МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL ACADEMY OF SCIENCES OF UKRAINE
STATE INSTITUTION NATIONAL ANTARCTIC SCIENTIFIC CENTER

XI INTERNATIONAL ANTARCTIC CONFERENCE

DEDICATED TO THE 160TH ANNIVERSARY OF THE BIRTH OF VOLODYMYR VERNADSKY – THE FIRST PRESIDENT OF THE UKRAINIAN ACADEMY OF SCIENCES, FOUNDER OF THE STUDY OF NOOSPHERE

Book of Abstracts

XI International Antarctic Conference
Kyiv, Ukraine,
May 10–12, 2023

Kyiv – 2023

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National Academy of Sciences of Ukraine
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THE CHALLENGES PRESENTED TO THE ANTARCTIC TREATY SYSTEM BY THE INVASIONS OF UKRAINE

A. D. Hemmings
Gateway Antarctic Centre for Antarctic Studies and Research, University of Canterbury, Christchurch, New Zealand; alandhemmings@xtra.co.nz

The functioning of the diplomatic fora of the Antarctic Treaty System (ATS) – the annual Antarctic Treaty Consultative Meetings for the 1959 Antarctic Treaty and the 1991 Madrid Protocol, and the meeting of the Commission for the 1980 Convention on the Conservation of Antarctic Marine Living Resources – has been problematical for 10–15 years. The difficulties thus pre-date the Russian Federation 2014 and 2022 invasions of Ukraine, and reflect wider geopolitical challenges, most obviously the tensions between Western states and China and worsening relations with the Russian Federation since the 2008 Russo-Georgian War. But, if the 2014 invasion of Crimea can be seen to have significantly worsened things, the 2022 invasion takes this to a new level and has presented the ATS with its greatest challenge since the adoption of the Antarctic Treaty – far more significant than the supposed challenges of the Falklands/Malvinas War, the UN General Assembly Question of Antarctica debates, or the rejection of the Convention on the Regulation of Antarctic Mineral Resource Activities (CRAMRA). The Russian Federation invasion of Ukraine – aside all the horror, illegality and barbarity visited on the people of Ukraine – involves a pre-meditated assault by one Antarctic decision-making state upon another; has impeded the normal functioning of Antarctic science; and has made Antarctic governance arrangements, dependent upon consensus decision-making, very difficult indeed. And this has occurred immediately after the hiatus imposed by the COVID 19 Pandemic, when a recovery (both operational and diplomatic) was hoped for. The challenges for the ATS include not only the direct effects of the invasion on Ukraine's ability to sustain its Antarctic programme, and Western states' consequential restrictions on cooperation with the Russian Federation – which may include Antarctic gateway state facilities – but indirect effects through the emergence of uncongenial internal ATS bloc-dynamics involving Western states and not only Russia, but China, Brazil, India and South Africa. Might this prove fatal to effective ATS operation, across scientific and logistics cooperation and diplomatic engagement in ATS fora, and preclude further ATS development over the coming decade? Will such stresses create reinforcing feedbacks to the initial, and already vexed, geopolitical confrontations emerging in the Antarctic region? Can we anticipate a point – albeit, surely, still some years ahead – when the recovery of international relations generally might be aided by resumed Antarctic cooperation and confidence-building measures within the Antarctic legal and diplomatic domain?

THE FIRST ANTARCTIC COMMUNITY'S EFFORTS TO COUNTER RUSSIAN FULL-SCALE MILITARY INVASION OF UKRAINE IN 2022

E. Dykyi, A. Fedchuk, D. Cheberkus
State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine; evgendykyi@gmail.com

The Antarctic Treaty System (ATS) has long been seen as an example of successful international cooperation for peace, research, and environmental protection for the benefit of all humanity. However, the military aggression of one Antarctic decision-making state against another has a destructive effect on the latter's national Antarctic program resulting in a sequestered budget, a reduced research program, and a need to support the scientists threatened or displaced by the warfare. The head office of the State Institution National Antarctic Scientific Center located in downtown Kyiv was partly destroyed because of a Russian missile attack on critical infrastructure and civilian objects on October 10th, 2022. This was the first case in the history of the Antarctic Treaty System when a state agency responsible for managing scientific research in the Antarctic Treaty Area on behalf of its government suffered destruction as a result of a direct military attack. Hereby such military aggression challenges the Antarctic Treaty as an early and critical arms-control instrument and could undermine the ATS regime itself. Following the Order of the Cabinet of Ministers (Ukrainian Government) of March 14th, 2022, No 7482/0/1-22, On the exclusion of Russian representatives from international organizations, professional associations, and international projects, the Ukrainian delegation's activity aims to assist interactions with allies' coalition regarding a consolidated response from the whole Antarctic community to Russian aggression. It is examined the first individual and collective efforts to counter Russian full-scale military invasion of Ukraine, made in 2022 by the highest annual international forum for the Antarctic governance – the 44th Antarctic Treaty Consultative Meeting (ATCM), and 41st Conservation of Antarctic Marine Living Resources (CCAMLR). It is argued that the condemnation in the strongest possible terms of Russian unjustifiable, unprovoked, and illegal invasion of Ukraine, as well as political protest to the Russian delegation – an unprecedented from almost 60 years of diplomatic practices by Antarctic Treaty Parties – will necessarily affect the further work of other Antarctic-related administrative and advisory bodies within the Antarctic Treaty System. It is expected that if the aggression continues, isolation measures such as international and national sanctions and institutional restrictions will be extended. In this case, further progress in rejecting any Russian initiatives and suspending ongoing joint projects with Russian partners will significantly complicate the diplomatic, research, fishery, and logistics activities of the Russian Federation within the Antarctic Treaty area until the situation allows for the resumption of such cooperation.

THE POLAR RESEARCH INFRASTRUCTURE NETWORKING FOR DEVELOPMENT OF EU POLAR SCIENCE

N. Biebow[1], V. Willmott Puige[1], E. O. Dykyi[2], A. P. Fedchuk[2], S. V. Zherebchuk[2]
[1]Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany;
[2]State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine; zerebcuksofia@gmail.com

The polar regions play a key role in the Earth's system. They are essential for our climate and are sentinels of climate change, human expansion, and the hunt of new resources. The polar regions are losing ice, and their oceans and land are changing rapidly. To understand and predict key processes in the polar regions and provide evidence-based information, the polar research community needs access to world-class research infrastructure operating in these regions.

To address that, the main EU polar research operators are joining their efforts in the POLARIN proposal. They will create an international network of polar research infrastructures and their services, aiming at addressing the scientific challenges of the polar regions. The network will include a wide array of complementary and interdisciplinary top level research infrastructures: Arctic and Antarctic research stations, research vessels and icebreakers operating at both poles, observatories, data infrastructures and ice and sediment core repositories. POLARIN will provide integrated, challenge-driven, and combined access to these infrastructures to facilitate interdisciplinary research on complex processes.

POLARIN will:

1. Provide challenge-driven transnational access to a large portfolio of research infrastructures.
2. Improve the access to data by improving data availability and interoperability between data infrastructures.
3. Provide virtual access to data and data services.
4. Provide data products for the scientific community and decision makers.
5. Train the young generation of polar researchers in optimally exploiting the infrastructures for their research.
6. Duly advertise the services offered by POLARIN and engage the infrastructure users to share their research outcomes with society.

The State Institution National Antarctic Scientific Center is a partner of this European infrastructure proposal offering *RV Noosfera* and Akademik Vernadsky station for transnational access.

RV Noosfera is equipped with a suite of laboratories and winch systems that allows to study the seabed at a depth of 8 km. In addition to a crew of 27 people, the icebreaker can accommodate up to 50 scientists. The vessel's autonomy of up to 2 months allows conducting research in any point of the World Ocean.

The Akademik Vernadsky station itself is a system with its own infrastructure, which ensures its operation throughout the year. All the year round 12 winterers work at the station.

VERNADSKY STATION: A SOCIOLOGICAL OBSERVATORY OF SCIENTIFIC ACTIVITY IN ANTARCTICA

M. Legal
School of Advanced Studies in the Social Sciences, Paris – Aubervilliers, France; *margot.legal@ehess.fr*

Since the Antarctic Treaty signature, Antarctica has become a continent dedicated to scientific activity and international cooperation. Thence it represents an emblematic field of research for the Science and Technology Studies since it concentrates most of the issues at stake in modern science such as risk management, human behaviour, environment protection, and international relations. Humanities and Social Sciences are now part of research programs of many Antarctic institutions following the Scientific Committee on Antarctic Research. Yet few fieldwork studies have been conducted in Antarctica to analyze the conduct of scientific activity in concrete terms.

In this respect, Vernadsky station represents a perfect case study. First, it is one of the most ancient operating stations in Antarctica that provides long-term data series in meteorological and geophysical research. Then it plays a key role for studying climate and environment changes. Vernadsky also experienced a change of nationality since the United Kingdom transferred Faraday Station to the freshly post-Soviet Republic of Ukraine. International relations and tensions with Russia for developing Antarctic research have been prominent to the present time, while post-USSR countries have remained quite invisible in the rising field of Antarctic Social Sciences Studies. Finally, Vernadsky station is at the forefront of climate change and tourism impact in Antarctic Peninsula.

Conducting scientific research in Antarctica at Vernadsky station involves a range of challenges. One of the main issues is to manage the scientific and historical heritage of the station while modernizing it, in order to reinforce international cooperation. Important changes occurred in recent years to open the station to new fields of research, to women, and to diversified collaborations. Substantial investments have been undertaken to modernize equipment and enable advanced research. Regulating human impact in Argentine Islands also became a priority regarding the important tourist influx in Antarctic Peninsula and questions the balance between scientific activity and tourism. Finally, living environment is a crucial issue in polar conditions especially for winterers. Collective life in Antarctica is framed by norms and rituals to preserve a wholesome atmosphere and to give sense to polar commitment.

Such modernization process that I observed during my ethnographic work at Vernadsky station was struck first by Covid pandemic. Then the beginning of the full-scale military aggression of Ukraine by Russia happened as a crucial ordeal at Vernadsky station. Yet it gave to the scientific activity a new meaning, turning the continuation of the Antarctic work into a symbol of resiliency. It also provided media visibility on Ukraine presence in Antarctica and acted as a possible catalyzer for reinforcing international cooperation.

Ultimately, the ongoing modernisation of Vernadsky station aims to reinforce Ukraine as a scientific and sovereign nation at international scale. The beginning of full-scale Russian agression dramatically confirmed this conclusion and illustrates the relevance to analyse scientific activity through a sociological perspective.

HF IONOSPHERIC SOUNDING FROM THE RV *NOOSFERA* DURING THE 28th UKRAINIAN ANTARCTIC EXPEDITION

A. V. Zalizovski[1,2,3]***, Y. M. Yampolski*** [2]***, I. Stanislawska***[3]***, E. V. Mishin***[4]***, O. V. Koloskov***[1,2,5]***, O. V. Budanov***[2]***, O. V. Bogomaz***[1,6]***, B. Y. Gavrylyuk***[1,2]***, A. O. Sopin***[1,2]***, A. S. Kashcheyev***[5]***, S. B. Kashcheyev***[2]***, V. M. Lisachenko***[2]***, A. I. Reznychenko***[2,3]

[1]*State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine; zalizovski@gmail.com*

[2]*Institute of Radio Astronomy, National Academy of Sciences of Ukraine, Kharkiv, Ukraine;*

[3]*Space Research Centre, Polish Academy of Sciences, Warsaw, Poland;*

[4] *Space Vehicles Directorate, Air Force Research Laboratory, Albuquerque, NM, United States;*

[5]*Department of Physics, University of New Brunswick, Fredericton, Canada;*

[6]*Institute of Ionosphere, NAS and MES of Ukraine, Kharkiv, Ukraine*

Space weather remains one of the key research topics since the space era began. Ionospheric plasma irregularities are essentially important for space weather because they can significantly impact propagation of radio waves along ionospheric and trans-ionospheric radio paths thus decreasing the quality of satellite navigation and HF and satellite communication. Therefore, developing novel techniques for ionospheric sounding and conducting dedicated experiments to study plasma irregularities and their impact on RF propagation are important tasks of space weather research. Ionospheric sounding is usually performed using HF radio waves (3-30 MHz) that efficiently interact with ionospheric plasma with typical plasma frequencies in the HF band.

A year ago, IRA created a radio observatory onboard the research vessel (RV) *Noosfera* (former flagship of Britain's Royal Scientific Navy RRS James Clark Ross bought by Ukraine in 2021) and conducted observations during the navigation of *Noosfera* from Punta Arenas to the Ukrainian Antarctic *Akademik Vernadsky* station (UAS) and back from January till April 2022. In 2023 we carried out HF sounding from RV *Noosfera* in March-April during her trip from Punta Arenas to UAS and back to Cape Town. RV *Noosfera* was equipped with a two-channel Doppler HF receiver and a passive Doppler ionosonde operating by the signals from an active ionosonde at UAS. We used the Doppler receivers with a pin antenna and the passive ionosonde with a dipole antenna. HF receivers deployed onboard are identical to that operated in the ground-based network of

Doppler HF receivers at UAS, Svalbard, Ukraine, and Africa. Bistatic ionospheric sounding was carried out using signals of time service stations in the Northern hemisphere that were received simultaneously onboard RV and at UAS. The signals from a special transmitter at UAS were received onboard RV as well. The range of tasks to be addressed includes studies of the characteristics of long-distance HF propagation including reflection or scattering off plasma irregularities of various nature, as well as scattering of HF signals off sea surface waves. Simultaneous vertical and oblique ionospheric sounding with changing base aims at studying the spatial plasma irregularities of different scales, as well as investigating the perspectives of launching the vertical and/or oblique sounding of the ionosphere at the Polish Antarctic station *Arctowski* located at King George Island.

UKRAINIAN BIOLOGICAL STUDIES IN THE ANTARCTIC, 2018-2023

***I. Parnikoza*[1,2], *I. Kozeretska*[1], *E. Dykyi*[1]**
[1]*State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Ukraine;*
[2]*Institute of Molecular Biology and Genetics, National Academy of Sciences of Ukraine, Ukraine; i.yu.parnikoza@imbg.org.ua*

Life Sciences activity is one of the main directions of Ukrainian Antarctic studies and has been conducted since the 1998/99 season. In the period of 2018–2023 already existing areas of life science research continued, and some new studies carried out according to the Ukrainian State Target Scientific Program of Antarctic Research have been launched: Marine research is ongoing on several sites in the water area of Galindez Island (Argentine Islands), where parameters of the marine ecosystem are regularly measured, and samples of bacterio-, phyto-, and zooplankton are collected. The purpose of these studies is to monitor the state of plankton groups depending on climatic conditions. In the framework of marine research, the biology of marine mammals is also studied: cetaceans and seals, their genetics and migration directions, the study of the parasitic fauna of marine organisms. A separate topic is the monitoring of penguin nesting populations within the framework of the CEMP program.

Research on terrestrial ecosystems has been going on for a long time. Since 2006, a monitoring site has been established on Galindez Island to study the dynamics of vascular plant populations in connection with external environmental factors. The directions of distribution of vascular plants and other terrestrial components of the biome, as well as their genetic structure, are also being studied. In 2019–2020 these studies have been expanded by increasing the number of monitoring objects – moss banks, as well as by initiating the study of microorganisms associated with plants. The adaptive potential of plants and terrestrial invertebrates of Antarctica, as well as their production of valuable secondary metabolites were also studied.

Medical-physiological and psychological studies of winterers are carried out.

An important area of current research is the study of the uniqueness and representativeness of the biodiversity of the Argentine Islands – Kyiv Peninsula region, in order to develop and implement an effective mechanism for its protection. For this purpose, visitor site guidelines for central Argentine Islands have been developed and adopted, as well as the existing guidelines for Winter Island have been adjusted. At the same time, documents are being developed to create a new Antarctic Specially Protected Area (ASPA) in the region.

All the above-mentioned researches are carried out in cooperation with foreign colleagues from the USA, Great Britain, the Czech Republic, Poland, Bulgaria and other countries. Furthermore, research within the Life Sciences group, although mainly focused on the Wilhelm Archipelago, also covers sites along the entire Antarctic Peninsula from King George Island to Alexander Island.

UKRAINIAN FISHERIES IN THE CCAMLR AREA AS AN IMPORTANT FACTOR IN KEEPING ON UKRAINIAN FISHERIES RESEARCH IN ANTARCTICA MARINE AREAS

K. V. Demianenko*, *L. K. Pshenichnov
Institute of Fisheries and Marine Ecology, Berdiansk, Ukraine; s_erinaco@ukr.net

Taking into account that the requirement for the presence of scientific observers on board vessels during fishing in the zone of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) is mandatory, in all years since 1994, when Ukraine became a member of the CCAMLR, Ukrainian scientists worked on every Ukrainian flagged fishing vessel during fishery period (until 2014 scientific observation at the CCAMLR area has been provided by the Southern Scientific Research Institute of Marine Fisheries and Oceanography (PivdenNIRO, Kerch), and since 2015 Ukrainian scientific observation in the CCAMLR marine areas is provided by the Institute of Fisheries and Marine Ecology (IFME, Berdiansk). Ukrainian scientists were invited and engaged by other countries to work on their fishing vessels as international scientific observers, in accordance with the requirements of the CCAMLR System for International Scientific Observation (SISO).

Each scientific observer has had and continues to have the opportunity to obtain valuable, unique in its origin scientific data and biological samples, what has always been the basis of relevant scientific research.

The following specialized scientific research expeditions of IFME were planned and realized in the CCAMLR zone with completely support of the Ukrainian fishing companies: from 2015 to 2019 – toothfish *(Dissostichus spp.)* longline survey in FAO statistical Subarea 48.2 (with the involvement of fishing vessel "Simeiz" of the "Fishing Company Neptuno" LLC; this work was initiated by PivdenNIRO in 2014 and continued by IREM since 2015); from 2019 to 2021 – toothfish *(Dissostichus spp.)* longline survey in Subarea 48.1 (with the

involvement of the fishing vessel "Calipso" of the "Fishing Company Neptuno" LLC); since 2020 a joint Ukrainian-Korean toothfish *(Dissostichus spp.)* longline survey in Subarea 88.3 has been started, and it continues currently (with the involvement of the fishing vessel "Marigolds" of the fishing company "Terra Trans LLC"); in the 2018/2019 season Ukrainian krill fishing vessel "More Sodruzhestva" (of the fishing company "IKF LLC") has took a part in the international synoptic krill *(Euphausia superba)* stock assessment survey in the Statistical area 48; from the 2017/2018 fishing season IFME has began regular collection of oceanological and hydrobiological data and samples on board of Ukrainian fishing vessels during fisheries and fisheries research activities in the Antarctic marine areas.

On the basis of the scientific works carried out involving Ukrainian fishing vessels in the CCAMLR area many projects of international scientific cooperation have been implemented, in particular jointly with scientific institutions of Canada, United Kingdom, New Zealand, Australia, the Republic of Korea, Canada, Chile, China, Germany. Analysis of fisheries, hydrobiological, and oceanological data is regularly presented by the Ukrainian scientists at the CCAMLR meetings.

All of the above-mentioned studies involving Ukrainian fishing vessels, if these works were carried out exclusively on scientific vessels with state funds, would cost the state tens of US dollar millions. Therefore, the participation of the Ukrainian fishing industry in fishery research as a contribution of the Ukrainian side to the CCAMLR objectives should be noted.

Successful Ukraine's experience in use of fishing vessels as a platform for research, as well as in the organization of international cooperation to achieve the maximum possible efficiency of processing the received scientific data and biological samples, was repeatedly noted within the CCAMLR framework.

THE RESULTS OF GLACIERS VELOCITY DETERMINATION USING SATELLITE DATA ON THE KYIV PENINSULA, WEST ANTARCTICA, 2015–2020.

***K. R. Tretyak*[1], *D. V. Kukhtar*[2]**
[1]*Lviv Polytechnic National University, Lviv, Ukraine;*
[2]*Ivano-Frankivsk National Technical University of Oil and Gas, Ivano-Frankivsk, Ukraine; kukhtar3088@gmail.com*

A complex study of glaciological processes requires the analysis of a large amount of data that is stretched over a time range. Access to such databases is provided by the Copernicus program, which was launched by the European Space Agency in 2014. The purpose of this program is the comprehensive and continuous monitoring of the Earth's surface, oceans and atmosphere by remote sensing methods, as well as the formation of open databases for further analysis and processing of the received data. The implementation of the Copernicus program is carried out with the help of seven Sentinel spacecraft missions. High-quality radar

and superspectral images of the entire territory of the globe are obtained by means of satellite monitoring with a frequency of 6–12 days. Remote sensing data can be downloaded through the Copernicus Open Access Hub portal or other resources.

The synthetic aperture radar (SAR) data acquired from the Sentinel-1 satellite make it possible to determine the ice velocity of glaciers and build ice flow velocity maps. For this purpose, we used the offset tracking method, which calculates displacements of points between two acquisitions. Our research was focused on the glaciers of the Kyiv Peninsula in the West Antarctic. In particular, on the two largest and longest: Trooz Glacier (65°20′S 63°58′W) and Wiggins Glacier (65°14′S 64°3′W). These glaciers terminate in the sea near the Argentine Islands. The close location of glaciers to Galindez Island and Ukrainian Antarctic Akademik Vernadsky station makes it possible to use climate data for further research to establish correlations between the dynamics of meteorological parameters in the region and changes in the velocity of glacier movement.

The radar images of the Sentinel-1A satellite were used for glacier velocity maps creation. The main characteristics of SAR images: acquisition mode – IW (Interferometric Wide Swath); data type – GRD (Ground Range Detected) with horizontal polarization. The interval between acquisitions was 12 days. The first radar image of the study area was obtained in May 2015. Thus, for the period from May 2015 to May 2020, 144 satellite images were received. After processing these data, maps of ice flow velocities were created for each consecutive pair of images. The maximum value of the velocity was recorded from each map for the Truz Glacier and the Wiggins Glacier. We will present some statistical results based on the obtained data for the two studied glaciers in the period 2015–2020.

The Trooz Glacier: maximum value of the velocity of the ice flow during the specified period varies in the range from 2.64 m/day (19 August 2015) to 4.05 m/day (18 April 2020); the average value 3.21 m/day.

