 18–20.10.2022, Poster, Workshop;
- B. Luks, J.I. López Moreno, L. Leppänen, E. Alonso-González, M. Błaszczyk, S. Gascoin, C. Deschamps-Berger, M. Osuch, J.C. Gallet, SIOS Polar Night Week 2021, In-situ snow measurements for distributed modelling of the seasonal melting; Longyearbyen, Norway, online, 11–15.01.2021, Poster, Conference;
- M.A. Kusiak, D.J. Dunkley, et al., Earth History, Dynamics and Planetary Habitability, Generations of Eoarchean crust: early results from the Poles Together project; Sundvollen, Norway, 15.11.2022, Poster, Conference;
- O. Głowacki, American Geophysical Union (AGU) Fall Meeting, Passive cryoacoustics as a developing tool for the monitoring of calving fluxes and calving styles; Chicago, Il, USA, 12–16.12.2022, Poster, Conference;
- M. Korhonen, M. Moskalik, O. Głowacki, Z. Świrad, Polish Scientific Networks – Climate Change: Science and Society, LONGHORN – Long-term monitoring in Hornsund; Wrocław, Poland, 28–30.09.2022, Poster, Conference;
- B. Luks, et al., A. Nawrot, E. Rets, T. Wawrzyniak, INARCH – International Network for Alpine Research Catchment Hydrology Workshop, High Arctic Fuglebekken experimental catchment on Spitsbergen, Svalbard; Baños de Panticosa, Spain, 18–20.10.2022, Poster, Workshop.

11.7 Publications

ARTICLES

Bartosiewicz, M., et al. (2022), Detritus-hosted methanogenesis sustains the methane paradox in an alpine lake, *Limnol. Oceanogr*. **68**, 1, 248–264, DOI: 10.1002/lno.12263.

Cabello-Yeves, P.J., et al., **M. Bartosiewicz** (2022), α-cyanobacteria possessing form IA RuBisCO globally dominate aquatic habitats, *ISME J.* **16**, 10, 2421–2432, DOI: 10.1038/s41396-022-01282-z.

Cabello-Yeves, P.J., et al., **M. Bartosiewicz** (2022), Elucidating the picocyanobacteria salinity divide through ecogenomics of new freshwater isolates, *BMC Biol*. **20**, 175, DOI: 10.1186/s12915-022-01379-z.

Harlov, D.E., **D.J. Dunkley**, et al. (2022), Zircon as a recorder of trace element changes during high-grade metamorphism of Neoarchean lower crust, Shevaroy Block, Eastern Dharwar Craton, India. *J. Petrol.* **63**, 5, egac036, DOI: 10.1093/petrology/egac036.

Głowacki, O. (2022), Distinguishing subaerial and submarine calving with underwater noise, *J. Glaciol.* **68**, 272, 1185–1196, DOI: 10.1017/jog.2022.32.

Bienhold, Ch., et al., **M. Korhonen** (2022), Effects of sea ice retreat and ocean warming on the Laptev Sea continental slope ecosystem (1993 vs 2012), *Front. Mar. Sci*. **9**, 1004959, DOI: 10.3389/fmars.2022.1004959.

Król, P., **M.A. Kusiak**, **D.J. Dunkley**, et al. (2022), Neoarchean magmatism in the southern Scott and Ragatt Mountains, Napier Complex, east Antarctica, *Precambrian Res*. **370**, 106530, DOI: 10.1016/j.precamres.2021.106530.

Kusiak, M.A., et al. (2022), Nano- and micro-structures in lunar zircon from Apollo 15 and 16 impactites: implications for age interpretations, *Contrib. Mineral. Petrol*. **177**, 112, DOI: 10.1007/s00410-022-01977-8.

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Laska, M., **B. Luks**, D. Kępski, et al., **P. Głowacki**, **A. Nawrot** (2022), Hansbreen Snowpit Dataset – over 30-year of detailed snow research on an Arctic glacier, *Sci. Data* **9**, 656, DOI: 10.1038/s41597-022-01767-8.

Sanchez-Cid, C., et al., D. Kępski, **B. Luks**, **A. Nawrot** (2022), Environmental and anthropogenic factors shape the snow microbiome and antibiotic resistome, *Front. Microbiol*. **13**, 918622, DOI: 10.3389/fmicb.2022.918622.