The Wiggins Glacier: maximum value of the velocity of the ice flow during the specified period varies in the range from 0.82 m/day (06 October 2015) to 4.05 m/day (11 May 2018, 13 January 2020); the average value 1.13 m/day.

NATIONAL ANTARCTIC PROGRAMS OF UKRAINE: BIBLIOMETRIC ANALISYS AND TRENDS

D. V. Cheberkus*, *O. M. Pnyovska
State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv; cheberkus81@gmail.com

Since Ukraine joined the Antarctic Treaty in 1992 it has demonstrated a strong commitment to the development of scientific research in Antarctica as one of the main Ukrainian priorities in the region, which has been implemented within the National Antarctic Programs. All Ukrainian Governments and Presidents of Ukraine had strong commitments to Antarctic Programs even in very difficult periods considering it a unique research program, which scientific outputs affect

political capabilities of the country. Ukraine had three National Antarctic Programs. The first one (1996–2000) was only a part of the Marine Research Program of the National Academy of Science of Ukraine, but the next two Antarctic Programs (2002–2010 and 2011–2023), were adopted by the Decree of the Government of Ukraine and still were focused on research.

Taking into account that 2023 is the last year of the current Program (2011–2023), it is important to evaluate its scientific outputs visibility and compare it with the previous Program (2002–2010). To this end, a comprehensive bibliometric analysis was applied for the period of 2002–2022. The study was based on 62046 records, retrieved from Scopus database, (research articles, review articles, letters etc.) with the word fragment "antarc" or 58 the most mentioned geographical names in Antarctica in the title, abstract or keywords of the paper.

For the previous Program period, during 2002–2010, Ukrainian Antarctic publications output scored 84 records, resulting 0,4% of the global Antarctic publications output (20854 records) and getting for Ukraine 29th position in the global Antarctic publication output country ranking. Since 2011 Ukrainian scientific sphere permanently suffered from insufficient funds, which affected the Antarctic Program outputs as well. The first and second trimesters of the current National Antarctic Program demonstrated stable lagging behind the global Antarctic publication pace, which dropped Ukraine down to 34th position in Antarctic publication output country ranking during 2011–2018.

But internal reforms in NASC in 2018, triggered research activation first of all in biological and environmental science, which contributed a rapid increase of publication activity for the last four years, achieving 1,5% of the global Antarctic publication output for Ukraine in 2022 (58 records) and regaining 29th position in global Antarctic publication output country ranking. For the entire period of the current Program (2011–2022), Ukrainian Antarctic publication output scored 287 publications, resulting 0,7% of the global Antarctic publications output (41192 papers).

The percentage of cited papers for both Programs demonstrates a relatively high level (85% for the previous Program and 70% for current Program), which lags behind the percentage of cited papers for global Antarctic publications output (90%) but is rather higher than the average percentage of cited papers for all publications from Ukraine for the same period (62%). The percentage of international collaboration for Ukrainian Antarctic publications (2002–2018 – 48%, 2019–2020 – 50%) is stable for both Programs and is much higher than all publications from Ukraine (2011–2022 – 35%).

Ukrainian Antarctic Journal is published by the State Institution National Antarctic Scientific Center since 2003. UAJ publications are presented in the Scopus database since 2021, and providing free access to its materials, the journal should become an additional source of popularization of the scientific outputs of the National Antarctic Program, as well as should help to strengthen international collaboration networking within the National Antarctic Program of Ukraine.

LEARNING FROM THE EXPERIENCE OF THE WORLD-CLASS EDUCATIONAL PROGRAMS IN ANTARCTIC STUDIES

A. P. Fedchuk*, *V. V. Savchenko
State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine; fedchuk@uac.gov.ua

Antarctic research is represented in many countries' national science priorities, highlighting the importance of understanding the role of Antarctica and the Southern Ocean in determining future climate and environment. This issue is especially of interest to those countries that make up the signatory states to the Antarctic Treaty, and undertake national polar research programs.

This research examines world-class multidisciplinary programs focus on the Polar Regions and offered by such as the University of Cambridge (in partnership with the British Antarctic Survey, BAS), the Centre for Antarctic Studies and Research (Gateway Antarctica) at the University of Canterbury, the Institute for Marine and Antarctic Studies at the University of Tasmania, the Arctic Centre at the University of Groningen (the Netherlands), etc.

It is argued that there are two different approaches in educational programs. The first one contributes to the course teaching of a variety of Earth's sciences courses intended for a good overview of Antarctica (for instance, at the Antarctic Research Center at the Victoria University of Wellington). This course makes it useful for science and non-science students alike. There are no formal laboratory sessions, but broader issues surrounding Antarctica are discussed in a series of tutorials. There is no need to have previously studied earth sciences, geology, or even science as the course is open to everyone.

Another approach covers the programs and courses which offer a Master's degree and a PhD in Antarctic Studies. Such programs are suitable for students from a variety of research backgrounds; have different structures designed to provide an integrated social and ecological overview in human-environment relations in the Polar Regions, with current practice in management, policy and law; obviously laboratory sessions and even conducting certain research at field camps (if possible); and prepare the students for jobs requiring a solid background in Antarctic science (natural or social) or policy/governance.

Therefore, learning from the experience of teaching world-class educational programs and courses in Antarctic Studies will help the State Institution National Antarctic Scientific Center to develop its own national program in partnership with the leading domestic universities in order to train qualified specialists for Ukrainian Antarctic Program needs.

Such National program will allow to solve the problem of ageing personnel, outflow of professionals to other (nonscientific) spheres, emigration to foreign countries (including refugees after the full-scale invasion of Russia) as well as help to meet the challenge of training a new generation of scientists and members of the upcoming Ukrainian Antarctic expeditions.

AN OVERVIEW OF THE YOPP-SH 2022 WINTER SPECIAL OBSERVING PERIOD

***D. H. Bromwich* and YOPP-SH Community**
Byrd Polar and Climate Research Center, The Ohio State University, Columbus, Ohio, USA; bromwich.1@osu.edu

The Year of Polar Prediction in the Southern Hemisphere (YOPP-SH) aims to enhance environmental prediction for the Southern Ocean and Antarctica on time scales up to a season. Following a very successful summer campaign, the project undertook an experiment aimed at improving the forecasting skill during the non-summer months, specifically during April 15–August 31, 2022. In view of the limited resources and personnel at that time of year, the emphasis was on limited duration events rather than continuous observing for the three months. These so-called Targeted Observing Periods (TOPs) focused on the prediction of major oceanic cyclones and associated phenomena like atmospheric rivers and featured enhanced collection of radiosonde ascents from 24 stations. Based on the summer results, a major effort was made to increase soundings from middle latitudes to better capture the oceanic cyclone characteristics. In contrast to the summer campaign, the region was divided into two sectors to make the investigations more tractable, namely East Antarctica-Ross Sea and the greater Antarctic Peninsula. Seven TOPs were obtained with durations lasting 5–10 days with coverage being both Pan Antarctic and just for the two regions. A forecasting team for each sector decided when the TOPs should be initiated. Some 1100 additional soundings were released during the TOPs, more than doubling the routine launches from the 24 stations. The presentation will summarize in more detail what was achieved, and early results from investigations into the value of the additional soundings in forecasting the TOP events using Polar WRF.

THE ANTARCTIC MESOSCALE PREDICTION SYSTEM: SUPPORT FOR INTERNATIONAL ANTARCTIC SCIENCE

***J. G. Powers*, K. W. Manning**
Mesoscale and Microscale Meteorology Laboratory, National Center for Atmospheric Research, Boulder, Colorado, USA; powers@ucar.edu

The Antarctic Mesoscale Prediction System (AMPS) is a real-time atmospheric modeling capability covering Antarctica and the high southern latitudes. In operation since 2000, it employs two numerical weather prediction (NWP) models – the Weather Research and Forecasting Model and the Model for Prediction Across Scales – to generate a broad range of graphical products. While its primary mission is to supply guidance to the weather forecasters of the United States Antarctic Program, this U.S. effort has provided logistical assistance to a host of nations operating across the continent. This has taken the form of

delivering tailored forecast products and model information. It has served the operations of both aircraft and research vessels of different international Antarctic programs.

AMPS has also been a resource for science across the continent. AMPS's real-time forecast information has supported scientific field campaigns, helping to improve observational efforts. For retrospective research, AMPS has maintained an archive of model output that has been used for studies of international researchers. The AMPS effort has also been a contributor to international collaborations such as the annual Workshop on Antarctic Meteorology and Climate, the International Polar Year, and the Year of Polar Prediction- Southern Hemisphere. This presentation describes AMPS and demonstrates how this U.S. effort supports the cooperative international Antarctic enterprise.

SECTION REPORTS

BOECKELLA POPPEI (MRAZEK, 1901) (CALANOIDA, CENTROPAGIDAE) OF THE ROCK POOLS OF THE ARGENTINE ISLANDS DURING THE SOUTHERN SUMMER 2021–2022

***M. Nabokin*[1], *V. Tkachenko*[2], *P. Kovalenko*[3]**
[1]*Ukrainian Scientific Center of Ecology of the Sea, Ministry of Environmental Protection and Natural Resources of Ukraine, Odesa, Ukraine; m.nabokin1@gmail.com*
[2]*University of California, Santa Cruz, California, USA;*
[3]*Institute for Evolutionary Ecology of the National Academy of Sciences of Ukraine, Kyiv, Ukraine*

The crustacean *Boeckella poppei* (Mrazek, 1901) (Calanoida: Centropagidae) is one of the main species of freshwater zooplankton of the Maritime Antarctic.

For the first time in the Maritime Antarctic region, a copepod was discovered in samples taken in the summer of 1961–1962 on the Signy Island (South Orkney Islands) (Heywood, 1967). Later, it was found throughout the territory of the Maritime Antarctic (Dartnall, 2017; Díaz, 2019; Nabokin, 2022), on the subantarctic islands (Dartnall, Hollwedel, 2007) and in the territory of South America (Bayly et al., 2003). There are also reports of dwarf populations of the species in the eastern Antarctic continent (Bayly, 1993). In general, various authors note *B. poppei* everywhere throughout the territory of the Maritime Antarctic and the Antarctic Peninsula.

For the Argentine Islands, there are short mentions of copepod findings on the Rocca Islands in 2007–2008 (Polishuk et al., 2009) and on the island of Uruguay (Chernov et al., 2020). No detailed information, such as morphological features or population structure, is provided for these findings.

The aim of this work was to study *B. poppei*, found in samples collected in the Antarctic summer of 2021–2022. Supplementing information on the distribution of the species in the water bodies of the Argentine Islands and adjacent territories, comparing some morphological features of the species with those of other populations.

In total, 54 samples of freshwater zooplankton were taken from 10 water bodies located on four islands between February and April 2022. Samples were collected by the standard method for zooplankton, by filtering 15 to 50 liters of water through a small Apstein net, the mesh size of gas is 100 μ. Some samples were taken using a qualitative method, and they do not allow us to estimate the number of zooplanktons in the reservoir. Samples were fixed in 95% ethanol. In the laboratory, the species was determined and the crustacean was measured according to two metrics: PDL – the mean length from the anterior extremity of the

prosome to the point of insertion of the urosome measured mid-dorsally; AP-RL – the mean length from the anterior extremity of the prosome to the end of the caudal rami. Morphological features of the structure of the fifth thoracic legs (P5) of males were also considered.

Of the 54 analyzed samples, boccelia was found in 15, 14 quantitative and 1 qualitative. Most of the findings were presented by adults. Copepodite stages of the crustacean were found only in two samples taken in February and early March. No nauplia stages were detected. This highlights the importance of early sampling to obtain information on annual development of population.

Crustaceans were found in five lakes of the Visimka Island (65.226º S lat., 64.210º W lon.) and three lakes of the Irizar Island (65.219º S lat., 64.201º W lon.). Previously, the presence of the species on these islands was not reported. The species was also discovered in the lake of King George Island. All lakes were fresh. No crustaceans were found in the brackish lakes of Deception Island.

According to the measurements, copepods have the following dimensions for the Irizar Island: M: PDL – 1.26 mm, AP-RL – 1.78 mm (n=6), F: PDL – 1.51 mm, AP-RL – 2.09 mm (n=5); for the Visymka Island: M: PDL – 1.33 mm, AP-RL – 1.95 mm (n=20), F: PDL – 1.69 mm, AP-RL – 2.39 mm (n=26); for the King George Island: M: PDL – 1.46 mm, AP-RL – 2.08 mm (n=6), F: PDL – 1.66 mm, AP-RL – 2.40 mm (n=4). For comparison, these metrics for the Ameri Oasis in the east Antarctica were: M: PDL – 1.02 mm, AP-RL – 1.40 mm (n=7), F: PDL – 1.01 mm, AP-RL – 1.18 mm (n=2) (Bayly et al., 2003). This may be indirectly related to latitude and temperature difference, which may make it possible to use this indicator as an indicator of climate change. However, additional research is needed to test this assumption.

The variability of the fifth pair of thoracic legs (P5) of males was also considered. In particular, the structure of the second segment of the right exopod (Re2) and the third terminal segment of the right endopod (Ri3) were compared. Thus, in both cases, developed spines are observed in crustaceans collected in the waters of the Argentine Islands. A similar pattern is observed for the King George and Patagonian copepods. Crustaceans sampled on Ameri Oasis opposite had reduced spines (Bayly et. al., 2003). This may indicate the isolation of the population of the Ameri Oasis and the existence of a connection between the populations of the Argentine and South Shetland Islands, as well as Patagonia. However, the research needs to be continued and deepened for final conclusions.

Conclusions:

1. *Boeckella poppei* was found in the lakes of the Irizar and Visimka islands. Previously, the presence of a crustaceans on these islands was not reported.

2. The crustaceans were found only in fresh water lakes.

3. During February–April, copepodite stages of copepod were observed singly. No nauplii were observed at all. This indicates the beginning of the annual development of the species before the start of research and indicates the need for an earlier start of annual monitoring.

4. The population of *B. poppei* in the Argentine Islands is larger than the crustaceans found in the east of the continent and slightly smaller than those found

in the South Shetland Islands. This may be indirectly related to latitude and temperature difference, which may make it possible to use this indicator as an indicator of climate change. However, this assumption needs data collection and verification.

5. The crustacean population of the Argentine Islands has morphological features close to those of the population of the South Shetland Islands and Patagonia. Together with the previous conclusion, this may indicate the proximity of these populations and possible exchange between them.

HELMINTH COMMUNITY IN *NOTOTHENIA CORIICEPS* IN ARGENTINE ISLANDS, WEST ANTARCTICA: INFECTION PATTERNS AND INDICATOR SPECIES

***T. A. Kuzmina*[1,2], *O. O. Salganskiy*[3], *Y. Y. Syrota*[1,2], *O. I. Lisitsyna*[1,2], *Y. I. Kuzmin*[1]**

[1]*I. I. Schmalhausen Institute of Zoology NAS of Ukraine, Kyiv, Ukraine; taniak@izan.kiev.ua;*

[2]*Institute of Parasitology, Slovak Academy of Sciences, Košice, Slovak Republic;*

[3]*Kyiv Zoo, Kyiv, Ukraine*

Parasitic organisms of various taxonomic groups are known to be the sensitive indicators of the state of marine ecosystems since the complex life cycles of parasites include various invertebrate and vertebrate animals as definitive, intermediate, and paratenic hosts. Due to the complexity of host-parasite systems, all changes in the marine ecosystem state influence the species diversity, composition and patterns of the parasite communities. Our study aimed to analyze the patterns of helminth infection of the Antarctic rockcod, *Notothenia coriiceps*, to understand the dynamics of parasite communities in this Antarctic fish over time and to highlight the helminth species as possible "indicators" of ecological changes in marine ecosystems.

The study was performed using helminth samples collected from 183 specimens of *N. coriiceps* in 2014–2015 and 2020–2021 in the vicinity of the Ukrainian Antarctic Akademik Vernadsky station (UAS), Galindez Island, Argentine Islands, West Antarctica. Of 31 helminth species recorded in *N. coriiceps*, 25 helminth taxonomical categories (nine trematodes, four cestodes, five nematodes, and seven acanthocephalans) were subjected to analysis.

Notothenia coriiceps was found to be the definitive host of 18 helminth species; 12 species parasitize rockcod at the larval stage using *N. coriiceps* as the second intermediate or paratenic host. The proportion of larval helminths in the samples was lower in 2014–2015 (73.4%) than in 2020–2021 (81.4%). The number of helminth species of the "dominant" category (infection prevalence >50%) increased from seven species in 2014–2015 to nine in 2020–2021.

In helminth infracommunities, the species richness was similar in 2014–2015 and 2020–2021. However, the abundance of helminths was significantly

higher in the sample collected in 2020–2021. In the helmint component community, the diversity indices (Shannon, Simpson, Pielou, Berger-Parker) evidenced higher evenness and lower domination in the sample collected in 2014–2015 compared to the sample collected in 2020–2021. Lower evenness in 2020–2021 was due to the larger relative abundance of larval *Pseudoterranova* sp. and *Corynosoma* spp.

A direct comparison of the helmint populations of 2014–2015 and 2020–2021 showed that nine species significantly changed their infection parameters during the six years. Seven species (*Pseudoterranova* sp., *Contracaecum* sp., *Ascarophis nototheniae*, monolocular metacestodes, bilocular metacestodes, *Metacanthocephalus rennicki*, and *Diphyllobothrium* sp.) were found to have a significant impact on the differences between helmint infracommunities. Contrary to our expectations, the range of changes in meteorological parameters (water and air temperature and water salinity) was insufficient to impact the helmint community patterns significantly; most patterns showed a stable trend, and observed fluctuations were close to the steady trend. Biological factors might have caused slight, but significant changes in the infection patterns, particularly by changes in the populations of intermediate, paratenic, and definitive hosts of helminths (marine invertebrates, mammals, and birds) included in the helminth transmission in Antarctic ecosystems.

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RETURN OF THE PRODIGAL SON TO THE ANTARCTIC HOMELAND: MORPHOLOGY AND MOLECULAR PHYLOGENETIC RELATIONSHIPS OF A NEW FISH LEECH (HIRUDINEA: PISCICOLIDAE) IMPLY A BIPOLAR BIOGEOGRAPHICAL PATTERN

***A. Utevsky*[1], *S. Utevsky*[1], *J. M. Cichocka*[2,3], *A. Bielecki*[2†], *M. Santoro*[4], *P. Trontelj*[5]**

[1] *Department of Zoology and Animal Ecology, V. N. Karazin Kharkiv National University, Kharkiv, Ukraine; andriy.utevsky@karazin.ua*

[2] *University of Warmia and Mazury in Olsztyn, Faculty of Biology and Biotechnology, Department of Zoology, Olsztyn, Poland;*

[3] *XI High School in Olsztyn, Olsztyn, Poland;*

[4] *Department of Integrative Marine Ecology, Stazione Zoologica Anton Dohrn, Naples, Italy;*

[5] *Department of Biology, Biotechnical Faculty, University of Ljubljana, Ljubljana, Slovenia*

Many systematic groups of marine organisms are found in both the Arctic and Antarctic regions, but do not occur in the areas in between. This kind of geographical pattern is known as bipolar distribution. The occurrence of fish

leeches (Piscicolidae) in high latitudes of both hemispheres with a gap in temperate and tropical waters has been considered and discussed for a long time. All cases of putative bipolar ranges of related taxa have been morphology-based hypotheses. Here, we present, for the first time, an instance of bipolar distribution substantiated by morphological and molecular data. The latter include the mitochondrial genes 12S rRNA, *COI*, *ND1* and tRNA Leu, and the nuclear 28S rRNA. A new genus and species of Antarctic piscicolids, *Austroplatybdellina prodiga*, is described. The new leech joined a Boreal-Arctic monophyletic group that is informally called "classic platybdellins". That clade is the core of the non-monophyletic subfamily Platybdellinae. *Austroplatybdellina prodiga* was further assigned to a monophyletic group along with two Boreal genera, *Crangonobdella* and *Beringobdella*, which share a number of systematically important morphological features with its newly described relative. It is hypothesised that the Boreal ancestor of the new leech crossed warm tropical waters and colonised the Antarctic. The colonisation was relatively recent as the low genetic distance between *A. prodiga* and its Boreal sister species suggests. This migration can be viewed as a return of a Boreal descendant of the Antarctic ancestor of Piscicolidae to the area of origin of the entire family, which follows from the basal position of the Antarctic *Megaliobdella szidati* in the family phylogenetic tree. This evolutionary scenario is reflected in the species epithet of the new leech.

MARINE MAMMAL RESEARCH AT UKRAINIAN ANTARCTIC AKADEMIK VERNADSKY STATION: INITIAL RESULTS OF FIVE YEARS OF DEDICATED SURVEYS

O. V. Savenko
State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine; o.v.savenko@gmail.com
Institute for Marine Sciences, Department of Ocean Sciences, University of California Santa Cruz, Santa Cruz, USA

Marine mammals are apex marine predators, playing an essential role in the Southern Ocean food webs. Timely information on their population dynamics and demography can help us reveal the impacts of global change on the Antarctic marine ecosystem. General monitoring of the presence of marine mammals around Ukrainian Antarctic Akademik Vernadsky station (Wilhelm Archipelago, Galindez Island) and some more specialized studies were carried out during all Ukrainian Antarctic expeditions. Although this monitoring lacked a systematic approach and - its results were mostly unavailable to international scientific and conservation community stakeholders. Since 2018, dedicated marine mammal research has been conducted in the nearshore waters around the Antarctic Peninsula, based at Vernadsky station and series of opportunistic and research vessel surveys. Our research program is based on long-term international partnerships with researchers from many countries. We synchronize our research protocols and share a common

scientific goal to better understand the ecology and status of marine mammal populations in the Antarctic and provide the scientific foundation for their conservation. A series of modern field and laboratory techniques are used in our studies, such as photo-identification, biopsy sampling, acoustic monitoring, use of unoccupied aircraft systems for image collection and photogrammetry, DNA profiling, hormone extraction and quantification etc. In this talk, I will present our initial findings regarding the ecology of several cetacean species (Megaptera novaeangliae, Balaenoptera bonaerensis, Orcinus orca, Berardius arnuxii, Eubalaena australis) and pinnipeds (Leptonychotes weddellii, Hydrurga leptonyx, Lobodon carcinophaga, Mirounga leonina and Arctocephalus gazella), including their migratory behaviour, feeding ecology, breeding patterns and ecophysiology. Dedicated year-round marine mammal studies should be performed annually as a part of multi-year biological research program of the State Institution National Antarctic Scientific Center in collaboration with researchers and Antarctic Programs of other countries.