Thoman, R.L., et al., **B. Luks** (2022), The Arctic, *Bull. Am. Meteorol. Soc*. **103**, 8, S257–S306, DOI: 10.1175/BAMS-D-22-0082.1.

Jarosz, K., et al., **M. Moskalik** (2022), A new paraglacial typology of high Arctic coastal systems: application to Recherchefjorden, Svalbard, *Ann. Am. Assoc. Geogr*. **112**, 1, 184–205, DOI: 10.1080/24694452.2021.1898323.

Świrad, Z.M., and A.P. Young (2022), Spatial and temporal trends in California coastal cliff retreat, *Geomorphology* **412**, 108318, DOI: 10.1016/j.geomorph.2022.108318.

Kincey, M.E., et al., **Z.M. Świrad** (2022), Modelling post-earthquake cascading hazards: Changing patterns of landslide runout following the 2015 Gorkha earthquake, Nepal, *Earth Surf. Proc. Land*. **48**, 3, 537–554, DOI: 10.1002/esp.5501.

Araźny, A., et al., **T. Wawrzyniak**, M. Osuch (2022), Climate change in the Arctic and Antarctic ecosystems, *Kosmos* **70**, 4, 579–595, DOI: 10.36921/kos.2022_2836 (in Polish).

Majdański, M., et al., A. Marciniak, B. Owoc, M. Osuch, **T. Wawrzyniak** (2022), Variations of permafrost under freezing and thawing conditions in the coastal catchment Fuglebekken (Hornsund, Spitsbergen, Svalbard), *Permafrost Periglac. Process*. **33**, 3, 264–276, DOI: 10.1002/ppp.2147.

Marciniak, A., M. Osuch, **T. Wawrzyniak**, B. Owoc, et al., M. Majdański (2022), Multi-method geophysical mapping of ground properties and periglacial geomorphology in Hans Glacier forefield, SW Spitsbergen, *Pol. Polar Res*. **43**, 2, 101–123, DOI: 10.24425/ppr. 2022.140363.

Osuch, M., **T. Wawrzyniak**, and M. Majerska (2022), Changes in hydrological regime in High Arctic non-glaciated catchment in 1979–2020 using a multimodel approach, *Adv. Clim. Change Res.* **13**, 4, 517–530, DOI: 10.1016/j.accre.2022.05.001.

Osuch, M., **T. Wawrzyniak**, et al. (2022), Changes in the flow regime of High Arctic catchments with different stages of glaciation, SW Spitsbergen, *Sci. Total Environ*. **817**, 152924, DOI: 10.1016/j.scitotenv.2022.152924.

OTHERS

Giżejewski, J. (2022), Arktyka. Wyprawy ku dalekiej północy. **In:** L. Będkowski (ed.), *Bieguny Ziemi, Pomocnik Historyczny. Polityka* **4**, 16–27 (in Polish).

Giżejewski, J. (2022), Arktyka. Wyprawy ku dalekiemu południu. **In:** L. Będkowski (ed.), *Bieguny Ziemi, Pomocnik Historyczny. Polityka* **4**, 29–41 (in Polish).

Giżejewski, J. (2022), Poczet wielkich polarników. **In:** L. Będkowski (ed.), *Bieguny Ziemi, Pomocnik Historyczny. Polityka* **4**, 42–51 (in Polish).

Głowacki, P. (2022), Baza Wiedzy – Polarne okno na świat także dla polskiej nauki. **In:** L. Będkowski (ed.), *Bieguny Ziemi, Pomocnik Historyczny. Polityka* **4**, 75–78 (in Polish).

Kusiak, M.A., **M. Lewandowski**, **A. Nawrot**, W. Miloch (2022), Dobrowolski. Reaktywacja. Antarktyczna misja (prawie) niemożliwa, *Biuletyn. Mineralogia, Petrologia i Geochemia w Polsce* **6**, 2–5 (in Polish).

Lewandowski, M. (2022), *Między Lodem a Mgłą, Czyli w Siwym Nigdzie*, Vectra, 224 pp. (in Polish).

Nawrot, A. (2022), Jako pierwsi Polacy po 1989 r. dotarliśmy do Oazy Bungera na Antarktydzie, *Wyborcza.pl*, 29 December, on-line, available from: https://wyborcza.pl/7,75400,29308180,dr-adam-nawrot-geofizyk-jako-pierwsi-polacy-po-1989-r-dotarlismy.html (in Polish).

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