IMPLEMENTATION OF ZOOPLANKTON MONITORING IN THE WATERS OF THE ARGENTINE ISLANDS, WEST ANTARCTIC PENINSULA

V. V. Tkachenko
Pryazovskyi National Park, Melitopol', Ukraine; tkachenko.vadvad@gmail.com
State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine

Zooplankton studies are an integral part of any comprehensive marine program. It is a convenient tool for monitoring changes in biotic and abiotic components of aquatic ecosystems. The state of mesozooplankton groupings is closely related to the indicators of phytoplankton concentration, carbon production, and the ice cover state, which is especially important for the Antarctic region. Those studies currently being carried out at Akademik Vernadsky station aim to describe the development patterns of mesozooplankton communities in the surface layer of coastal waters under intense climatic changes. Essential monitoring includes systematic sampling at particular points in a fixed horizon, a relatively simple task for the conditions of various coastal water areas, and non-trivial for the Antarctic region. Changing weather conditions and dynamic ice cover make it difficult to find appropriate sampling points, tools, and methods. During the 26th Ukrainian Antarctic Expedition (2021–2022), standard mesozooplankton sampling methods were tested and adapted, and year-round monitoring was initiated for the first time. It includes working with Nachtai and Apstein nets. The work is carried out from an inflatable boat unsuitable for automatic winches, making it difficult to tow effectively even in the surface layer (100–0 m). During the 26th Ukrainian Antarctic Expedition, 22 quantitative and 62 qualitative samples were collected and processed. The results indicate that there is not enough to work in the surface

layer; zooplankton concentrations are low and unstable. However, our results are of considerable scientific interest and can be used for comparison with other areas. Subsequently, this work must be supplemented with in-situ observations using underwater cameras, as this is one of the few available ways to perform observations at depths of more than 100 m and more.

UNCERTAINTIES IN ESTIMATING TOOTHFISH SPECIES ABUNDANCE IN SOUTHERN OCEAN USING TAGGING

L. Pshenichnov
Institute of Fisheries and Marine Ecology, Berdiansk, Ukraine; lkpbikentnet@gmail.com

In recent years, in the area of responsibility of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), three target fish species have been fished in the Southern Ocean: Antarctic toothfish (*Dissostichus mawsoni*), Patagonian toothfish (*Dissostichus eleginoides*) and Mackerel icefish (*Champsocephalus gunnari*). Research surveys are also being carried out for these three species.

One of the main duties of scientific observers in the Southern Ocean on board fishing vessels during fishing and research activities is tagging of fish (two species of toothfishes). Within CCAMLR there are standardized protocols and equipment for tagging. This standardization is a necessary component of the tagging program as CCAMLR uses fishery tagging-to-recapture rates as the basis for estimating toothfish species abundance. The CCAMLR Secretariat receives and maintains data on all tagged fish and subsequent recaptures of those fish. Each recapture is associated with a tagging event to validate data used in population estimates and to analyze movement and growth rates of fish. CCAMLR uses a catch-recapture approach in estimating toothfish species abundance.

Determining the absolute abundance of fish biomass by tagging is based on the assumption that the number of tagged fish is related to the number of tagged fish caught in the same way that the number of fish caught by the fishery is related to the total number of fish of commercial size in the reservoir. However, in practice, using this ratio, it is possible to obtain reliable data mainly for fish with a relatively long-life cycle and well tolerated tagging. The main errors associated with the use of this method are explained by the underestimation of the behavior of tagged fish, which are unevenly distributed among the rest of the fish in the population. The percentage of tags lost by fish and the mortality of tagged fish tagged in different biological states is not the same, and this affects the results of determining the value of fish biomass.

Two additional uncertainties have been noted by scientific observers aboard fishing vessels in Antarctica for the persistence of tags after tagging or during the capture of tagged fish. When sampling the catch (catching toothfish on the bottom longline at depths of more than 500 meters), quite often the giant Antarctic squid

(*Mesonychoteuthis hamiltoni*) eats the catch (toothfish), including previously marked toothfish, as part of the fish population. Sometimes giant squid are brought to the surface along with the catch – toothfish, which the squid eats in the process of hauling the longline (hooks with the catch) on board the vessel. Squids live in pelagic waters at depths of 500–700 meters, raising catches on board the vessel attracts squids. Seabirds (albatrosses and petrels) can also harm the Fish Tagging Program by tearing tags from newly released fish that do not immediately go to the depths but remain on the surface for some time. Probably, the tags attract birds by their resemblance to the potential food of birds – small crustaceans.

MOLECULAR-GENETIC ANALYSIS OF *COLOBANTHUS QUITENSIS* POPULATIONS FROM THE MARITIME ANTARCTIC USING RETROTRANSPOSON-BASED MARKERS

***I. O. Andreev*[1], *I. I. Konvalyuk*[1], *I. Yu. Parnikoza*[1,2], *V. A. Kunakh*[1]**

[1] *Institute of Molecular Biology and Genetics, National Academy of Sciences of Ukraine, Kyiv, Ukraine; i.o.andreev@imbg.org.ua*

[2] *State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine*

Colobanthus quitensis (Kunth) Bartl. (Caryophyllaceae), the Antarctic pearlwort, is one of two vascular plant species found in the maritime Antarctic. The species has the wide range, which covers the western coast of Antarctic Peninsula and the southern Andes, and extends from Alexander Island in south to Mexico in north, but population genetic studies of this species are limited to a few reports. Furthermore, *C. quitensis* populations in the maritime Antarctic may be a useful model for studying the microevolution due to the fragmented range and limited population size. In this study, to continue the previous population genetic analysis of the species from the Argentine Islands-Kyiv Peninsula region, we assessed genetic variation and analysed genetic structure of *C. quitensis* populations located across the central and northern parts of maritime Antarctic.

In total, 215 plants from 22 isolated populations from four distant regions were analysed, including four from Margaret Bay, 14 from the Argentine Islands-Kyiv Peninsula region (Graham Coast), one from Anvers Island (Danco Coast) and three from South Shetlands. DNA was isolated from dried leaf tissue using the modified CTAB protocol. Genetic analysis was carried out using six iPBS markers described by Kalendar et al. (2010) and applied earlier by Androsiuk et al. (2015). The following indices of genetic variability were calculated: percentage of polymorphic bands (P), Shannon's information index (I), Nei's gene diversity (expected heterozygosity, He), and Nei's unbiased genetic distances between populations.

In total, 275 amplified bands were scored, among which 263 (95.6%) were polymorphic. The percentage of polymorphic bands in individual populations of

the maritime Antarctic ranged from 2.1% for Deception Isl. to 62.7% for King George Isl. with an average of 38.8%. The indices of genetic variability calculated from the PCR data for the total sample were as follows: Shannon diversity index (I) – 0.085±0.002; unbiased Nei's gene diversity (expected heterozygosity, He) – 0.058±0.002; and the average Jaccard's pairwise genetic distances – 0.331. The highest values of genetic variability were found for the Argentine Islands-Kyiv Peninsula region, and the lowest was in Margaret Bay region. A three-level analysis of molecular variance (AMOVA) used to detect variation among individuals within populations, among populations from the same region, and among four regions, most of the genetic variation was found within populations (42.6%). The levels of differentiation among different populations and among regions were almost the same (28.6% and 28.8%, respectively). These results indicated a limited gene flow among the different pearlwort populations and population groups in the maritime Antarctic.

As in the previous study, the principal coordinate analysis (PCoA) discriminated two main groups of plants. One of them included plants from the northern part of the range of the species in Antarctic, while the another consisted of plants from its southern part, with the boundary between them lying across the Argentine Islands-Kyiv Peninsula region. Only one population from the greatest of Berthelot Islands was mixed and contained the plants belonging to one or another of these two groups. These results give evidence for the existence of at least two relatively independent centres of dispersal of the species in the region.

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IN SILICO ANALYSIS OF DaICE1 AND DaICE2 STRESS-INDUCIBLE TRANSCRIPTION FACTORS OF *DESCHAMPSIA ANTARCTICA*

O. M. Bublyk*, *I. O. Andreev*, *V. A. Kunakh
Institute of Molecular Biology and Genetics, National Academy of Sciences of Ukraine, Kyiv, Ukraine; o.m.bublyk@imbg.org.ua

DaICE1 and *DaICE2* genes (inducer of CBF expression) of the extremophile plant *Deschampsia antarctica* were assembled for the first time from raw whole genome and transcriptome sequencing data available in GenBank. They encode some of the key TFs involved in the regulation of gene expression under cold stress as well as of various physiological processes including stomatal development and flowering time.

The putative proteins encoded by the predicted genes contain characteristic bHLH and ACT-like domains and conserved motifs typical of ICE TFs. Phylogenetic analysis confirmed their homology to orthologous ICE proteins of other grass species. Two variants of the *DaICE1* gene were found: a variant that encodes a full-length protein, and a variant with a large deletion resulted in the loss

of the N-terminus and part of the bHLH domain in the coded protein. The protein product of the latter gene can potentially act as a microProtein participating in the negative regulation of stomatal differentiation processes. Two variants of the *DaICE2* coding sequence were also assembled, which differed by four single-nucleotide polymorphisms, three of which were synonymous. In contrast, the promoter sequences of these variants had numerous substitutions, insertions and deletions. Both *DaICE1* and *DaICE2* genes consisted of three introns and four exons.

The length of putative DaICE proteins ranged from 160 aa to 521 aa, the estimated molecular weight ranged from 17.44 to 54.67 kDa, the theoretical isoelectric points were 5.02 for DaICE2 and 5.36 for DaICE1, and the instability index ranged from 59.21 to 75.75. All proteins were predicted as unstable. For all proteins, nuclear localization was predicted and nuclear localization signals were identified. Furthermore, a large number of potential sites for post-translational modifications such as glycosylation, phosphorylation, ubiquitination, sumoylation were revealed.

The 3D structures of the DaICE proteins were predicted using the Phyre2 web portal. Numerous *cis*-elements involved in abiotic and biotic stress response were found in the promoters of *DaICE* genes; they made up the largest group of the identified *cis*-elements. Furthermore, *cis*-elements associated with the light response and involved in the regulation of growth and development were revealed. The sets of *cis*-elements identified in the promoters of *DaICE1* and *DaICE2* genes were mainly identical or similar in function, which is consistent with the similarity of the main functions of these TFs.

The expression of *DaICE* genes was measured by counting the number of homologous reads from RNA-Seq data of different tissues of wild- and laboratory-grown *D. antarctica* plants searched in GenBank with SRA BLAST. The studied *DaICE* gene variants were expressed in all or most of different tissues of plants from both growing conditions. The expression of *DaICE1* variants was, in general, higher in wild- than in laboratory-grown plants. No clear pattern was found in the expression of *DaICE2* variants that would distinguish plants grown under different conditions. In general, *DaICE* expression levels were lowest in the roots of both plants' variants and in the leaves of wild plants, and slightly higher in the flowers, crowns, and leaves of wild plants compared to the laboratory ones.

The study expands the list of characterized orthologous *ICE* genes of grasses, contributes to the discovery of molecular mechanisms of plant stress resistance, and may have further practical application in genetic engineering.

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FIRST INTRON LENGTH POLYMORPHISM OF B-TUBULIN GENES OF *COLOBANTHUS QUITENSIS* FROM THE ARGENTINE ISLANDS-KYIV PENINSULA REGION

A. M. Rabokon[1], Yu. O. Bilonozhko[1], A. S. Postovoitova[1], L. O. Kalafat[1], I. Andreev[3], V. A. Kunakh[3], I. Yu. Parnikoza[2], I. A. Kozeretska[2], Ya. V. Pirko[1], Ya. B. Blume[1]

[1] *Institute of Food Biotechnology and Genomics, National Academy of Sciences of Ukraine, Kyiv, Ukraine; tkacheva_ua@ukr.net*

[2] *State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine;*

[3] *Institute of Molecular Biology and Genetics, National Academy of Sciences of Ukraine, Kyiv, Ukraine*

The history of Antarctic vascular plants is still not fully understood. Recent studies have come to opposite conclusions regarding the timing of the spread of both species to the maritime Antarctic. It was recently shown that it could have survived the Last Glacial Maximum in the case of *Deschampsia antarctica* (Fasanella et al., 2018) and spread only in late-Pleistocene in the case of *Colobanthus quitensis* (Biersma et al., 2020). However, in addition to the time of spread, it is also extremely interesting to find out the patterns of spread of such a not active in dispersal cushion plant as the *Colobanthus quitensis.*

In total, 93 DNA samples from 11 isolated *C. quitensis* populations of Argentine Island-Kyiv Peninsula region were examined using the TBP method, based on estimating the first intron length polymorphism of β-tubulin genes. TBP analyses were performed according to Breviario et al. (2007). The electrophoretic analysis of all samples allowed to identify the formation of DNA fragments in the range from 380 bp to 1900 bp. Fragments up to 1200 bp were probably the targets, as they were the most distinct among all runs of the experiment. These fragments were further analyzed and fragments longer than 1200 bp were discarded as artifacts. Besides, a DNA fragment of approximately 880 bp in length was excluded from the analysis as a non-specific DNA fragment, as it was only detected in a subset of the experiments.

Investigation of the first intron length polymorphism allowed us to identify two main groups of *C. quitensis* populations in the study region. One of them includes plants from the most southern in terms of location in the studied region – Cape Pérez, Darboux Island. Another group contains samples from all other research sites in the studied region (these places are located to the North from the previous ones). Contrary to the above groups, the biggest of the Berthelot Islands (Ukraine Island) presents plants belonging to both identified groups. Such findings allow us to assume the possibility of existence of two variants of genotypes for this marker in the studied region, which probably originate from the north and the south and are combined in the largest population found in the studied region on the Ukraine Island.

It has previously been shown that *D. antarctica* clusters of geographic distribution in the Antarctic may correspond to isolated genotypes of this plant. In particular, it was shown that the *D. antarctica* from the region of the Argentine Islands-Kyiv Peninsula, geographically isolated from the *D. antarctica* from the southern coast of Anvers Island, was genetically distinct. Further research can show whether a similar phenomenon is observed in the *C. quitensis* as well.

MONITORING OF TERRESTRIAL ECOSYSTEMS IN THE ARGENTINE ISLANDS: REMOTE SENSING OF THE MOSS BANKS

***A. Puhovkin*[1,2,3], *T. Kazantsev*[1], *M. Bartak*[2], *Y. Shepeta*[1], *A. Dzhulai*[1], *N. Miryuta*[1], *H. Yevchun*[1], *I. Parnikoza*[1,4]**

[1] *State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv; antonpuhovkin@gmail.com*

[2] *Masaryk University, Faculty of Science, Department of Experimental Biology, Brno, Czech Republic;*

[3] *Institute for Problems of Cryobiology and Cryomedicine of the National Academy of Sciences of Ukraine, Kharkiv, Ukraine;*

[4] *Institute of Molecular Biology and Genetics, National Academy of Sciences of Ukraine, Kyiv, Ukraine*

Long-term monitoring of vegetation is becoming extremely important because of increasing global warming in the regions along the Antarctic Peninsula. In our study, we focused on regular mapping of four moss banks dominated by *Polytrichum strictum* in Galindez Island using two cameras of two types and under the same conditions.

Aerial photography was performed using the unmanned aerial vehicle (UAV) DJI Phantom 4 Pro V2.0 (Daijang Innovations, Shenzhen, China). A standard (built-in) DJI FC6310S camera with a focal length of 8.8 mm/24.0 mm (equivalent to a focal length of 35 mm) was used to obtain RGB images. In addition, the Parrot Sequoia multispectral camera equipped with four monochrome sensors: green (530–570 nm), red (640–680 nm), red edge (730–740 nm), NIR (770–810 nm) was used.

A study of the moss bank was conducted based on green and dark (non-green) parts of the moss bank. We evaluated the changes in green and brown colour classes (as well as incorporated lichens, guano or another cover influence to general moss colour state). In such case, brown (non-green) colour class was distinguished into red, brown and black colour categories (i.e., subgroups). They were selected for a detailed ground investigation to estimate moss vitality parameters. We did not find sufficient technical background to monitor all the visually distinguishable moss colour categories using remote sensing, but two selected (green and brown (non-green) moss colour states) mostly reflect the modern approach to vegetation monitoring.

The results of our study allow us to confirm the green colour class as healthy moss and understand what the categories of the non-green moss state are. Brown moss is not completely dead. Having some minimum physiological activity (chlorophyll fluorescence), red moss is formed in the event of a rapid die-off of *Polytrichum strictum*, presumably under the influence of a violent influx of organic matter from penguins or under point influence of sea birds. Our observations also characterize black moss, confirming that it is completely dead, probably due long-term accumulation of snow and, presumably, the influence of wind.

Determination of the relative area occupied by green and brown (non-green) moss and inlay estimated by normalized difference vegetation index (NDVI) analysis can be used as an indicator of changes in the state of moss groups for their long-term monitoring.

ASSEMBLAGES OF THE NITROGEN CYCLING BACTERIA AS A POSSIBLE INDICATOR OF THE ORNITOGENIC IMPACT

Ye. Prekrasna-Kviatkovska[1], A. Yerkhova[2], M. Pavlovska[1], M. Dzyndra[1], I. Parnikoza[1,3]

[1]State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine; preckrasna@uac.gov.ua

[2]Open International University of Human Development "Ukraine", Kyiv, Ukraine;

[3]Institute of Molecular Biology and Genetics, National Academy of Sciences of Ukraine, Kyiv, Ukraine

Ornitogenic impact is one of the shaping factors for the development of the terrestrial ecosystems in the maritime Antarctic. The impact of birds is reflected in the other components of the ecosystems, which is not narrowed to the presence of birds themselves. Along with the chemical composition, the microbial communities' composition may indicate the ornitogenic effect on the ecosystem.

A study of the microbial assemblages of *tall moss turf subformation* was realized on Galindez Island (Argentine Islands) in 2020. Right here, the changes in the vegetation cover due to gentoo penguins (*Pygoscelis papua*) expansion are being evidenced. The composition of microbial assemblages was estimated by metagenomic sequencing of 16S rRNA amplicons (Illumina Novaseq) and bioinformatic analysis in QIIME 1.0 and R Studio 4.5.

Fragments of the subformation not affected by birds' expansion were populated by bacteria belonging to *Subgroup_2*, *Bryobacter*, *Acidobacteriales*, *Granulicella*, *Occalatibacter*, *Candidatus Solibacter*, *Acidobacteriaceae*, *Acidimicrobia*, *Ktedonobacteraceae*, *Acidothermus*, *Acetobacteraceae*, *Gemmatimonas* etc. Microbial assemblages of moss cover affected by birds (moderate impact) contained these taxa as well. Besides these taxa, another group of sub-dominating bacteria was detected: *Simplicispira*, *Polaromonas*, *Psychrobacter*, *Luteoibacter*, *Chryseobacterium*, *Gelidibacter*, *Flavobacterium*,

Aequorivita, Tissierella, Pedobacter, Gottschalkia, Sporosarcina, Tychonema, Arthrobacter. Among this group, there are inhabitants of the penguins' intestines, however the vast of typical birds' intestinal microbes were not detected. The second group of bacteria dominated in microbial communities of the moss desolated by penguins' impact (heavy impact). Within this group, there were bacteria capable of urine acid degradation and denitrification. Besides, the number of ammonia- and nitrite-oxidizing bacteria (*Nitrosomonadaceae, Nitrospiraceae*) in impacted and desolated moss was higher ($p>0.05$) compared to unaffected moss.

A number of nitrifying and denitrifying bacteria, which is likely dependent on the guano input, may indicate both presence of the ornitogenic impact and its duration/intensity. The ratio of the microbes belonging to the particular taxonomic group in the substrate may be used as an indicator for the further monitoring of the terrestrial ecosystems in the maritime Antarctic.

INFLUENCE OF ORNITHOGENIC ENVIRONMENTAL LOAD ON THE NUMBER DENSITY OF ANTARCTIC INVERTEBRATES

***P. A. Kovalenko*[1], *O. O. Iarovyi*[2], *V. A. Gorobchyshyn*[1,3], *I. Yu. Parnikoza*[2,4], *I. A. Kozeretska*[2]**

[1]*Institute for Evolutionary Ecology, National Academy of Sciences of Ukraine, Kyiv, Ukraine; ilovebiofack@gmail.com;*

[2]*State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine;*

[3]*Taras Shevchenko National University of Kyiv, Kyiv, Ukraine;*

[4]*Institute of Molecular Biology and Genetics, National Academy of Sciences of Ukraine, Kyiv, Ukraine*

Antarctic terrestrial ecosystems are characterized by the expected low species diversity. Climatic changes in the area of the Antarctic Peninsula are the most significant in recent decades of observation, which leads to changes in terrestrial ecosystems in particular. There has been an active expansion of gentoo penguins (*Pygoscelis papua*) on Galindez Island, (Argentine Islands) recently. Changes in the distribution of penguins can affect other components of ecosystems, which was the subject of the current study.

We tried to evaluate the impact of the ornithogenic load on the groups of Antarctic invertebrates (Insecta, Acari, Collembola, Nematoda) in different vegetation substrates. For that, three localities were established on Galindez Island areas with the vegetation formations most typical for the Argentine Islands: bryophyte carpet and mat subformation and tall moss turf subformation. These locations are placed at a small distance from each other but are different in the levels of ornithogenic influence: Locality 1 (D1 Meteo) is characterized by a significant ornithogenic impact and a high level of biogens in the substrate: this colony of *P. papua* has been located since season 2007/2008. Locality 2 (moss bank on the Shyia Ridge) is characterized by moderate ornithogenic impact and

lower content of nitrogen-containing compounds; the colony of *P. papua* are present only for two years (since 2019). Locality 3 (Smith moss bank) is characterized by low ornithogenic impact and low level of nitrogen-containing compounds; there are no penguin colony, only one nest of south polar skuas (*Stercorarius maccormicki*) found. From each locality for each vegetation material, five samples of approximately equal substrate volume were taken from a square with an area of 1 m^2: four samples from the corners of this square and one from the center. The types of vegetation materials were following: *Sanionia georgicouncinata*, *Warnstorfia fontinaliopsis*, *Bryum pseudotriquetrum*, *Polytrichum strictum* (states with different vitality) and macroalga *Prasiola crispa*. The density of specimens of the following groups of invertebrates was analyzed: Collembola, Nematoda, Acari, Insecta (*Belgica antartica*: Chironomidae), Tardigrada.

The highest total density of studied invertebrate groups was observed in the neutrophilic substrate with *P. crispa* on the dead *S. georgicouncinata* and *P. strictum* (242.2 specimens/cm^2, 168.84 specimens/cm^3) of locality 1, the smallest – in green (alive) *P. strictum* (1.11 specimens/cm^2, 0.31 specimens/cm^3) of locality 2.

For three vegetation types which were present in all three localities (1 – *B. pseudotriquetrum* tufts; 2 – *P. crispa* on dead *S. georgicouncinata* and *P. strictum*; 3 – *P. strictum* dead/alive), we also compared the average values of the number of specimens of the studied invertebrates per unit of area and volume for all localities. These data were compared via the Mann-Whitney U-test. It was found that in all vegetation variants in locality 1, compared to the other two, the total density of studied invertebrate groups was statistically significantly higher, at the same time, in two of the three studied vegetation material cases (except for *P. crispa* on dead *S. georgicouncinata* and *P. strictum*, where in locality 2 there is a higher density of specimens), no statistically significant difference in the density of studied groups of invertebrates between localities 2 and 3 was found. So, biogenic output from plants colonies stimulates invertebrates' populations. Further studies with more replications are necessary for a more accurate assessment.

CONTRIBUTION OF THE UNITED TEMPERATURE FACTORS INFLUENCE INDICES ON PLANTS TO UNITED QUALITY LATENT INDICES (UQLI) OF PLANTS ADAPTABILITY FOR DESCHAMPSIA ANTARCTICA É DESV. DURING FOUR SEASONS

***N. Miryuta*[1], *M. Savenets*[2], *L. Pysarenko*[2], *G. Myryuta*[3,1], *O. Poronnik*[3,1], *I. Parnikoza*[1,3]**

[1]*State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine;*

[2]*Ukrainian Hydrometeorological Institute, State Emergency Service of Ukraine and the National Academy of Sciences of Ukraine, Kyiv, Ukraine;*

[3]*Institute of Molecular Biology and Genetics, National Academy of Sciences of Ukraine, Kyiv; i.yu.parnikoza@imbg.org.ua*

The aim of this research has been application of developed calculation algorithms for United Quality Latent Index of plant adaptability (UQLI, I^{q}_{i}) and United Temperature Influence Index (UTII, I^{tk}_{i}) based on average monthly temperature, and United Temperature Influence Index^{+} (UTII^{+}, I^{Tk}_{i}) based on the sum of the accumulated positivity temperatures in the four seasons dynamics. Dynamic research was conducted on a sample of 11 experimental *Deshampsia antarctica* É Desv. populations on Galindez Island (Argentine Islands, the maritime Antarctic) in the summer seasons 2017/18 (k=1), 2018/19 (k=2), 2019/20 (k=3) and 2020/21 (k= 4). Research and analysis of plants morphometric indices was carried out. Protective and reserve proteins electrophoretic spectra of seeds were analysed. The total plants number value in these populations was used. I^{q}_{i} was determined based on the spatial differences in these three data sets for sample eleven populations in each of the four summer seasons. The temperatures values obtained from microclimatic loggers located on experimental populations near plants. The temperature variables in the form of the average monthly temperature and the positive accumulated temperatures sum by decade were calculated. The temperature variables influence on the measured plant population adaptability indices was studied. To calculate I^{tk}_{i} and I^{Tk}_{i} we used influence of temperature variables spatial differences which decrease during the summer season on all main plants' characteristics spatial differences during each summer season. The I^{tk}_{i} and I^{Tk}_{i} contribution to the I^{q}_{i} complex index were determined for eleven populations in the dynamics of four summer seasons. The populations affected by latent indices in each summer season were identified.

The contributions of I^{tk}_{i} average values to I^{q}_{i} were ~85% in summer season k=1 for the whole Galindez Island plant population (G-population), 72% in summer season k=2 for the G-population excluding two populations, −71% in summer season k=3 for the G-population, 85% in the summer season k=4 for the G-population, excluding two populations. The contributions of I^{Tk} average values to I^{q}_{i} were ~83% in summer season k=1 for the G-population, 89% in summer season k=2 for the G-population excluding two populations, −74% in summer season k=3 for the G-population excluding two populations, 76% in summer

season k=4 for the G-population. The combination of both temperature factors during four summer seasons showed that temperature factors in different combinations influenced on the I^{qk}_i sign change in three populations; different combinations of temperature and latent factors influenced on the I^{qk}_i sign change in six populations; only latent factors influenced on the I^{qk}_i sign change in two populations.

The further research perspective will be to continue a started monitoring with the new components addition in part of summer seasons. This will make it possible to establish which of last help plants adapt to changing temperature conditions.

ANTIMICROBIAL POTENTIAL OF RHIZOSPHERIC *ACTINOMYCETOTA ISOLATS* FROM THE CENTRAL MARITIME ANTARCTIC

***I. I. Roman*[1], *I. Parnikoza*[2,3], *O. M. Gromyko*[1]**

[1] *Ivan Franko National University of Lviv, Lviv, Ukraine; ivan.roman@lnu.edu.ua*

[2] *State Institution National Antarctic Scientific Centre, Ministry of Education and Science of the Ukraine, Kyiv, Ukraine;*

[3] *Institute of Molecular Biology of Ukraine, National Academy of Science of Ukraine, Kyiv, Ukraine*

Antarctica has low number of biochore, which populated by a small number of species. This is related to difficult climatic conditions, including low temperatures, high levels of UV radiation, low nutrient content, etc. However, evolution in such environments promotes the development of adaptation mechanisms, including cold-tolerant enzymes, effective antioxidant systems, and unique natural compounds. These properties can reduce the cost of raw material production processes in the biotechnology industry. *Actinomycetota*, which are producers of many active compounds, remains the most attractive for research. Although there is some research data, little is known about the distribution of mycelial actinomycetes in the Antarctic. Several new species have been reported (*Streptomyces hypolithicus*, *S. fildesensis*, *Micromonospora endolithica*, *Amycolatopsis antarctica*, but based on our previous research, we believe that the diversity of Antarctic actinomycetes remains poorly understood.

The rhizosphere of the Antarctic hair grass (*Deschampsia antarctica* É. Desv.) from Stella Point (65°14.847’ S, 64°15.164’ W) (Galindez Island, the maritime Antarctic) was used for the research. For isolation, a suspension was prepared, diluted, and inoculated into selective media. Isolates with a typical actinomycete morphology were selected and used for the isolation of bacterial DNA by the salting out method. Amplification of gene 16s rRNA was performed according to standard methods. Sequencing was performed using the Sanger method. The sequences were analyzed in NCBI (https://blast.ncbi.nlm.nih.gov/Blast.cgi). The test for antibiotic production was

performed using the stroke method. Bacterial and yeast strains, including *Escherichia coli*, *Pseudomonas aeruginosa*, *Bacillus subtilis*, *Staphylococcus aureus*, *Mycobacterium smegmatis*, and *Candida albicans* were used as indicator pathogens.

Thirty-one isolates were isolated from the rhizosphere of the Antarctic hair grass, belonging to six genera: *Streptomyces* (22 isolates), *Nocardia* (3 isolates), *Micromonospora* (2 isolates), *Embleya* (2 isolates) *Actinoplanes* (1 isolate), and *Kribbella* (1 isolate). This is the first report on the isolation of representatives of the genera *Embleya* and *Actinoplanes* from the Antarctic. Almost 42% of the isolates inhibited the growth of at least one indicator pathogen. The studied isolates were active mainly against gram-positive bacteria, such as *B. subtilis, S. aureus, M. smegmatis*. Significantly less, only 13%, were active against *C. albicans*. The worst activity levels were against gram-negative bacteria, with only 10% of isolates active against *E. coli* and no isolates active against *P. aeruginosa*. Since gram-negative bacteria usually cause dangerous diseases and easily become resistant to antibiotics, the search for new compounds has a high prospect. It is also important to note that both members of the genus *Embleya* produced antibiotics. Following study of the secondary metabolism of this genus can provide new compounds since *Embleya scabrispora* could produce hitachimycin with antitumor, antibacterial, and antiprotozoal activities and *E. hyaline* was produce nybomycin which is an effective agent against antibiotic-resistant *S. aureus.*

ADAPTATIONS OF ANTARCTIC BACTERIA *PAENIBACILLUS TUNDRAE* IMB B-7915 TO THE INFLUENCE OF COPPER (II) CHLORIDE

S. Y. Komplikevych*, *O. D. Maslovska*, *S. O. Hnatush
Ivan Franko National University of Lviv, Lviv, Ukraine; solomiia.komplikevych@lnu.edu.ua

Heavy metals are widespread in Antarctic biotopes, in particular in the Argentine Islands (Wilhelm Archipelago), where the Ukrainian Antarctic Akademik Vernadsky station is located. This is confirmed by the studies of Fabri-Jr et al. (2018), Liu et al. (2021), Parnikoza et al. (2017), Parnikoza, (2019), Bedernichek et al. (2020) and by our results (Komplikevych et al., 2023). One of the mechanisms of the toxic effect of heavy metals is the formation of free radicals with subsequent damage to biomolecules. It is known that at low temperatures the processes of formation of free radicals intensify due to an increase in the solubility of oxygen (Tribelli & López, 2018). Therefore, the adaptations that occur in psychrophilic and psychrotolerant microorganisms can be important for resistance to the influence of heavy metals. The strain *Paenibacillus tundrae* IMB B-7915, isolated from the substrates from the Berthelot Island, can grow in a medium with 50 μM Cd^{2+}, 1 mM Fe^{2+}, 2 mM Cu^{2+}, 0.6 mM Cr (VI), 15 mM Mn^{2+}, 10 mM Co^{2+}. The aim of the work was to investigate the content of lipid peroxidation, oxidative

modification of proteins products and the activity of enzymes of the antioxidant defense system of bacteria *Paenibacillus tundrae* IMB B-7915 under the influence of copper (II) chloride.

Cells of a two-day culture of bacteria *P. tundrae* IMB B-7915 were precipitated, washed, and incubated for one hour in Tris-HCl buffer (pH 7.5) containing 2–8 mM copper (II) chloride, after which the washed cells were inoculated into soy tryptone broth. Bacteria were grown for 3 days at a temperature of 30 °C. The content of diene conjugates, lipid hydroperoxides, thiobarbituric acid reactive species, carbonyl groups in proteins, and the activity of enzymes of the antioxidant system (catalase, superoxide dismutase) was determined photometrically on the 1st, 2^{nd,} and 3rd days of culture growth using the methods described in detail in the article (Hnatush et al., 2022).

Lipid peroxidation (LPO) is a bioindicator of oxidative stress. The content of primary LPO products under the influence of copper (II) chloride did not differ or was lower than in the control during 3 days of cultivation of *P. tundrae* IMB B-7915. The content of secondary LPO products under these conditions increased with increasing duration of cultivation but was also lower compared to the control. Besides lipids, proteins are damaged under the influence of free radicals. One of the markers of such damage is the presence of carbonyl groups in proteins. The content of carbonyl groups in the proteins of *P. tundrae* IMB B-7915 during the 1st day of growth decreased by 25–55%, compared to the control. During further cultivation, the content of carbonyl groups in proteins also decreased significantly. Under these conditions, the activity of the antioxidant defense system enzymes increased. In particular, during the 1st day of bacterial growth, superoxide dismutase and catalase activity were 15.7–28.4 and 2.4–11.9 times higher than the activity of these enzymes in the control. During further cultivation, superoxide dismutase and catalase activity decreased and slightly differed from the control.

Therefore, bacteria *P. tundrae* IMB B-7915 effectively counteract the effects of copper (II) chloride. Superoxide dismutase and catalase activity are important in this process. However, there are probably other important factors that ensure the survival of *P. tundrae* IMB B-7915 under conditions of heavy metal stress, which require further research.

EFFECT OF COLLAGEN PEPTIDES FROM THE HYDROBIONT *DIPLULMARIS ANTARCTICA* ON OBESITY DEVELOPMENT

***N. G. Raksha*[1], *S. A. Shchypanskyi*[1], *T. M. Maievska*[2], *O. M. Savchuk*[1]**
[1]*Educational and Scientific Center "Institute of Biology and Medicine", Taras Shevchenko National University of Kyiv, Kyiv, Ukraine; nkudina@ukr.net*
[2]*Ukrainian Fishing Industry Cluster of Innovations, Kyiv, Ukraine*

Obesity is currently a major public health problem worldwide. Considering a lack of modern therapies and effective inexpensive drugs to prevent obesity progress, the search for new approaches and the development of new medicines

characterized by effective preventative and therapeutic action, as well as a high safety profile is a promising direction for the research. Nowadays, peptides are being actively studied as possible alternatives to drugs for the prevention and treatment of obesity. Marine hydrobionts are considered a promising source for peptide production. The peptides derived from their tissues have a great number of activities, including antibacterial, anticoagulant, antitumor, and immunomodulatory. Here, we investigated the ability of collagen peptides derived from jellyfish of the Antarctic region – *Diplulmaris antarctica* – to influence the development of obesity in rats fed a high-calorie diet. Given the abundance of *Diplulmaris antarctica* in the Antarctic region, this species may be a sustainable source of collagen as well as collagen peptides. Collagen peptides were produced by pepsin hydrolysis of jellyfish-derived collagen. The purity of collagen and collagen peptides was confirmed by SDS-polyacrylamide gel electrophoresis. To determine the anti-obesity effect of collagen peptides, rats were fed a high-calorie diet for ten weeks and were simultaneously treated *per os* with collagen peptides (1 g per kg of body weight every other day) for the next six weeks.

In our experiment, the overweight of the rats in response to consumption of high-calorie food was confirmed by an increase in body mass index (BMI). Treatment with collagen peptides showed beneficial effects on obesity development, as the body mass index of animals that received the collagen peptides was within the control value. It was found, that the rats that received high-calorie food were characterized by an increase in body weight gain. The administration of collagen peptides effectively prevented an increase in body weight gain in rats fed a high-calorie diet. The decrease in both BMI and body weight gain of the rats treated with collagen peptides compared with obese rats may be due to a decrease in the need for animals to consume high-calorie food. Based on our results, we state peptides can affect satiety as the animals that had free access to food and received collagen peptides consumed significantly less feed compared to rats that were on a high-calorie diet.

Summing up the results, collagen peptides derived from the jellyfish *Diplulmaris antarctica* may be promising therapeutic agents for the treatment of obesity and its associated complications.

FEATURES OF SLEEP IN WINTERERS AT THE ANTARCTIC STATION

***D. G. Lutsenko*[1,*], *O. V. Shylo*[1], *K. M. Danylenko*[2,3], *Y. V. Moiseyenko*[2], *N. P. Babii*[2], *I. V. Deyneka*[2], *A. V. Khytryi*[2], *O. L. Lutsenko*[4]**

[1] *Institute for Problems of Cryobiology and Cryomedicine, National Academy of Sciences of Ukraine, Kharkiv, Ukraine; lutsenkodmytro@gmail.com*

[2] *State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine;*

[3] *Kharkiv National Medicine University, Kharkiv, Ukraine;*

[4] *Sxope Inc. Tampa, USA*

Since the first expeditions to Antarctica, one of the most common health disorders is sleep disturbance. Currently, the causal mechanisms of such disturbances during long expeditions to the Antarctic have not been precisely identified. But it is believed that sleep disturbance is one of the main symptoms of the "Antarctic syndrome". All these processes are accompanied by disturbances in the normal rhythm of biological processes, which can lead to both "polar insomnia" and increased sleepiness in winterers. It can affect the general working capacity of the expedition participants. Therefore, during 2016–2022, a psychophysiological study of the several features of sleep-in winterers at the Antarctic station was conducted. The winterers of the 21st, 23rd–26th Ukrainian Antarctic expeditions (54 men and 4 women, average age 38) took part in the study. Self-testing of the winterers was carried out quarterly using the IDS-S30 questionnaire. The analysis showed that the dynamics of subjective problems of sleep quality were characterized by individual characteristics, but the peak values of its disturbances (difficulty falling asleep ~74%, restless sleep ~57%,) fell on the period of the middle of the Antarctic winter. Waking up too early was observed the same number of times during the season (25%) and there were more cases of excessive sleep-in autumn and spring (up to 34%). Attention is also drawn to the fact that some winterers had sleep problems until the end of the expedition, which can increase the load on the adaptive reserves of the body, leading to a state of fatigue and chronic stress.

Further research may be helpful in clarifying the problem of treating the manifestations of the "Antarctic syndrome" in winterers, associated, among other things, with the processes of negative changes in the sleep-wake cycle, which can lead to the accumulation of fatigue with a subsequent increase in stress load on the body with all the negative aspects of this phenomenon.

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U-Pb AGE AND PT CONDITIONS OF FORMATION OF ZIRCON FROM DYKE LAMPROPHIRES (ARGENTINE ISLANDS AREA, WILHELM ARCHIPELAGO, WEST ANTARCTICA)

***G. V. Artemenko*[1], *V. G. Bakhmutov*[2], *D. K. Wozniak*[1], *L. M. Stepanyuk*[1], *Yu. O. Lytvynenko*[1]**

[1] *M.P. Semenenko Institute of Geochemistry, Mineralogy and Ore Formation, National Academy of Sciences of Ukraine, Kyiv, Ukraine; regulgeo@gmail.com*

[2] *S.I. Subbotin Institute of Geophysics, National Academy of Sciences of Ukraine, Kyiv, Ukraine*

The dike of lamprophyres among granodiorites of the Andean complex was discovered on Locator Island (Roca Islands, southern part of the Wilhelm Archipelago, West Antarctica) near the remains of an old British Lighthouse (S65^{o} 10.734'; W64^{o} 29.455'). The thickness of the dike is up to 0.5 m. The dike rocks dip angle is 70^{o} to the northeast. The lamprophyres chemically correspond to the basic rocks of the calc-alkaline series with high magnesian #mg 0.56. They contain high levels of tungsten (28.7 g/t), copper (445 g/t), zinc (207 g/t) and lead (123 g/t).

The results of U-Pb geochronological studies. Zircon form lamprophyres is represented by two types of crystals. The first type is transparent yellowish-pink individuals of pyramidal-prismatic habit, and it dominates in terms of quantity. The second type is the formation of a flat outline. The dimensions are usually 0.3–0.7 mm along the L_4 axis. A small amount of biotite inclusions is observed. Many fluid inclusions were found in zircon crystals. The results of the isotope research have shown that the lamprophyre zircon contains very little lead, and a significant proportion of it is the lead isotope ^{204}Pb. For this reason, the age values are more reliable not based on lead-lead (^{207}Pb/^{206}Pb), but on uranium-lead ratios of ^{238}U/^{206}Pb. According to the data obtained, zircon from lamprophyres was formed 50–60 million years ago.

Inclusions in zircon crystals. The inclusions in zircon are dominated by primary melt inclusions and less often by mineral inclusions. The former can sometimes occupy up to 30% of the crystal volume. Among the mineral inclusions, potassium feldspar, albite and potassium-sodium feldspar, apatite, and quartz were diagnosed. In the peripheral part of zircon crystals, apatite occurs in the form of elongated prismatic crystals. It is significant that feldspar inclusions have a rounded, mostly slightly elongated teardrop shape. They occur in crystals of pyramidal-prismatic habit. Among the fluid inclusions, one primary inclusion of CO_2 fluid was detected, the remaining inclusions are represented by primary crystallized melt inclusions. The CO_2 fluid density is 0.804 g/cm^3 (Tpp = −57.4 $^{\circ}$C, Th = +16.0 $^{\circ}$C (in the liquid phase)). The inclusion was found in a flat type of

zircon crystals. The fluid pressure in the inclusion of CO_2 fluid with a density of 0.80 g/cm^3 at a temperature of 1000 °C is 470 MPa, at 1200 °C – 530 MPa, which corresponds to the fluid pressure of the magma during the crystallization of the flattened type of zircon and the peripheral zone of the first type of crystals.

Melt inclusions. In the peripheral part of the crystals, they have an irregular elongated shape, sometimes tubular faceted. Their length can reach 0.2–0.3 mm. The inclusions in the rest of the crystal volume have a rounded teardrop shape. Silicate glass obtained during heating procedure of inclusions has an acidic composition. Almost all inclusions crack during heating. The inclusions were being heated for 7–9 hours. The glass of inclusions does not form a homogeneous mass during three hours of heating at a temperature of 1300 °C. It was not possible to obtain a reliable temperature of homogenization of inclusions formed during the growth of zircon in acidic magma. It probably exceeds 1100–1200 °C. The temperature of the basic magma exceeds the closure temperature of the U-Pb system of zircon.

Discussion of results and conclusions. It was determined that zircons from dike lamprophyres breaking through granodiorites of the Andean complex are between 50 and 60 million years old. Zircon in intrusive rocks is often one of the first and highest-temperature minerals to crystallize from magmatic melt. In our case, zircon crystallization occurred at the end of lamprophyre formation, since the primary melt inclusions have an acidic composition. At the same time, the presence of a primary inclusion of CO^2 fluid in zircon indicates its genetic connection with the basic magma melt. The very low zircon content in the basic magma caused zircon crystallization at the end of its crystallization. In addition, the cracking of melt inclusions in zircon during the heating process indicates a high fluid pressure that breaks their tightness. This pressure is caused by the presence of CO_2 fluid in the composition of the melt inclusion.

MAGNETIC FIELD MAPPING OF THE WILHELM ARCHIPELAGO SHELF ZONE, WEST ANTARCTICA

***V. Bakhmutov*[1,2], *T. Yegorova*[1,3], *M. Bakarzhiyeva*[1], *O. Mytrokhyn*[4], *V. Shpyra*[1], *V. Maksymchuk*[5], *M. Orlyuk*[1], *A. Romenets*[1]**

[1]*S.I. Subbotin Institute of Geophysics, National Academy of Sciences of Ukraine, Kyiv, Ukraine; bakhmutovvg@gmail.com*

[2]*Institute of Geophysics, Polish Academy of Sciences, Warszawa, Poland;*

[3]*University of Parma, Department of Life Sciences and Environmental Sustainability, Parma, Italy;*

[4]*Kyiv Taras Shevchenko National University, Educational-Scientific Institute 'Institute of Geology', Kyiv, Ukraine;*

[5]*Carpathian Branch of S.I. Subbotin Institute of Geophysics, National Academy of Sciences of Ukraine, Lviv, Ukraine*

The Antarctic Digital Magnetic Anomaly Project (ADMAP) is an international research effort to construct a magnetic map of the continent based on ground, satellite, marine, and aeromagnetic surveys. Our contribution reports the magnetic mapping of the shelf zone in the SE part of the Wilhelm Archipelago, West Antarctica, based on magnetic surveys conducted with Zodiac boats. A spectacular feature of this area is the strong magnetic anomaly of the Antarctic Peninsula (AP) Batholith, which was the product of subduction-related Mesozoic-Cenozoic arc magmatism on the former margin of Western Gondwana. We constructed and analyzed a detailed magnetic map of magnetic field anomalies using field observations of rock exposures on the islands and magnetic properties of rocks from laboratory data. The oldest volcanic rocks of Jurassic to Lower Cretaceous age relate to N-NE trending bands of negative magnetic field. The largest feature in the study area is an Upper Cretaceous / Paleogene granodiorite complex that produces a positive magnetic anomaly. Many smaller anomalies are also present over gabbroid bodies of Cretaceous age. Two-dimensional magnetic modeling shows that inhomogeneities in the upper crust may have magnetic susceptibilities in the range of 0.005 to 0.42 SI. Magnetic field anomalies also delineate an orthogonal system of tectonic faults, including the main NE fault along the Penola Strait (sub-parallel to the AP coastline) and four intersecting faults. These fault systems may be associated with different stages of continental margin evolution along the Antarctic Peninsula.

We gratefully acknowledge the contribution of members of wintering teams and season expeditions of Ukrainian Antarctic Akademik Vernadsky station who provided logistic support of magnetic survey. Special thanks to Viktor Tarasov, Yevheniy Nakalov, Yevhenii Brillinh, Oleh Romanyuk, Yurii Otruba and Dmytro Litvinov for performing magnetic measurements.

GABBROID INTRUSION OF GIRARD BAY (KYIV PENINSULA OF THE GRAHAM COAST, WEST ANTARCTICA)

***D. S. Chertova*[1], *O. V. Mytrokhyn*[1,2], *V. G. Bakhmutov*[3]**
[1] *Taras Shevchenko National University of Kyiv; dariia.chertova@gmail.com*
[2] *Institute of Geological Sciences, National Academy of Sciences of Ukraine, Kyiv, Ukraine;*
[3] *Institute of Geophysics, National Academy of Sciences of Ukraine, Kyiv, Ukraine*

Kyiv Peninsula forms the most notable topographical element of the mainland on the Graham Coast. Despite the fact that the Ukrainian Antarctic station operates near Kyiv Peninsula its internal hard-to-rich area still remains poorly studied by geologists. Therefore in 2017, 2019–2020 O. Mytrokhyn and V. Bakhmutov carried out a reconnaissance geological survey in several bays going into its coast.

Geological structure of Girard Bay for sure is unknown because the rocks are possible to observe just within relatively small separate outcrops that are free from permanent snow and ice. An entrance of the bay consists of volcanic rocks that were described by Curtis as Upper Jurassic volcanic group (1966). New outcrops were discovered and studied by Ukrainian geologists on the southern and eastern rocky coasts of Girard Bay. They are comprised of plutonic rocks among which gabbroids were the most common. On the southern coast gabbroids form steep cliff with a length of 500 m and a height of at least 200 m. The layered stratum observed above is probably composed of volcanites. The layering of the volcanites is inclined to the west toward probable contact with gabbroids. The contact itself is covered by glacier.

Gabbroids from the southern coast are medium-grained mezocratic to leucocratic rocks. In thin section, they demonstrate hypidiomorphic cumulative textures. Major minerals are plagioclase $An_{61–99}$, orthopyroxene $Wo_{3–4}En_{64–67}$, and clinopyroxene $Wo_{31–41}En_{43–48}$. Minor mineral is Ti-magnetite. Ilmenite, apatite, zircon, pyrite, chalcopyrite, sphalerite, titanite are accessories. Idiomorphic grains of the plagioclase and orthopyroxene are oriented plane-parallel and they can form cumulate clusters. Intercumulus clinopyroxene and Ti-Magnetite are xenomorphic. Petrographic studies revealed that studied gabbroids are only slightly altered by low-temperature metamorphism. Minor metamorphic minerals are cummingtonite-actinolite, quartz, muscovite, and chlorite.

Gabbroids from the eastern outcrop are more altered by postmagmatic processes than gabbroids from the southern one. It manifests by greener rock color and areas pierced by small, probably quartz, veins. Petrographical research proves the changes by the appearance of epidote, prehnite, talc, biotite, and chlorite. There are differences in primary minerals' chemical composition for plagioclase $An_{21–100}$ and clinopyroxene $Wo_{41–48}En_{38–46}$. Also, it is observed higher concentrations of ilmenite, zircon and apatite. Ti-magnetite is completely absent in the gabbroids of the eastern outcrop. Instead, there is appreciable concentration of titanium-free magnetite.

The question of whether the gabbroids of the two studied areas can be parts of one intrusive body has not been finally resolved. Obviously, not all differences in the mineralogy of the studied gabbroids can be explained only by the different intensity of metamorphic transformations. It is likely that the differences in the chemistry of pyroxenes and Fe-Ti oxides are due to other reasons.

NEW INSIGHTS ABOUT ORBICULAR GABBRO FROM THE HOVGAARD ISLAND, WILHELM ARCHIPELAGO OF THE WEST ANTARCTICA

***A. V. Ivko*[1], *O. V. Mytrokhyn*[1,2], *V. G. Bakhmutov*[3]**

[1] *Taras Shevchenko National University of Kyiv, Kyiv, Ukraine; antonazivko@gmail.com*

[2] *Institute of Geological Sciences, National Academy of Sciences of Ukraine, Kyiv, Ukraine;*

[3] *Institute of Geophysics, National Academy of Sciences of Ukraine, Kyiv, Ukraine*

A new variety of orbicular rocks was discovered in 2020 during a geological survey on the Hovgaard Island. It is the rarest petrographic representative of the orbiculites namely orbicular gabbro. The name *"hovgaardite"* was proposed for the new rock variety based on the peculiar features of its mineral composition *(Mytrokhyn and Bakhmutov, 2021)*. Irregular patch 200 m^2 of the hovgaardite lies in the common amphibole gabbroids of the Hovgaard Island. Igneous breccias are common among host gabbroids and hovgaardites. Comb-layred gabbroids were also found on the nearby Vedel Islands.

Like all other orbicular rocks, hovgaardite contains the orbicules that are large spherical mineral aggregates with concentric-zonal and radiate structure. Distinctive feature of the hovgaardites is their mineralogy.

Orbicules consist of extremely calcium plagioclase ($An_{85–97}$), hornblende (#Mg=0,77–0,81), actinolite, Mg-Fe mica, chlorite, magnetite. In addition to them, clinopyroxene ($Wo_{48–50}En_{43–47}Fs_{5–8}$), spinel ($Sp_{65–72}Hrc_{12–19}Mt_{13–17}$), corundum, talc (?) and quartz may be present. Accessories are apatite, epidote, pyrite and chalcopyrite.

Inter-orbicular matrix consists of plagioclase ($An_{45–90}$), clinopyroxene, orthopyroxene, hornblende, actinolite, Mg-Fe mica and magnetite. Beside them there are talc and chlorite. Apatite, ilmenite, pyrite, titanite, leucoxene, zircon and galena are accessories.

The geological position and textures of the hovgaardite indicate that its crystallization occurred at the shallow depths. Authors suggest that the origin of the hovgaardite is similar to some orbicular gabbroids in cordilleran-type batholiths. According to modern concepts their manifestations can be an indicator of decompression-driven crystallization of superheated hydrous mafic magmas in subvolcanic conduits. From the other side, some identified features of hovgaardite may contradict or complement mentioned concepts. Anyway, they represent

specific link between deep-seated arc plutons and surface volcanic eruptions near Graham Coast region.

GEOLOGICAL SURVEY ON THE ARGENTINE ISLANDS (WILHELM ARCHIPELAGO, WEST ANTARCTICA)

O. V. Mytrokhyn[1,2], V. G. Bakhmutov[3]
[1] *Taras Shevchenko National University of Kyiv, Kyiv, Ukraine; mitrokhin.a.v@ukr.net*
[2] *Institute of Geological Sciences, National Academy of Sciences of Ukraine, Kyiv, Ukraine;*
[3] *Institute of Geophysics, National Academy of Sciences of Ukraine, Kyiv, Ukraine*

In 2017, 2019–2020 the authors carried out geological survey and large-scale geological mapping on the Argentine islands where the Ukrainian Antarctic station is located. It was found out that significant area of the surveyed territory is covered with permanent snow and ice even in the most favorable time from January to April inclusive. Metamorphosed volcanites of the Argentine Islands Formation (AIF) make up most of the coastal outcrops as well as the highest elevations on the Galindez, Winter, Skua, Black, Leopard, Shelter, Three Little Pigs, Indicator, Grotto, Corner, Uruguay, Irizar and Fanfare islands. Poorly stratified lapilli tuff, tuff breccia, pyroclastic breccia and andesitic lavas are the most common. Stratified ash tuff, tuffites, sandstones, mudstones and cherts are subordinate. All the rocks have been subjected to varying grades of contact-thermal metamorphism, metasomatism and tectonic deformations. The most intense transformations can be observed near contacts with the Barchans-Forge granitoid (BFG). The volcanites of the AIF are correlated with the Antarctic Peninsula Volcanic Group (APVG). The Jurassic-Cretaceous age for AIF volcanites is defined by indirect data. The lower age limit coincides with the one accepted by Tomson and Pankhurst (1983) for APVG. The upper age limit is determined by Paleocene age of granitoids intruding AIF on the Barchans Islands. The age of AIF needs further clarification. We continue to search for the least metamorphosed volcanites for isotopic dating.

An apical part of microdiorite intrusion (or several intrusions?) is fragmentary exposed under AIF on the Galindez, Winter, Indicator and Corner islands. Authors assume that these microdiorites intruded in the time interval between the AIF volcanites accumulation and their subsequent metamorphic transformation. The contact metamorphism of the AIF was apparently caused by an even later intrusion of Paleocene granodiorites exposed on the Barchans and Forge islands. The intrusive contact of the BFG with the intensively metamorphosed volcanites was recorded on the eastern coast of these islands. Paleocene age 60,9±0,8 Ma was determined by Bakhmutov et al. (2013) with Ar-Ar isotope dating of the biotite from the Barchans granodiorite. So BFG intrusion belongs to the youngest representatives of the Antarctic Peninsula Batholith.

Small mafic and intermediate dykes are scattered throughout the exposed area of the Argentine Islands. More than two dozen dykes intrude in BFG. But their greatest number intrudes in the AIF. Several dykes also cross the microdiorite intrusion on the Galindez Island. Cross-cutting relations between different dykes proved their multi-stage intrusions. Mesozoic dykes occur exclusively in the AIF. They were subject to low-temperature metamorphism and, in some places, to tectonic deformation together with the host volcanites. Cenozoic dykes intrude in both BFG and AIF. Some of them are subvolcanic dykes. They intruded after the exhumation of the host granitoids, no earlier than the beginning Miocene.

The youngest geological formations on the Argentine Islands are modern glacial and marine coastal sediments. In addition to Holocene glacial formation there are evidences of an older, apparently Pleistocene glaciation namely erratic boulders, glacial striation and other. The authors plan their further study to clarify the geology of the subglacial bedrock as well as to reconstruct the features of the ancient glaciation namely its extent, thickness and travel routes.

ICE COVER POSITION AND VELOCITY ANALYSIS OF THE TRUZ GLACIER (KYIV PENINSULA) ACCORDING TO SATELLITE REMOTE SENSING DATA

S. V. Kadurin, K. P. Andreeva
Odesa I. I. Mechnikov National University, Odesa, Ukraine; kadurins@gmail.com

The object of the study is the ice cover of the Kyiv Peninsula, especially the Trooz Glacier. The subject of the study is the dynamics of ice flow under the influence of climatic factors. The main goal of the work is to establish changes in the position and velocity of the Trooz Glacier during 2020–2022 years in comparison with climate variations in the same time interval.

Velocity field analysis of Trooz Glacier ice flow was determined using the results of remote sensing from the Copernicus Sentinel-1 satellite. The observation interval for velocity calculation was 12 days, thus starting from January 1, 2020 to July 25, 2022, 78 intervals were selected and analyzed. One hundred control points along all glacier and their main tributaries were detected. All velocity calculation has been made for these control points. All climate parameters were taken from https://power.larc.nasa.gov.

It was established that the Trooz Glacier could be divided into three main parts according to the ice flow velocity. The estuarine part where the systems of crevice type tensile cracks are developed and the highest movement speeds of up to 4 m/day detected. The central part with the widest valley of the glacier can be characterized by average movement speeds of 0.5–0.6 m/day. The upper parts of valleys and straits can be singled out, where there is a certain periodicity of ice masses movement with an average speed of 0.6 m/day, but with accelerations up to 1.2 m/day.

It was established that the ice flow velocity dynamics of various parts of glacier has certain connections with changes in the environment climatic characteristics. Delaying in time between ice flow movements and climate changes is a main peculiarity of such an interaction. The presence of climatic changes, primarily changes in the average air temperature and the amount of precipitation, has a certain effect on changes in velocity of various parts of the glacier, especially in the mouth part, with a time delay of 48–50 days.

MONITORING OF GLACIER SURFACES IN THE ARGENTINE ISLANDS (ANTARCTIC PENINSULA) REGION BASED ON ARCHIVE MATERIALS

Kh. I. Marusazh*, *I. R. Savchyn*, *H. O. Nesmyrna
Institute of Geodesy, Lviv Polytechnic National University, Lviv, Ukraine; khrystyna.i.marusazh@lpnu.ua

The glacial situation at the Antarctic Peninsula (AP) exerts a notable effect on this region's formation and course of glaciologic processes. Therefore, the studies of the local features of the regimes of some region glaciers are urgent and relatively accessible.

Consider the changes in small glaciers and ice caps in the AP region using the example of the Argentine Islands (Galindez, Winter and Skua islands) in the Wilhelm Archipelago. For research, we chose spatiotemporal data covering the period of 1935–2005. One of the topographic maps was built according to the research results from February 1935 to February 1936 during the British Graham Land Expedition in 1934–1937, published in 1938. Also, a space-time array of data involved archival cartography materials published in 1963, which were based on the results of a complete aerial survey of the entire territory of Graham Land and aerial photos of Argentine islands troves received in December 1956 during the ex-Falkland Islands and Dependencies Aerial forwarding Survey Expedition in 1955–1957. In addition to archival cartographic materials, the results of aerial surveys carried out in 2005 by representatives of the British Antarctic Survey were also used. Aero surveying was done with an analogue camera Zeiss RMK A 15/23 (focal length 153 mm) with a height of 5500m.

The study was based on integrating different spatiotemporal data into a single system for performing retrospective monitoring of changes in glacier surface on the Galindez, Winter, and Skua islands. For integrating spatiotemporal data, the UTM coordinate system is selected (zone 20, South). A set of ground control points (GCP) from the 24th Ukrainian seasonal Antarctic Expedition was used to integrate archival cartographic materials into the selected coordinate system and for creating an orthophoto by aerial survey data. As points of the plan-elevation basis of precise used contours of the area, which were identified on different spatiotemporal data. The accuracy of determining the planned coordinates of points was 5–10 cm, and the accuracy of determining heights was 10–20 cm.

Using archival maps and received orthophoto, digitized limits and created DEM of glaciers on Galindez, Winter and Skua islands in different research periods. The identification of the boundaries of glaciers was carried out in a manual mode based on the visual interpretation of data. It should be noted that the error of determining the based on cartographic materials depends on the map scale. Scales of used archival cartographic materials are 1:13,716 and 1:10,000. For aerial survey data, the accuracy of points coordinates depends on the resolution of the orthophoto – 1.5 m in 2005. Triangular irregular networks (TIN) were built for glacier surfaces on Galindez, Winter and Skua islands in different periods.

By analysing the results of TIN and some profiles, we can summarize that the thickness of ice cover is reduced by about 7–10 m from 1938 to 1963 and, on average, by 5–7 m from 1963 to 2005. So, the rate of glaciers melting has slowed. Still, the presented monitoring results suggest a non-uniform character of changes in the glaciers since the western part of the glacier on Galindez shrinks faster than the southern parts of both glaciers. Further monitoring of Antarctic coastal glaciers is essential for the timely detection of changes in them and for establishing patterns for assessing regional climate variability.

LITHOLOGICAL AND MICROPALEONTOLOGICAL CHARACTERISTICS OF SHALLOW-WATERS BOTTOM SEDIMENTS IN THE AREA OF UAS AKADEMIK VERNADSKY

O. P. Olshtynska, S. M. Stadnichenko, S. B. Shekhunova
Institute of Geological Sciences, National Academy of Sciences of Ukraine, Kyiv, Ukraine; ol-lesia@ukr.net, stadnik_sm@ukr.net

Based on the results of a bottom sediment columns comprehensive study for the shallow waters in the area of the Ukrainian Antarctic Akademik Vernadsky station, new data on their textural peculiarities, mineral, and chemical composition, species composition of diatoms, silicoflagellates were obtained, and sedimentation conditions were determined. Studies of the material, granulometric, and mineral composition of sediments and X-ray diffraction analysis of rock-forming minerals were carried out using electron microscopy techniques; ultrasonic disintegration of samples was used to extract paleontological residues; microalgae taxonomic composition determination and their photographing were carried out in light and electron microscopes. The research material is bottom sediment samples obtained in 2018 near Galindez I. (65°14'49.9"S 64°15'00.7"W) column length 15 cm, 8 samples were studied; near Winter I. (65°14'50.5"S 64°15'37.3"W) length 17 cm, 7 samples studied; Stella Creek (st. A418 (65°14'55.8"S 64°15'11.1"W) column length 27 cm, 8 samples studied). Lithologically, the sediments are represented by light to dark gray with a greenish-pale shade of sandy pelitic silt and sandy silt (Winter); gray, light gray with a greenish tinge of silt, silty pelite, and pelitic silt (Galindez I., Stella Creek). The mineral composition is represented by terrigenous quartz, plagioclase, chlorite, illite, amphibole, siderite; ilmenite (with pyrophanite

molecule), zircon, monazite; opal (biogenic), authigenic component (bacteriomorphic framboidal clusters of iron sulfide microcrystals, calcium sulfate). In the chemical composition, according to the results of energy dispersive x-ray microanalysis, silica prevails, the total content of sulfate is 0.57–2.19% (Winter), 0.73–1.68% (Galindez I.), 2.14–3.07% (Stella Creek) and chlorine 0.5–2.54% (Galindez I.), 1.99–4.92% (Stella Creek) 3.93–7.44% (Winter I.). In the samples from Galindez I., an interlayer containing up to 17% calcium phosphate (P_2O_5 – 9.67–15.82%) was recorded in the upper part of the studied section. More than 60 species of diatoms belonging to 32 (Galindez I., Winter I.) and 34 genera (Stella Creek) have been identified. Epiphytes prevail – from 65% to 75%, among them the most numerous representatives of the genus Amphora (20–30%) and Cocconeis (25–30%), a great number is *Cocconeis fasciolata, C. costata, A. copulata, A. proteus*. Open sea and ocean plankton is represented singly by seasonal sea ice *Thalassiosira antarctica* and *Thalassiosira lentiginosa* (Galindez I.). In the Stella Creek complex, benthic and epiphytes (dominant); summer sea benthos and epiphytes; cryophilic; cold-water Antarctic marine plankton; open sea and ocean plankton were revealed. Comparison of diatom complexes and lithological characteristics of the bottom sediments of Galindez I., Winter I., and Stella Creek indicate similar conditions of sedimentation in these water areas: these are marine shallow basins up to 10 m deep, with water temperature during active diatom vegetation from −1° to +1°C. Sedimentation took place in cold-water conditions similar to current ones. A small number of oceanic species of diatoms indicates that the studied water areas are shielded from the open sea conditions impact. Most oceanic species are identified in the Winter Strait sediments. The influence of oceanic waters from the outer shelf is also indicated by a relatively higher chlorine content than in the sediments of Galindez I. and Stella Creek, and a lower sulfate content. In addition, the coarsest sandy silt sediments of the Winter Strait indicate more hydrodynamically active conditions for their formation. An insignificant number of cryophilic indicates the absence of actively drifting ice and shielding from currents transporting icebergs from the continent. In winter, the studied water areas probably froze to the bottom. In the spring season, there is a significant desalination of the coastal sea waters.

MEASUREMENT ACCURACY INCREASE AT AIA OBSERVATORY

Yu. P. Sumaruk [1,3], ***A. A. Marusenkov*** [2], ***V. E. Korepanov*** [2], ***P. V. Sumaruk*** [3]
[1] *State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine; yurisumaruk@gmail.com*
[2] *Lviv Centre of Institute for Space Research, National Academy of Sciences of Ukraine and State Space Agency of Ukraine, Lviv, Ukraine;*
[3] *S. I. Subbotin Institute of Geophysics, National Academy of Sciences of Ukraine, Kyiv, Ukraine*

The Geomagnetic Observatory "Argentine Islands" (AIA) is the main component of the Ukrainian Antarctic Akademik Vernadsky station. It is the basic one in the region of the Antarctic Peninsula for the international INTERMAGNET network. Therefore, one of the most important tasks is to obtain high-quality measurements of the magnetic field. The process of modernization of measuring equipment, the active work of which began in 2018 and is continuing to this day, facilitated this. In recent years, new instruments were installed at the observatory: basic three-component fluxgate magnetometer LEMI-025, one-component DI magnetometer Mag-01H and scalar magnetometers GSM-19 and GSM-90. At the same time, an analysis of the accuracy of absolute measurements at the station was carried out. This was necessary because their data allow plotting the baseline for basic magnetometer, being the basis for ensuring the reliability of the obtained observation results. The results of absolute observations at the observatory were calculated using two different methods. A comparison of the obtained results showed certain shortcomings or inaccuracies in their application and a rather large scatter of data.

On the basis of the completed work, a new method of calculating absolute observations was proposed, which was tested on the data of the geomagnetic observatory. In comparison with the results of two known procedures, it was shown that the new approach (methodology) allows obtaining a significantly smaller (sometimes up to 4 times) spread of basic values, especially when conducting absolute observations at an increased level of magnetic disturbances.

The errors of the DI magnetometer were also calculated, namely the zero offset of the magnetic sensor, the collimation error of the azimuth δ and the collimation error of the tilt ε of its sensitivity axis relative to the theodolite axes. These data were also used to improve the accuracy of the processing results.

As a result of the installation of new devices and the application of new method of calculating observation data, it was possible to improve the data quality at the AIA Geomagnetic Observatory.

INFRASOUND AND SEISMIC ARRAYS AT VERNADSKY STATION - THE FIRST EXPERIENCE OF YEAR-ROUND OBSERVATIONS

***O. I. Liashchuk*[1], *Yu. A. Andrushchenko*[1], *Yu. S. Otruba*[2]**
[1]*Main Center of Special Monitoring, National Space Facilities Control and Test Center, State Space Agency of Ukraine, Gorodok, Ukraine; alex_liashchuk@ukr.net*
[2]*State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine*

A solid set of geophysical equipment has been deployed at Vernadsky station, some of which has been supplying data to the scientific community for more than half a century. In addition to existing measuring instruments, a small-aperture infrasound array based on Chaparral Physics Model 64Vx sensors (microbarometers) was installed at the station in 2021. The array is supplemented with Gopher seismic sensors. A new digital three-component seismic station Guralp CMG-40TDE with a 24-bit data recorder was also installed.

The distance between infrasound and seismic sensors is 100 meters. The advantage of an array over a single sensor is a significant increase in the signal-to-noise ratio, which makes it possible to distinguish a coherent signal from a background of incoherent noise. Also, the array allows you to estimate the speed of the signal and its direction, which greatly increases the possibilities of analysis. In the infrasound array, the signal from the sensor is fed to a four-channel 24-bit ADC and then to a workstation, where the data archive is formed. Time synchronization is carried out using the Station's time server. Seismic sensors incorporate a microcontroller with a 12-bit ADC, digital data from all sensors are processed by a mini-computer based on LatePanda. The processing result is stored in a separate archive. All received infrasonic and seismic data are stored on the Station server in the miniSEED format. Since 2022, these data have been transmitted via the SeedLink protocol via satellite channels to the National Data Center (Ukraine), which made it possible to use them for real-time processing. Thanks to this, the station is included in the seismological network of the Antarctic Peninsula and in the National Seismic Observation Network of Ukraine.

During the year, the registration conditions at the station vary greatly, which makes it possible to observe a wide range of phenomena or only a small part of them. The beginning of 2022 was marked by the largest recent eruption of the volcano Hunga, Tongo. Station instruments recorded this event at a distance of almost 9 thousand kilometers. Even a small tsunami came to the station and was recorded. Among other things, the main sources of signals that were recorded by an array of sensors were meteorological phenomena, storm activity, orographic processes, iceberg breakaways and avalanches. The distribution of these phenomena in space and time makes it possible to more fully assess the picture of what is happening in the region and determine, in combination with other research methods, the degree of influence of one or another factor on the environment.

TECTONOMAGNETIC MONITORING OF MODERN GEODYNAMICS OF THE WILHELM ARCHIPELAGO (WEST ANTARCTIC)

V. Maksymchuk, I. Chobotok, R. Kuderavets, Ye. Nakalov, N. Pyrizhok
Carpathian Branch of I.I. Subbotin Institute of Geophysics, National Academy of Science of Ukraine, Lviv, Ukraine; valmaksymchuk@gmail.com

Tectonomagnetic research is carried out in the area of Akademik Vernadsky station in the western Antarctic with the aim of studying the modern geodynamics of the lithosphere of the Antarctic Peninsula, tectonic zoning and the detection of tectonically active faults and blocks of the earth's crust. These problems are relevant for the station region, located in the zone of geodynamic influence of subduction processes on the borders of the Antarctic plate and the Skotia plate, the Bransfield Rift. Tectonomagnetic research is based on the study of temporal changes in the local magnetic field by conducting periodic geomagnetic observations on a network of stationary points – a tectonomagnetic polygon.

Research at the Antarctic Tectonomagnetic Polygon in the Ukrainian Antarctic Akademik Vernadsky station area has been carried out since 1998. The network of points of the landfill was created gradually from 7 points in 1998 to 28 points in 2021. Given the specifics of the work area, landfill sites were established mainly on the islands of the archipelago and on the slope of the Antarctic Peninsula: from the Berthelot Islands in the south to Petermann Island in the north; from the Barchans in the west to Kyiv Peninsula in the east. All points of the test site on the terrain are fixed with brass marks for positioning the magnetometer sensor with an accuracy of a few millimeters. During the entire period of operation of the landfill (1998–2020) and at intervals of 1–3 years, 13 cycles of geomagnetic observations were conducted.

Based on the results of the observations, the spatio-temporal structure of tectonomagnetic anomalies within the polygon was investigated. Three anomalous zones have been identified in the spatial structure of the tectonomagnetic field. The western zone (The Barchans, the Three Little Pigs islands, Forge Islands, Skua Island, and Grotto Island) is characterized by a negative linear trend and intense field changes up to −44 nT during 1998–2020 on the Three Little Pigs islands. The central zone (Galindez, Skua, Yalour, Uruguay, Irizar islands) is characterized by small changes in the field, which fluctuate within the margin of error (±1.5–2 nT). In the eastern zone (Rasmussen Hut, Rasmussen Island, Cape Tuxen), the field is almost without anomalies in 1998–2003 and with a sharp negative trend after 2004 (Rasmussen Hut).

A comparison of the spatial structure of tectonomagnetic anomalies with geological and tectonic data shows that the most intense anomalies tend towards the distribution of volcanics and intrusions in the region. Their correlation with seismicity can testify to the possible connection of tectonomagnetic effects with geodynamic processes. Anomalous changes in the magnetic field on the Three Little Pigs islands in 2008–2011 and 2017–2021 preceded a period of seismic activation in the Bransfield Rift, where earthquakes with M>5 were recorded.

We assume that changes in regional tectonic stresses can be felt at observation points located in favorable geotectonic conditions. These stresses are locally reflected in the geophysical fields, and the Three Little Pigs islands are a "special" point that responds to changes in tectonic stress caused by the preparation of strong earthquakes at great distances.

Taking into account the piezomagnetic mechanism of tectonomagnetic anomalies, the magnitude and direction of changes in tectonic stresses in the upper part of the earth's crust were estimated. It was concluded that in the area of the archipelago, the rocks are subjected to tensile horizontal stresses in the eastern part of the landfill and compression in the western part (several bar/year), which is compared with the results of geodetic observations of the earth's crust.

PHYSICAL MODELING OF ELECTROMAGNETIC SOUNDINGS FOR GEOLOGICAL CONDITIONS NEAR UKRAINIAN ANTARCTIC AKADEMIK VERNADSKY STATION

O. Ya. Sapuzhak, S. A. Deshchytsya, O. I. Pidvirnyy, V. V. Koliadenko, O. I. Romanyuk, O. V. Syroyezhko, N. V. Zabrodska
Carpathian Branch of Subbotin Institute of Geophysics of the National Academy of Sciences of Ukraine, Lviv; olehsapuzhak@gmail.com

Research of the upper part of the geological section near Ukrainian Antarctic Akademik Vernadsky station (UAS) using electrical prospecting methods has not yet been carried out. Implementation of such observations allows expanding the range of new experimental data of the region and clarifying the geological structure, revealing local inhomogeneities associated with tectonic features and possible mineral deposits. Working out the methodology of such observations was developed using physical modeling of electromagnetic fields. The basis for physical modeling is an electrolytic bath with a saturated salt solution (specific electrical resistance about 0.05 Ohm·m, electrolyte layer depth 0.35 m). 3D models are formed from materials of different electroconductivity in the electrolytic bath. The first stage of the model creation was the analysis of a priori geological and geophysical data in order to establish the geoelectrical situation in the area of Akademik Vernadsky station. On this basis, observation systems were developed and a number of physical models were created for the research region. The models correspond, in a first approximation, to some of islands of the region or to the characteristic inhomogeneities of different electrical resistivity, taking into account the criteria of similarity in relation to the use of electromagnetic soundings and geometric shapes on a scale of 1:1000. For modeling, the Time Domain ElectroMagnetic (TDEM) and Vertical Electrical Sounding methods were applied. The producing and measurement of electromagnetic (TDEM method) or electric (VES method) fields are carried out at the boundary between air and the surface of the model environment. Experimental observations by both methods were carried out on the developed physical models in various combinations of their elements. A

number of regularities in anomalous changes of the electrical parameters of the environment have been established. These anomalies are caused by various factors such as the location, geometric dimensions, electrical resistivities of objects. Each method has its own advantages and disadvantages. In particular, the method of electromagnetic sounding gives better results in the local detection of objects with both high and low electrical resistivities. And the method of vertical electrical soundings is more effective for detecting a rock layer of low resistivity that overlaps a body of high resistivity.

The obtained results of the physical modeling of electroprospecting observations made it possible to find out about their possibilities in the geological and geoelectrical conditions of the UAS location. Besides, using the established patterns of electromagnetic signal propagation, we can evaluate the possibilities of obtaining results and optimal configuration of electroprospecting installations for the time domain electromagnetic method. Also, the investigations allow for a more reliable geoelectrical interpretation of the electroprospecting data near the UAAVS, taking into account the possible distorting effects of local heterogeneities, coastline, sedimentary or mineralized layers, etc.

Physical modeling of electromagnetic fields for geoelectrical conditions in the area of Akademik Vernadsky station gave positive results. Therefore, the logical development of this direction will be the future study of the upper part of the geological section using electrical prospecting methods in natural conditions of the Antarctica.

The research was carried out under the project of the State Institution National Antarctic Scientific Center.

SEARCHING FOR WAYS TO POPULARIZE KNOWLEDGE ABOUT ANTARCTICA FOR CURIOUS STUDENTS

V. S. Yatsenko
Institute of Pedagogy, National Academy of Educational Sciences of Ukraine, Kyiv, Ukraine; iatsenko_v@ukr.net

The New Ukrainian School prioritizes the quality of knowledge, the development of students' individual characteristics, teaching them the ability to learn, work, and the capability to develop themselves in the process of further self-education in accordance with the requirements of life.

The course of geography of continents and oceans (7th grade) is aimed at educating, training and developmental learning, including the study of the global problem of humanity – environmental protection, the formation of students' knowledge about the role of natural conditions in life and the study of geocomplexes at three levels of its organization: local, regional and global; the laws of development of the geographical shell, its territorial differentiation. In the course of studying the geography of continents and oceans, students are convinced that all natural complexes and the geographical environment in general emerged in

the process of development of our planet, all its parts are interconnected, it is constantly changing in time and space.

In order to teach students to acquire knowledge on their own, they should be taught to think creatively and, the most important thing, to act.

Training sessions cannot be standardized and formalized and always be the same.

In the process of studying the geography of continents and oceans, the teacher's creative attitude to the choice of different types and forms of training will make it possible to plan individual, frontal and group work of students.

Methodologists propose, in addition to the classical forms (classes, study excursions, optional classes, etc.), to conduct travel classes, where students determine not only the cognitive goal but also choose the way of travel, prepare drawings or models, write diaries, reports, draw mapping schemes; classes that use quizzes, tests, competitions in knowledge and skills, etc.

In preparation for studying Antarctica, a unique South Polar region, students are asked to present its nature in the following areas: how Antarctica was explored, the Southern Ocean, seas, fauna, the ice continent, stone Antarctica, climate, etc. Unfortunately, the current curriculum in general secondary education institutions of Ukraine provides only 2 hours to study the continent, plus 1 hour from the reserve of hours. As a result, it is difficult for twelve-year-old students to learn the extensive educational material that polar scientists have collected to this day. What do we offer?

Firstly, geography teachers should think of ways to organize creative cooperation with polar scientists, in particular, the State Institution National Antarctic Scientific Center of the Ministry of Education and Science of Ukraine, and scientists from specialized research organizations.

Secondly, to organize creative meetings with real polar explorers, as such meetings are possible in almost all regions of Ukraine. To do this, we should prepare questions for polar explorers and collect new media publications about Ukrainian research at Ukrainian Antarctic Akademik Vernadsky station.

Thirdly, to involve pupils and students of Ukraine in scientific and practical events, both at the national and regional levels, dedicated to Antarctic topics. In particular, these could include exhibitions of students' artwork, photo exhibitions of polar scientists, detailed presentations of the results of research about whales, the ocean, the ozone hole, climate change and records, and various forms of international cooperation.

IMPLEMENTATION OF O/X POLARIZATION MODES SEPARATION FOR VERTICAL SOUNDING OF THE IONOSPHERE AT UKRAINIAN ANTARCTIC AKADEMIK VERNADSKY STATION

O. V. Koloskov[1,2,3], ***A. S. Kashcheyev***[3], ***O. V. Bogomaz***[1,4], ***A. O. Sopin***[1,2], ***A. V. Zalizovski***[1,2,5]

[1]*State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine;*

[2]*Institute of Radio Astronomy, National Academy of Sciences of Ukraine, Kharkiv, Ukraine;*

[3]*Department of Physics, University of New Brunswick, Fredericton, Canada;*

[4]*Institute of Ionosphere, NAS and MES of Ukraine, Kharkiv, Ukraine; o.v.bogomaz1985@gmail.com*

[5]*Space Research Centre, Polish Academy of Sciences, Warsaw, Poland*

IPS-42 and SDR-based ionosonde (ISDR) are carrying out vertical sounding of the ionosphere at t Ukrainian Antarctic Akademik Vernadsky station (UAS) since 1983 and 2017 respectively. They operate simultaneously and share the same antenna system that consists of two transmitting (LF Tx and HF Tx) and two receiving (LF Rx and HF Rx) rhombic antennas oriented in the magnetic north–south direction.

Trends in the development of modern ionosondes suggest polarization measurements that enable O- and X-propagation modes of the ionospheric signal to be separated. One of the possible ways to perform such measurements at UAS using the available equipment is an upgrade of the ISDR system with a second receiving channel and installing two Rx antennas orthogonally. However, such antenna system cannot be installed near the main building due to insufficient space. Therefore, the most suitable place for mounting of the new orthogonal antennas is near the VLF hut (~400 m apart from the main building). Moreover, an additional benefit of this location is a reduced level of interference produced by radio equipment and electronic devices operating at the station.

In March 2022, a new dual-channel passive SDR-based ionosonde was installed in VLF hut. Initially, the passive ISDR used two HF320A horizontal dipole antennas. In July 2022, a new antenna system was mounted. It consists of two cross-rhombic antennas oriented along the magnetic north–south and east–west directions. The lengths of the horizontal and vertical diagonals of the rhombs are ~35 m and ~10 m, respectively. It is close to the original HF Tx and Rx antenna sizes, with their diagonals being ~40 m and ~20 m respectively. Measured standing wave ratio in the new antennas is also of the same order of magnitude. The installed passive ionosonde contains only the receiving part and works synchronously with the active ISDR located in the main building. To synchronize

operation of multiple ISDRs, BG7TBL GPS-controlled oscillator is used as an external reference clock and PPS signal source.

The results of comparison of ionograms obtained by all ionosondes operating at UAS show that passive ionosonde gives more detailed information about the ionosphere especially in some cases, for example, when F-spread is observed or one of the propagation modes of the ionospheric signal is absorbed. It is especially important for ionogram scaling.

The results obtained at UAS and during the measurement campaign onboard the research vessel *Noosfera* in 2022 (when one-channel passive ionosonde was operating synchronously with the ISDR at UAS) demonstrate a possibility of creating a multi-position facility for sounding of ionosphere at Antarctic stations located near UAS. The advantages of a distributed network of passive ISDRs near UAS are high information content, high reliability, low cost, low power consumption, and the absence of electromagnetic pollution at the receiving sites.

IONOSPHERIC RESPONSE TO SOME MODERATE GEOMAGNETIC STORMS OVER UKRAINIAN ANTARCTIC STATION AND MAGNETICALLY CONJUGATE REGION

***M. O. Reznychenko*[1,2], *D. V. Kotov*[1], *O. V. Bogomaz*[1,3], *O. V. Koloskov*[3,4,5], *V. M. Lisachenko*[4]**

[1]*Institute of Ionosphere, NAS and MES of Ukraine, Kharkiv, Ukraine; marina.shulga23@gmail.com*

[2]*Space Research Centre of Polish Academy of Sciences, Warsaw, Poland;*

[3]*State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine;*

[4] *Institute of Radio Astronomy, National Academy of Sciences of Ukraine, Kharkiv, Ukraine;*

[5] *Department of Physics, University of New Brunswick, NB, Fredericton, Canada*

During geomagnetic storms, a large amount of energy entering the magnetosphere from the solar wind significantly changes the state and structure of the Earth's upper atmosphere due to interaction of the ionospheric plasma with the neutral atmosphere. The ionospheric response to such disturbances can cause positive and negative ionospheric storms, which lead to an increase and decrease in the F2 layer peak electron density, respectively. Understanding the basic physical processes associated with the features of ionospheric storms is one of the priority areas of ionospheric physics. The study of ionospheric effects of specific geomagnetic storms simultaneously over the Antarctic Peninsula and its magnetically conjugated region is of particular interest.

This study is devoted to investigation of variations the ionospheric plasma parameters (h_mF_2 and N_mF_2) in the Southern and Northern hemispheres in the American longitudinal sector caused by moderate (K_p=6) geomagnetic storms which occurred in October 12, 2021 and March 13, 2022. For this purpose, the

experimental data obtained by ionosonde at Ukrainian Antarctic Akademik Vernadsky station (UAS) and ionosonde located near the magnetically conjugated point of UAS – MIT Haystack Observatory (USA), as well as the results of physical modelling of the ionosphere were used. In addition, data from TIMED/GUVI instrument was analyzed and found significant changes in the thermosphere density and composition for geomagnetically disturbed periods.

Our research shows that manifestations of geomagnetic storms over the UAS and Millstone Hill were similar. A strong negative response of the ionosphere to geomagnetic storm on October 12, 2021 was revealed both over UAS and Millstone Hill. There is almost three-fold decrease in the F2-layer peak density during the daytime of the disturbed period. The results obtained for the March 13 geomagnetic storm show that at both investigated stations the electron density increased during daytime hours by almost 1.5 times compared to quiet periods. Of particular interest was the decrease of daytime N_mF_2 values in March 12, the day before onset of the geomagnetic storm. The main hypotheses about the physical mechanisms that could lead to such ionospheric response for the investigated periods are presented.

UPGRADING THE NETWORK OF INTERNET-CONTROLLED DOPPLER HF RECEIVERS FOR GEOSPACE RESEARCH

***A. I. Reznychenko*[1,2], *O. V. Koloskov*[1,3,4], *A. V. Zalizovski*[1,2,3], *V. M. Lisachenko*[1], *Y. M. Yampolski*[1], *M. Pozoga* [2], *O. V. Budanov*[1], *S. B. Kashcheyev*[1], *I. I. Pikulik*[1]**

[1]*Institute of Radio Astronomy, National Academy of Sciences of Ukraine, Kharkiv, Ukraine; artem.reznychenko@gmail.com*

[2]*Space Research Centre of Polish Academy of Sciences, Warsaw, Poland;*

[3]*State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine;*

[4]*University of New Brunswick, NB, Fredericton, Canada*

The network of spatially separated internet-controlled Doppler HF receiving sites of the Radio Astronomy Institute of the National Academy of Sciences of Ukraine (IRA NASU) makes it possible to study the peculiarities of the HF radio signals propagation on radio paths of different lengths and latitudes. The important feature of this research is the ability to record and analyze of both energy and spectra of test radio signals with high accuracy. The continuous measurements make it possible to study various ionospheric processes and the effect of cosmic (energy flows from above) and atmospheric (near-surface energy releases, flows from below) factors on them. Such research provides the development of the engineering models linking the parameters of signal propagation with the conditions of atmospheric and space weather. Therefore, obtaining and accumulating data corresponding to different geo- and heliophysical conditions and collected for different latitudinal regions is very important. The network includes both high latitudes receiving points located in the Arctic (Tromso, Norway;

Longyearbyen, Svalbard Island) and Antarctica (at the Ukrainian Antarctic Akademik Vernadsky station (UAS)) and mid-latitudes sites located in Ukraine. As a result of the russian aggression, several monitoring points of the HF receiver network in Ukraine were destroyed by the invaders. Therefore, the restoring, upgrading and supporting the network by new observation points, especially those located on the territory of European countries friendly to Ukraine, are very urgent task. In August 2022, together with colleagues from the Space Research Centre of Polish Academy of Sciences, a new HF receiving site was created in Borowiec, Poland, which temporarily replaces the lost sites, and will supplement them in the future. The new facility consists of two independent receiving channels and can operate offline or under remote control via the Internet. Since August 2022, HF receivers in Borowiec register the HF signals from the CHU time service station (Canada) and send the results of observations to the database. In October 2022, the measurements of HF signals from the HAARP heating facility (Alaska, USA) were conducted using the Borowiec site. The HF receivers located in the Arctic and on UAS were used during this heating campaign as well. We will discuss in presentation the creation and testing the new measuring sites, relocation of the central database storage, upgrading the primary processing and data transfer software, and will present the preliminary results obtained using the updated network of HF receivers.

ON THE PROSPECTS OF GEOSPACE OBSERVATIONS AT UKRAINIAN ANTARCTIC AKADEMIK VERNADSKY STATION

***O. V. Koloskov*[1,2,3], *A. V. Zalizovski* [1,2,4], *Y. M. Yampolski*[2], *A. V. Shvets*[5,6]**

[1]*State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine;*

[2]*Institute of Radio Astronomy, National Academy of Sciences of Ukraine, Kharkiv, Ukraine;*

[3]*Department of Physics, University of New Brunswick, NB, Fredericton, Canada; alex.koloskov@unb.ca*

[4]*Space Research Centre of Polish Academy of Sciences, Warsaw, Poland;*

[5]*O.Ya. Usikov Institute for Radiophysics and Electronics, National Academy of Sciences of Ukraine, Kharkiv, Ukraine;*

[6]*Research Center for Realizing Sustainable Societies, Chofugaoka, Chofu, Tokyo, Japan*

The continuous space physics observations at Ukrainian Antarctic Akademik Vernadsky station (UAS) (former Faraday station) lasting from the middle of the previous century created the most comprehensive and multi-parametric geospace database in Antarctica. Initially, the British Antarctic Survey supported meteorological observation, geomagnetic field registration, the ionosphere's vertical sounding, ozone content monitoring, and VLF measurements. After transferring to the jurisdiction of Ukraine in 1996, the cluster of electromagnetic

research instruments at UAS was significantly enhanced by adding portable digital ionosondes and GNSS-TEC receiver capable of observing ionospheric conditions around the station, intelligent HF Doppler receivers for investigation of ionospheric conditions at long\very long distances and ELF\VLF waveband magnetometers controlling lightning activity, electromagnetic pollution, and lower ionosphere worldwide. It is worth mentioning that HF and ELF instruments are a part of the global, national diagnostic network provided by real-time internet access. Lastly, improvement is commissioning the geospace measurements on board the new Ukrainian research vessel *Noosfera*, which allows multi-position observation in any place of the world ocean in synergy with the UAS cluster.

The state-of-the-art measuring equipment allows to formulate original scientific problems promising for geospace research at the UAS cluster: a) interaction of atmospheric and space weather systems; b) monitoring of worldwide thunderstorm activity as an indicator of global climate changes; c) overall VLF/ELF diagnostic of the lower ionosphere; d) monitoring of industrial influence on the electromagnetic climate of Earth. The presentation will describe in detail how these global geoscience problems will be investigated using the instrumentation installed at the station and on board the research vessel *Noosfer*a. Several options for cooperative activity with the international scientific community and possibilities of integrating Ukrainian data into world space weather services will also be discussed.

Further improving the quality, competitiveness, and information content of geospace observation requires upgrading the existing research facilities. The most effective investments will be discussed as well. They are as follows: a) implementation of a more powerful HF amplifier for digital ionosonde, which will allow efficient diagnostics of fast ionospheric processes and multi-position location of ionospheric processes at distances of 1000 km and more; b) commissioning of ELF sensors with the bandwidth up to 1 kHz, which will make it possible to perform unique ELF\VLF measurements of global thunderstorm activity and conditions of the lower ionosphere within the entire waveband 0.01–24000 Hz; c) installation of ultra-wide-band SDR-based receivers for monitoring long-range propagation of HF signals.

MULTIPOSITION ELF OBSERVATION OF LIGHTNING CAUSED BY THE TONGA VOLCANIC ERUPTION

***O. V. Koloskov*[1,2,3], *Y. M. Yampolski*[2], *O. V. Budanov*[2]**
[1]*Department of Physics, University of New Brunswick, NB, Fredericton, Canada; alex.koloskov@unb.ca*
[2]*Institute of Radio Astronomy, National Academy of Sciences of Ukraine, Kharkiv, Ukraine;*
[3]*State Institution National Antarctic Scientific Center, Ministry of Education. and Science of Ukraine, Kyiv, Ukraine*

Hunga Tonga event, which occurred on January 15, 2022, was the largest volcanic eruption ever accurately observed by modern instruments. It has generated various effects in the ocean, atmosphere and ionosphere. This study presents and discusses the significant amplification of lightning activity during the Tonga event. According to the data of a ground-based global lightning detection network GLD360 operated by Vaisala [https://graphics.reuters.com/TONGA-VOLCANO/LIGHTNING/zgpomjdbypd/], a maximum number of about 25 thousand strikes in 5 minutes was recorded during the eruption peak. It corresponds to 170% of total lightning occurring on average on Earth. Thus, the Tonga eruption initiated the most robust thunderstorm amplification ever detected. We studied the signatures of this effect in the ELF records. Our analysis demonstrated robust amplification of Schumann resonance (SR) signals formed by the global lightning activity and the growth of the number of individual ELF bursts generated by powerful lightning in the vicinity of Tonga. Our SR measurements performed simultaneously in Antarctica (Ukrainian Antarctic Akademik Vernadsky station (UAS)), Arctic (Svalbard, "Sousy" facility) and Ukraine (Radio Astronomy Observatory – RAO) detected firm peaks of the intensity of SR signals coinciding with the growth of a number of lightning discharges around Tonga detected by GLD360. The behaviour of spectral and polarization parameters is similar for all SR modes and observation sites despite differences in geographical locations and distances from the source to observers. Geolocation of transient events from Antarctic and Arctic sites demonstrates the huge amplification of the number of super-powerful lightning discharges within the eruption area. The ELF registrations have shown that:

1) During the peak activity, the number of ELF transients and variation of the intensity of the first SR mode matched well both with each other and in different hemispheres.

2) At the initial and relaxation phases, the intensity of the 1-st SR mode is in good agreement with the curve of the number of lightning strikes registered by GLD360.

3) The ELF data demonstrate the similarity in both hemispheres increase of the intensity of the 1-st SR mode (6.1 times in the peak of the event) and of the number of transients (12.6 times) in comparison with their typical values. To confirm that this result corresponds to a ~6 and ~12-fold increase in the total

intensity of thunderstorms and the number of powerful discharges, respectively more detailed comparison with external data (for example, GLD360) is required.

The multiposition ELF observations confirm the data of other diagnostic techniques that in the maximum phase of the event, the number of lightning in the vicinity of the epicentre significantly exceeded the total number of lightning over all other parts of the Earth. This effect can be used to refine models for the propagation of resonant ELF signals in the Earth-ionosphere cavity. Due to the high sensitivity of the measuring equipment and the absence of local interference in Antarctica, the refined models will further improve the methodology and results of thunderstorm activity monitoring on the entire planet from UAS.

CLIMATIC CHANGES IN THE IONOSPHERE OVER THE ANTARCTIC PENINSULA ACCORDING TO THE DATA OF LONG-TERM VERTICAL SOUNDING OF THE IONOSPHERE AT *AKADEMIK VERNADSKY* STATION.

***V. M. Lisachenko*[1], *A. V. Zalizovski*[1,2,3], *O. V. Koloskov*[1,2,4], *Y. M. Yampolski*[1], *S. B. Kashcheyev*[1], *B. Y. Gavrylyuk*[1,2], *A. O. Sopin*[1,2], *O. V. Budanov*[1], *A. S. Kashcheyev*[4]**

[1] *Institute of Radio Astronomy, National Academy of Sciences of Ukraine, Kharkiv, Ukraine;*

[2] *State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine;*

[3] *Space Research Center of the Polish Academy of Sciences, Warsaw, Poland;*

[4] *Department of Physics, University of New Brunswick, NB, Fredericton, Canada;* alex.koloskov@unb.ca

Vertical sounding of the ionosphere at *Faraday/Akademik Vernadsky* station has been conducted almost continuously since the end of the 1950-s. The Australian-made IPS-42 ionosonde has been operating since 1983. In 1996, ionospheric sounding was pointed in the Memorandum on the station transfer as one of the most important field of research that must be continued after the station transfer. Since 2017, a portable Doppler ionosonde developed and manufactured in collaboration between the Abdus Salam Centre for Theoretical Physics (ICTP, Italy) and Institute of Radio Astronomy of the National Academy of Sciences of Ukraine is operating at Ukrainian Antarctic *Akademik Vernadsky* station (UAS) [1] in conjunction with IPS-42 [2]. In 2022, a new antenna system in vicinity of VLF-hut and a passive position of the ionosonde were launched into operation at the UAS. It made possible to distinguish the O- and X- polarization modes in the signals reflected from the ionosphere. Also, the passive position of the ionosonde was successfully tested on board the research vessel *Noosfera* during her navigation in Drake Passage and along the Antarctic Peninsula in 2022.

Long-term ionospheric observations at the UAS allow us to analyze not only the dynamic variations in ionospheric parameters, but also the long-term, climatic

changes in the ionosphere over the Antarctic Peninsula. The current work aims to study the climate changes at the ionospheric heights, and their response to solar radiation and corpuscular activity. We will report the details of long-term changes in the ionosphere based on the data of vertical sounding at the UAS in different seasons for almost three solar cycles. The features of ionospheric climate changes will be demonstrated both within solar cycles and from cycle to cycle.

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THREE-POSITION MEASUREMENTS OF VLF ATMOSPHERICS: ONBOARD THE RESEARCH VESSEL *NOOSFERA*, AT VERNADSKY STATION AND AT AN OBSERVATORY IN UKRAINE

***A. V. Shvets*[1,2], *O. Bogomaz* [3,6], *O. V. Koloskov*[4,5,6], *A. A. Shvets*[2], *Yu. M. Yampolsky* [5], *Y. Hobara* [1,7,8], *M. Hayakawa*[9,10]**

[1]*Research Center for Realizing Sustainable Societies, The University of Electro-Communications (UEC), Chofu, Tokyo, Japan; shvets@ee.uec.ac.jp*

[2] *O.Ya. Usikov Institute for Radiophysics and Electronics, National Academy of Sciences of Ukraine, Kharkiv, Ukraine;*

[3] *Institute of Ionosphere, Kharkiv, Ukraine;*

[4] *University of New Brunswick, Fredericton, New Brunswick, Canada;*

[5] *Institute of Radio Astronomy, National Academy of Sciences of Ukraine, Kharkiv, Ukraine;*

[6] *State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine;*

[7] *Graduate School of Informatics and Engineering, UEC, Chofu, Tokyo, Japan;*

[8] *Center for Space Science and Radio Engineering, UEC, Chofu, Tokyo, Japan;*

[9] *Hayakawa Institute of Seismo Electromagnetics Co., Ltd. (Hi-SEM), UEC Alliance Center, Chofu, Tokyo, Japan;*

[10] *Advanced and Wireless Communications Research Centre, UEC, Chofu, Tokyo, Japan*

VLF receiving facilities were installed at Ukrainian Antarctic Akademik Vernadsky station in 2019 and at Radio Astronomy Observatory near Kharkiv, Ukraine in 2020 as a supplement of the ELF receivers to improve the accuracy of localization of ELF transient sources. They are also designed to monitor the lower ionosphere by measuring the tweek-atmospherics at night time. Similar VLF facility was installed later onboard the Ukrainian research vessel *Noosfera* and it

operated on the route from Odesa to Akademik Vernadsky station in January – March 2022. VLF receiving facilities measure the vertical electric and two orthogonal horizontal magnetic field components in the frequency range from 750 Hz to 24 kHz. Recording with a sampling frequency of 48 kHz of the three components of atmospherics begins when the signal from the omnidirectional electric antenna exceeds a predetermined threshold. Absolute time synchronization of the records was provided with the pulse-per-second (PPS) signal from GPS receivers. The duration of the recording depends on the time of day at the observation point and it is 60 ms at night and 7.5 ms during the daytime. The selected recording duration for night time ensures the registration of tweek-atmospherics. Two horizontal components of the Poynting vector, calculated from three field components, made it possible to unambiguously determine the direction to sources. Signals from radio stations operating in VLF range, GPS NMEA messages, and information from gyrocompass of the ship were additionally used to determine the direction to sources during the measurement campaign onboard the vessel *Noosfera*. We discuss the applicability of a configuration with these three globally spaced observation points for the localization of powerful lightning discharges. Time of arrival (TOA) and combined TOA and direction-finding methods were used, and the locating results were compared with data from the global lightning location network WWLLN. A modified technique was used to estimate the effective height of the lower ionosphere based on tweek-atmospheric analysis combined with lightning location results.

RF MEASUREMENTS ON BOARD THE UKRAINIAN RESEARCH VESSEL *NOOSFERA*

A. V. Zalizovski[1,2,3]***, Y. M. Yampolski*** [2]***, O. V. Koloskov***[1,2,4]***, S. B. Kashcheyev***[2]***, V. M. Lisachenko***[2]***, O. Shvets***[5]***, A. S. Kashcheyev***[4]***, O. V. Bogomaz***[1,6]

[1]*State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv; zalizovski@gmail.com*

[2]*Institute of Radio Astronomy, National Academy of Sciences of Ukraine, Kharkiv, Ukraine;*

[3]*Space Research Centre, Polish Academy of Sciences, Warsaw, Poland;*

[4]*Department of Physics, University of New Brunswick, Fredericton, Canada;*

[5]*O.Ya. Usikov Institute for Radiophysics and Electronics, National Academy of Sciences of Ukraine, Kharkiv, Ukraine;*

[6]*Institute of Ionosphere, NAS and MES of Ukraine, Kharkiv, Ukraine*

The former flagship of Britain's Royal Scientific Navy RRS James Clark Ross was bought in 2021 by Ukraine and renamed to *Noosfera* (http://uac.gov.ua/en/icebreaker-noosphere-en/). During her first voyage from Ukraine to Antarctica we carried out the RF measurements in various scientific fields. The installed equipment includes high frequency (HF) and very low frequency (VLF) receivers and corresponding antenna systems. HF instrument

identical to devices used in the ground-based network of Doppler HF receivers at the Ukrainian Antarctic *Akademik Vernadsky* station (UAS), on the Svalbard archipelago, in Ukraine and Africa was deployed on-board. Bistatic sounding of the ionosphere were carried out using signals of time service stations and special transmitters. The range of tasks to be addressed includes studies of the features of long-distance HF propagation, in particular, by scattering on plasma irregularities of various natures, as well as scattering of HF signals by the sea surface waves and to solve the radio-oceanographic problem. We also received the signals of Doppler ionosondes, which are currently operating in Ukraine and UAS [1], on board the ship. Simultaneous sounding of the ionosphere in vertical and oblique modes with varying distance between the ionospheric reflection points while the ship is moving was conducted.

The second line of measurements was the monitoring in VLF band of global lightning activity and the conditions of the lower ionosphere. Together with the already operating three-position (Ukraine-Antarctic-Arctic) ELF system, the land-ship VLF system will essentially complement a synchronous network for monitoring the global thunderstorm activity.

At the time of writing the abstract we plan to conduct the HF measurement (radio oceanographic, long distance propagation, and oblique ionospheric sounding) on the way of *Noosfera* from Punta-Arenas to UAS and back in March-April, 2023, correcting the shortcomings of the first measuring campaign of 2022. We will present the first results of marine RF measurements obtained during voyages of the *Noosfera* in 2022 and 2023.

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TWENTY YEARS OF ELF ELECTROMAGNETIC FIELD MONITORING IN ANTARCTICA AT VERNADSKY STATION (REVIEW)

Yu. M. Yampolski [1], ***O. V. Koloskov*** [1,2,3], ***O. V. Budanov*** [1], ***V. E. Korepanov*** [4]
[1] *Institute of Radio Astronomy, National Academy of Sciences of Ukraine, Kharkiv, Ukraine;*
[2] *State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine;*
[3] *Department of Physics, University of New Brunswick, Fredericton, NB, Canada;*
[4] *Lviv Centre of Institute for Space Research of NAS and SSA of Ukraine, Lviv;*
yampol@rian.kharkov.ua, yyampol46@gmail.com

The report presents the results of systematic twenty-year measurements of natural and industrial electromagnetic radiation in extremely low frequency (ELF) range at the Ukrainian Antarctic Akademik Vernadsky station (UAS). The ELF

waves propagate over long distances with low attenuation due to the channeling of energy in a spherical cavity between the Earth's surface and the low boundary of ionosphere which forms the global Schumann resonator (SR). The emissions in this range are mainly provided by two sources – natural and man-made. The natural source of these emissions is global lightning activity (GLA), the main three centers of which are located in the equatorial regions of Southeast Asia, Africa and America. The source of man-made emissions is the global network of powerful electric energy transmission lines (PTL) operating in the frequency range 50 (60) Hz. The Antarctic region, specifically the area close to Vernadsky station, where there are no local thunderstorms and any industrial activity, is an optimal place for monitoring of GLA and PTL radiations. Systematic continuous measurements of ELF fields were started at the UAS in 2002 using sensitive magnetometer system created in Ukraine. Then in 2013, similar system was installed in Spitsbergen archipelago. Since then, the two-position ELF interferometer has been operating in a synchronous mode in the polar regions of both hemispheres continuously. On-line access to Antarctic and Arctic database is provided via Internet.

For over twenty years the ELF research in Antarctica was carried out in cooperation with colleagues from the USA, Europe, and Asia. During this time, a number of fundamental and applied scientific problems have been formulated and solved. The main ones are listed below.

1. It was shown that the SR may be used as an indicator of periodic and sporadic solar activity. The responses of SR characteristics to regular variations in solar activity, such as the 11-year cycle, seasonal and diurnal changes in the illumination of the lower ionosphere in the northern and southern hemispheres have been established. The reaction of resonant fields to X-ray flashes, and precipitation of high-energy charged particles into the high-latitude atmosphere have been studied.

2. The two-position coherent Antarctica – Arctic system made it possible to locate super-powerful lightning discharges, to restore their spatial-temporal distribution at a planetary scale, and to detect an anomalous increase in lightning activity during powerful volcanic eruptions. Long-term monitoring of the intensity of the fundamental resonant mode made it possible to trace the relationship between thunderstorm activity and temperature behavior in Africa and Latin America.

3. Continuous observation of PTL radiation with frequency 60 Hz made it possible to study the inter-annual, seasonal, weekly (weekend effect) and diurnal variations in the production and consumption of electricity in North America. In addition to periodic regular variations in behaviour of PTL radiation, the sporadic blackouts of electricity have been identified in the US and Canada remotely. ELF radiations from the industrially developed regions of the northern hemisphere pollute the electromagnetic climate of the Earth even in ecologically clean areas such as Antarctica.

YEAR OF POLAR PREDICTION IN THE SOUTHERN HEMISPHERE AT VERNADSKY STATION: PRELIMINARY RESULTS ON CLOUD CHARACTERISTICS FROM THE RADIOSOUNDING MEASUREMENTS AND MODELLING

***A. Chyhareva*[1,2], *S. Krakovska* [1,2]**
[1]*Ukrainian Hydrometeorological Institute, State Service of Emergencies of Ukraine and National Academy of Sciences of Ukraine, Kyiv, Ukraine;*
[2]*State Institution National Antarctic Scientific Centre, Ministry of Education and Science of Ukraine, Kyiv, Ukraine; achyhareva@gmail.com*

Clouds remain to be the source of the high uncertainty in weather forecasting and climate models. The microphysical characteristics of clouds and precipitation are understudied due to a lack of *in-situ* measurements. This problem is especially essential in the Polar regions and Antarctica, particularly and requires broad cooperation and coordination among operators of polar stations. The Year of Polar Prediction in the Southern Hemisphere (YOPP-SH) under the World Meteorological Organization's (WMO) World Weather Research Programme (WWRP) and World Climate Research Program (WCRP) was one of such recent comprehensive international initiatives. It aimed to unite direct atmospheric measurement facilities of the majority of Antarctic stations to improve the weather forecast.

State Institution National Antarctic Scientific Center and Akademik Vernadsky station meteorological staff made a great effort for the YOPP-SH this year. During the Target observing periods (TOPs), 63 radiosondes were launched for the first time in 28 years of Vernadsky station history. It is over 10% of 609 total radiosondes over Antarctica launched at 16 Antarctic Stations actively involved in YOPP. There is a lot of additional data including on cloud and precipitation properties gathered due to the YOPP-SH initiative. Undoubtedly, their analysis will improve our understanding of polar clouds essentially.

This research focused on the high-intensity precipitation events in austral winter, TOPs, studied with the regional atmospheric model PolarWRF and the measurements at Vernadsky station. PolarWRF simulations were forced by ERA5 reanalysis over the domain centred over the Vernadsky station region with the 1-km resolution, and 10-minute temporal outputs were analysed. For the cloud microphysics parameterization, Morrison's and Thomson's double moment schemes were used and compared.

PolarWRF simulation outputs were compared to the measurements by the Micro Rain Radar-Pro and radisounding at Vernadsky station and were used to analyse the atmospheric profile of thermodynamic and microphysics characteristics over the Antarctic Peninsula mountains and Vernadsky station. Preliminary results retrieved from the PolarWRF model and verified with MRR-Pro and radiosounding measurements show the dynamic of cloud layers over the Antarctic Peninsula mountains and features of precipitation formation, like melting layer, over Vernadsky station.

SYNOPTIC CONDITIONS OF THE EXTREME PRECIPITATION RECORDS IN ANTARCTICA

***S. González-Herrero*[1,2,3], *F. Vasallo*[3], *J. Bech*[2,4], *I. Gorodetskaya*[5,6], *B. Elvira*[3], *A. Justel*[7]**

[1]*WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland; sergi.gonzalez@slf.ch*

[2]*Department of Applied Physics – Meteorology, University of Barcelona, Barcelona, Spain;*

[3]*Antarctic Group, Spanish Meteorological Agency (AEMET), Spain;*

[4]*Water Research Institute, University of Barcelona, Barcelona, Spain;*

[5]*Centre for Environmental and Marine Studies (CESAM), Department of Physics, University of Aveiro, Aveiro, Portugal;*

[6]*Interdisciplinary Centre of Marine and Environmental Research (CIIMAR), University of Porto, Matosinhos, Portugal;*

[7]*Department of Mathematics, Universidad Autónoma de Madrid, Madrid, Spain*

Extreme precipitation records (EPRs) occur when all atmospheric ingredients that produce precipitation are optimized. EPRs are well constrained in many regions in the world. However, this is not the case in Antarctica, where the limitations of the instrumentation for measuring solid precipitation and the reduced number of stations available prevent accurate measurements of the most extreme precipitation events in the continent. Here, we present a list of the EPRs for different durations estimated by the ERA5 reanalysis and the RACMO2 regional climate model (Gonzalez-Herrero et al. 2023). The EPR in ERA5 are 110 mm and 4267 mm for a day and a year duration, respectively. The analogue figures for RACMO2 are 279 mm and 7353 mm. Although they differ greatly in magnitude, both datasets present a similar power law scaling exponent, suggesting a coherence between datasets. All the EPRs in the continent are found in the Antarctic Peninsula, especifically in Loubet and south Graham Coasts, and in the north of Alexander Island, where orographic enhancement increases precipitation amounts. We present four case studies simulated by ERA5 for different durations to provide the synoptic atmospheric mechanisms that produce such extreme events. The common factors for the occurrence of extreme precipitation events in Antarctica are the low latitude region where all the events occur with steep orography and presence of atmospheric rivers impinging the mountains. However, some other factors, such as microphysical processes can also play an important role in some cases with less dynamic forcing. In longer durations, it is a climatological flow parallel to the Antarctic Peninsula and the succession of intense moisture advections which play a major role on achieving extreme precipitation.

References:

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HYDROLOGICAL STRUCTURE OF WATER AREAS ADJACENT TO AKADEMIK VERNADSKY STATION

***V. M. Komorin*[1,2], *Yu. I. Popov*[1], *Yu. M. Dikhanov*[1], *V. M. Bolshakov*[1], *A. V. Matveev*[2]**

[1]*Ukrainian Scientific Center of Ecology of the Sea, Ministry of Ecology and Natural Resources of Ukraine, Odesa;*

[2]*Odesa District of State Hydrography, Odesa, Ukraine; vkomorin@gmail.com*

Based on the data of complex ecological surveys in the interisland zone of the Argentine Islands (Wilhelm Archipelago), an analysis of the hydrophysical structure of the area's waters was made. The work was carried out in the period 2013-2022. Observational data from 1950 were also used, first at British Faraday station, and then at Ukrainian Antarctic Akademik Vernadsky station.

The main purpose of the work was to study the mechanisms of formation and transformation of water masses in the shelf zone of the Antarctic Peninsula under the influence of external atmospheric and internal hydrodynamic factors under conditions of significant climate change. As a result, an idea was obtained about the spatial and temporal variability of the oceanographic parameters of the waters of the water areas adjacent to the Akademik Vernadsky station. An analysis of the results of observations in the Penola Strait showed that the main feature of the summer vertical structure of the waters is its three-layer structure. The middle of the layers, the cold intermediate layer (CIL), separates the relatively warm, inversion in temperature and much more saline deep waters and the heated, freshened surface waters in summer conditions.

The sources of CIL water in the strait and further on the shelf are numerous outlet glaciers, including the Wiggings Glacier and the Eddington Bay Glacier – Bussay of the Antarctic Peninsula, which generate significant volumes of very cold and fresh water. The frequent recurrence of northeasterly winds, caused by active cyclonic activity off the western coast of the Antarctic Peninsula, contributes to the drift transfer of surface waters in southerly directions. In this case, in the deep and intermediate layers, a reverse, compensatory transfer can occur.

The volumetric TS analysis of the waters of Penola Strait and the waters located south of Margaret Bay, as well as the calculation of geostrophic water transfers in the strait, lead to the assumption of the northern transfer of intermediate-deep waters from the area of Margaret Bay to the deep layers of the relatively shallow Penola Strait. An analysis of average monthly January air temperatures since 1950 shows that during the first 50 years of this period there was a pronounced positive linear trend. Over the past 20 years, the sign of the air temperature trend has reversed. The level fluctuations show an annual variation with an amplitude of 10 cm. Diurnal and semidiurnal tides play a dominant role in the level fluctuations.

RAIN FRACTION OF PRECIPITATION DURING THE 21st CENTURY AS AN INDICATOR OF CLIMATE CHANGE IN THE ANTARCTIC PENINSULA REGION

***S. V. Krakovska*[1,2], *A. Yu. Chyhareva*[1,2]**

[1] *Ukrainian Hydrometeorological Institute, State Service of Emergencies of Ukraine and National Academy of Sciences of Ukraine, Kyiv, Ukraine; svitlanakrakovska@gmail.com*

[2] *State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine*

The Antarctic Peninsula region (AP) is affected by climate change, which is represented by one of the highest warming rates in the world and raising the possibilities of the melting of glaciers, shrinking of sea-ice cover, and collapsing of ice shelves. Such changes could dramatically impact the sensitive ecosystems of the region and beyond. Precipitation regime plays a crucial role in such regional climate change, particularly when a higher fraction of precipitation becomes liquid and occurs in events such as atmospheric rivers that bring warm moist air from sub-tropics. Thus, evaluation of the changes in liquid precipitation fraction according to RCP scenarios will help to elucidate the effects of possible climate change over the AP region in the 21st century.

In the presented work, we'll show assessed liquid precipitation properties under climate change over the AP region under the RCP4.5 and RCP8.5 scenarios using Polar-CORDEX (Coordinated Regional Downscaling Experiment – Arctic and Antarctic Domains) model outputs for the 21st century. This study extends our previous research on the temperature regime and wet/dry indices for the AP and focuses on the parameters that represent particularly liquid phase of precipitation in warmer future climate. We evaluated changes in rain fraction of total precipitation for the future periods 2041–2060 and 2081–2100, comparing them to the historical period of 1986–2005.

From the previous studies we know that all cloud amounts, liquid content in clouds, the annual precipitation and frequency of extreme precipitation events will increase over the AP by the end of the 21st century under both RCP scenarios. The quantitative characteristics of liquid precipitation and their fraction in the amount of yearly precipitation were obtained in addition and analysed. We have found that changes in rain fraction of precipitation have similar tendencies and patterns under the RCP4.5 and RCP8.5 scenarios, with more remarkable changes for the RCP8.5 scenario through the end of the 21st century. It is found that the annual liquid precipitation amount and liquid precipitation fraction will increase over the region. The most significant changes are expected for the west coast of AP and over the ocean to the west of AP, while the lowest changes are projected for the ridge of the AP mountains. However, the rates of expected changes vary within the broad AP region.

ON THE ROLE OF GEOPHYSICAL AND ATMOSPHERIC FACTORS IN THE CLIMATE OF THE WESTERN ANTARCTIC REGION

V. E. Tymofeyev, Ya. V. Kykhtenko
Ukrainian Hydrometeorological Institute of the State Emergency Service of Ukraine and National Academy of Sciences of Ukraine, Kyiv, Ukraine; tvvladys@gmail.com

Solar radiation reaching the Earth's atmosphere and surface is the main climate-forming factor that largely determines the conditions of our environment. The current state of the climate system is characterized by a slowdown in the phase of global warming, a decrease in solar activity, changes in the speed of rotation of the earth, against the background of increased activity of El Niño, changes in atmospheric circulation, which are identical in both hemispheres.

Earth's climate is determined by the combined action of external (geophysical) and internal factors (ocean-atmosphere). Incident Solar radiation controls a large number of important processes, such as evaporation, melting of snow and glaciers, photosynthesis of plants and the associated absorption of carbon, etc. The transformation of solar radiation occurs within the atmosphere, depending on the degree of its transparency. Variability of the atmospheric transparency depends on the weakening intensity of the solar radiation due to the degree of dustiness, moisture, influence of the underlying surface. Despite the great development of climate modeling, many aspects of natural climate-forming factors are still insufficiently studied.

One of them is surface incident solar radiation with coherent periods with a predominant decrease ("darkening") and increase ("brightening") of surface solar radiation, according to models of anthropogenic air pollution. The main lightening/darkening periods include booms (1930–1940s, the "early lightening"), recessions (1950s–1980s, the "darkening"), and the resumption of growth since the 1980s. Fluctuations in atmospheric transparency have significant effects on climate, and dimming have been masked greenhouse warming until the 1980s, when it gradually changed to brightening. Better transparency in the first half of the 20th century may have contributed to rapid surface warming during the 1930s and 1940s, so it may accelerate current warming.

Over the past hundred years, two phases of global surface air temperature increase have been registered – at the beginning of the 20th century and since the 1980s, a similar trend has been noted at the Antarctic Peninsula. The recent trend is associated with the activation of the warm phase of the El Niño phenomenon in the Pacific Ocean, the anomalies of recent years – with the super El Niño of 2016, after which the global temperature somewhat stabilized and cold episodes prevailed.

In a long-term plan, the greatest warming was observed at Akademik Vernadsky station until the mid-1990s, then the tendency to increase air temperature slowed down and a slight cooling has been observed until 2016, and the last years again showed a slight warming. Along with some decrease in the

amount of atmospheric precipitation and decrease in total cloudiness, there is an increase in solar radiation components, including ultraviolet. A particularly significant increase was noted for the duration of sunshine (DS) since the beginning of 2000, by 12% for the annual amount, and up to 21% in October-November, and a similar change in DS was characteristic for Eastern Europe as well as for Ukraine. Thus, one can expect continued melting of glaciers not only under conditions of summer warming, but direct influence of the sun

The analysis of atmospheric circulation during the period of modern warming includes the eastward expansion of the area of action of the main centers of atmospheric action, the displacement of cyclone trajectories southward in both hemispheres, the deepening of cyclonicity in the western Antarctic sector. As a result of the transformation in the barometric fields to the end of the 20th – beginning of the 21st century, an increasing influence of subtropical anticyclones, the Pacific and South Atlantic ridges is registered, which leads to an increase in the zonal flow intensity and, accordingly, the Antarctic Oscillation. This is also a manifestation of greater stability of atmospheric circulation processes over time, a change in the intensity of like-blocking events that, in turn, leads to an increase in direct sun hours and the intensity of direct solar radiation. Further, this may significantly affect Antarctic ecosystems, especially marine ones during the development of the spring ozone anomaly.

UMKEHR OZONE ALTITUDE PROFILES BEFORE AND DURING OZONE HOLE TIMES OVER FARADAY/VERNADSKY ANTARCTIC STATION

***Y. Andrienko*[1], *G. Milinevsky*[1,2,3], *J. Shanklin*[4], *A. Grytsai*[1], *O. Evtushevsky*[1], *Y. Shi*[3], *O. Ivaniha*[2]**

[1]*Physics Faculty, Taras Shevchenko National University of Kyiv, Kyiv, Ukraine; andrienko.j@gmail.com*

[2]*State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine;*

[3]*College of Physics, ICFS, Jilin University, Changchun, China;*

[4]*British Antarctic Survey, Cambridge, United Kingdom;*

Since the mid-70s of the last century, the total ozone column and the vertical ozone distribution have been measured at the Faraday/Vernadsky Antarctic station. Ozone observations have been provided using the Dobson spectrophotometer. During the analyzed period, three spectrophotometers measured ozone parameters at the station. From 1973 to 1984, Dobson 073 and from 1984 to 1996, Dobson 031 were used at Faraday station. After the transfer of Faraday station to Ukraine in 1996, till 2005, spectrophotometer Dobson 031 operated at Vernadsky station, replaced by Dobson 123 in 2005. The results of a unique series of available Umkehr ozone observations since 1973 and the corresponding calibration tables for each spectrophotometer allow retrieving profiles of the vertical distribution of

ozone over the Faraday/Vernadsky station in the years of the ozone hole formation over Antarctica. The ozone hole was observed in September- October when the total ozone column values decreased to less than 220 Dobson Units (DU).

We created Umkehr ozone profiles for 1973–2009 and investigated variations in the vertical ozone distribution in September–October. The shape and value of the profiles and total ozone column are different before and after the occurrence of the ozone hole. In 1973–1980, the profiles of the vertical ozone distribution had a narrow maximum with values of partial ozone column in the range of 70–110 DU/layer. The maximum ozone concentration is located at 16–20 km altitude. In profiles built in 1985–2009, the partial ozone column values at the maximum are much lower ~60 DU/layer in ozone hole conditions. The profiles have two maxima: a smaller one at an altitude of up to 10 km with a partial ozone column value of about 20 DU/layer and a larger one at the height of ~ 25 km with values of about 30 DU/layer and a significant minimum observed at an altitude of about 16 km with values ~10 DU/layer. A partial ozone column increases to 60–80 DU/layer when the ozone hole edge is dynamically displaced relative to the station, and a high ozone amount accumulated outside the ozone hole is observed. The profiles without depletion were retrieved when the edge of the ozone hole was located out of the station. The assimilated plots of the ozone distribution from the TEMIS website (https://www.temis.nl/protocols/O3global.php) confirm the presence of an ozone hole over the station for the dates with "double maxima" observed.

We thank all British and Ukrainian winterers who provided Dobson Umkehr ozone measurements for years at Faraday/Vernadsky station.

THE ROSSBY WAVE 2000–2021 CLIMATOLOGY IN THE ARCTIC DURING SUDDEN STRATOSPHERIC WARMINGS

Y. Shi [1], O. Ivaniha [2], G. Milinevsky [1,2,3], O. Evtushevsky [3], A. Grytsai [3], W. Han [1], A. Klekociuk[4,5], Y. Wang [6], X. Wang [7]

[1]International Center of Future Science, College of Physics, Jilin University, Changchun, China;
[2]State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine;
[3]Physics Faculty, Taras Shevchenko National University of Kyiv, Kyiv, Ukraine;
[4]Antarctic Climate Program, Australian Antarctic Division, Kingston, Australia;
[5]Department of Physics, University of Adelaide, Adelaide, Australia;
[6] Chang Guang Satellite Technology Co., Changchun, China;
[7] College of Electronics, Jilin University, Changchun, China;
genmilinevsky@gmail.com

The main components of planetary waves (PW) with wavenumbers 1 and 2 at the middle and polar latitudes, still need to be better understood in terms of their temporal-spatial-altitude evolution. The planetary wave parameters were retrieved

to identify long-term changes and evaluate possible trends in PW characteristics. The PW (or Rossby waves) parameters are examined by considering variations in the geopotential height Z field in the stratosphere and mesosphere. Z data fields were reviewed from December to April in the 2000–2021 period at pressure levels of 100, 10, and 1 hPa (altitudes ~15, 30, and 45 km) and latitudes of 0–90°N. We used the Microwave Limb Sounder (MLS) data on-board the Aura satellite and the MERRA-2 reanalysis. The PW amplitude from Z was obtained using the Fourier transform. The most significant wave-1 amplitude is observed in the latitude range 50–80°N and at a pressure level of 10 hPa. From December to March, the latitudinal position of the maximum wave-1 amplitude shifts to the pole, reducing the size of the stratospheric polar vortex. The maximum wave-2 amplitude is located in the latitudinal band 50–75°N. The most prominent trend towards the pole is more clearly seen for wave-1, while this displacement is much smaller for wave-2 at 10 hPa. According to the 2000–2021 climatology, two peaks of planetary wave-1 activity in the winter and spring are observed at the end of December – beginning of January and at the end of January – mid-February, respectively. Note that the maximum wave-2 activity is recorded in the interval between the two peaks of wave-1 activity and occurs in mid-January. The amplitudes of waves-1 and -2 anticorrelate during their evolution, as evidenced by the maxima and minima locations. For consecutive winters of 2018–2021, a cross-correlation was calculated at several altitudes with positive values r = 0.4–0.8, significant at the 95% level, when wave-1 lags wave-2 by at least 2–5 days. The altitude transition from a negative (in the stratosphere) to a positive (in the mesosphere) correlation between the waves-1 and -2 amplitudes is revealed. The penetration of planetary waves from the troposphere into the stratosphere causes the perturbation of the polar vortex, shifting it relative to the pole and deforming it. The increase in PW activity can lead to a sudden stratospheric warming (SSW) event. Therefore, long-term wave amplitude changes can influence the polar vortex, as well as the frequency occurrence and dynamic characteristics of the SSW events.

TEMPERATURE TRENDS FOR HIGH-LATITUDE REGIONS OF EUROPE AND ANTARCTICA

A. V. Paznukhov*, *Yu. M. Yampolsky
Institute of Radio Astronomy, National Academy of Sciences of Ukraine, Kharkiv, Ukraine; paznukhov@rian.kharkov.ua

For more than a century, there has been an increase in the average air temperature above the Earth's surface, which has accelerated sharply in recent decades. This phenomenon is known as global warming. Temperature changes vary in different parts of the world. The Arctic is warming at twice the global average and temperatures are highly variable.

In this paper, it was analyzed a large series of air temperatures from 2002 to 2015. This data is provided by the World Meteorological Organization (WMO) and the National Climatic Data Center (NCDC), which provide daily updates from more than 10,000 ground weather stations around the world. To estimate the regional values of the average daily temperature, the entire globe was divided by us into identical cells with equal angular dimensions of 10 degrees in latitude and longitude. Then, depending on the coordinates of each weather station, they were associated with the corresponding cells. Further, the average daily temperatures at all stations that are included in one cell were averaged and, thus, the average temperature of the regional cell was estimated. Further analysis was performed using these daily averages. This method of estimating temperature trends was successfully used by us earlier to compare the behavior of continental temperatures with annual variations in thunderstorm activity in Africa and Latin America (http://rpra-journal.org.ua/index.php/ra/article/view/1268).

The temperature in Scandinavia is compared with other regions which lie at the same latitude, as well as in the more northern regions of the Arctic. It was found that the long-term course of temperatures in Scandinavia does not differ from the course in the entire range of latitudes from 60 to 70 degrees north latitude. There is no warming trend in this range, but it is clearly visible in the more northern regions of the Arctic. A comparison was also made with the territories lying at the same latitudes in the southern hemisphere. It was found that in Antarctica the situation is the opposite, the most noticeable warming is observed in the range from 60 to 70 degrees south latitude, and as it approaches the pole, it weakens. Near the South Pole, on the contrary, a cooling trend is observed.

A search was made for the weekend effect in the air temperature in the Scandinavian region. Weekly variations were found, the maximum air temperature is observed at the end of the weekend and at the beginning of the working week.

TRANSFORMATION OF THE INTERNAL SOLITARY WAVES BENEATH RIDGED ICE

K. Terletska*, *V. Maderich
The Institute of Mathematical Machines and Systems Problems, National Academy of Sciences of Ukraine, Kyiv, Ukraine; kterletska@gmail.com

The motivation for this study is the rapid decrease of sea ice, which has been observed in the Arctic in the last few decades. This resulted in enhanced turbulent mixing and melting ice cover. Internal wave-driven mixing is an important factor in the balance of heat and salt fluxes in the Polar Ocean. Internal gravity waves are generated by various sources, including tidal currents over the bottom topography varying in time wind, vortices, and lee waves. Another source of energy for internal waves in the near-surface pycnocline can be an interaction of ice keels with tides. These waves, in the form of internal solitary wave (ISW) chains, often propagate in pycnocline in a stratified ocean under ice cover. The interaction

between internal waves and ice cover is complex and depends on both the characteristics of the ice and the characteristics of internal waves. ISW shear, convective instabilities, and breaking on topographic inhomogeneities extract kinetic energy from ISWs for turbulence and subsequent mixing that result in increasing the melting of ice. The relief of the underside of the ice and, in particular, the presence of ice keels can essentially affect the ISW transformation, breaking, and energy dissipation. The using non-hydrostatic numerical modeling is a useful tool to study processes of internal solitary wave propagation under polar ice and interaction with the system of the ice keels. It was shown, that during the interaction with smooth ice cover, maximum energy loss could reach about 60% near the ice shelf edge resulting in accelerated melting of the ice. It was suggested that the blocking parameter B (ratio of the upper layer beneath the ice to internal wave amplitude) controls the transfer of energy across the shelf ice edge, that is, more energy is reflected if the ratio increases. When the ice depth decreased, the ice-ISW interaction and resultant dissipation weakened. This decrease also affected the disintegration of ISWs; the transmitted leading waves gradually became dominant, and less energy was dissipated locally. The influence of geometry and location of ice keels on ISW transformation was considered. It was found that the more frequent keel system (with the distance between the keel less than the wavelength) destroys the ISWs faster. The ice cover draft, ISW amplitude and length, keel height and slope, and distance between keels were responsible for the evolution and disintegration of an ISW beneath the ice cover while the boundary friction beneath the ice cover had little effect. The results of the present research could be important in the understanding of ISW impacting the energy transfer and heat balance in the Arctic Ocean.

DIFFERENCES AND SIMILARITIES IN LOCAL TEMPERATURES AT A MICROSCALE IN THE MARITIME ANTARCTICA

***M. Savenets*[1], *L. Pysarenko*[1], *S. Krakovska*[1,2], *D. Pishniak*[2], *A. Yevchun*[2,3], *I. Parnikoza*[2,4]**

[1] *Ukrainian Hydrometeorological Institute, State Emergency Service of Ukraine and National Academy of Sciences of Ukraine, Kyiv, Ukraine; savenets@uhmi.org.ua*

[2] *State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine;*

[3] *National University of Kyiv-Mohyla Academy, Ministry of Education and Science of Ukraine, Kyiv, Ukraine;*

[4] *Institute of Molecular Biology and Genetics, National Academy of Sciences of Ukraine, Kyiv, Ukraine*

Despite its harsh environment, Antarctica is home to terrestrial organisms that developed adaptive mechanisms for unfavorable conditions, and flora species are among them. From the perspective of climatology, these areas arouse interest

as they form a rather unique microclimatological regime allowing local flora to withstand negative weather impacts. Understanding of microclimate in Antarctica is important for assessing the impacts of climate change on local biota. It may also improve our knowledge about interconnections between meteorological processes at different spatial scales, which is valuable for weather modeling. This study discusses the main differences and similarities in local temperatures at a microscale recorded near native plants in the maritime Antarctic.

The study was carried out using measurements of local temperature (LT) on the surface (substrate) near local plants (37 temperature loggers) in the Argentine Islands – Kyiv Peninsula region over the period 2019–2020. These areas were classified by their type of location and horizon obstruction. The following groups were defined among the location types: rock slopes, rock terraces, rock ledges, and others; while area by horizon obstruction was divided into flat open areas, rocky areas, and protected areas mainly by relief microforms.

Depending on the season, all LT near the ground were on average 2–7 °C warmer than the surrounding air. Intra-annual LT variability was well detected and replicated air temperature changes. This variability was better observed on rock terraces and open areas. In contrast, LT on rock ledges, in clefts, and other protected areas had less significant intra-annual variations and more inertial in a daily scale. LT strongly correlated with standard air temperature measurements on rock slopes. The significant correlation in these areas did not disappear during the cold season, which typically indicated less snow cover. Wind influences were typically more significant on rock ledges. The sunshine duration had a greater impact on north-exposed rock ledges. These areas showed higher reliance on direct radiation heating.

This study presents the main differences and similarities in LT on a micro-scale that influence native vascular plants in the maritime Antarctic. Our results show the benefits of microclimatological measurements for meteorological and biological research and the possibilities of finding indicative processes for studying climate change in polar regions.

LARGE-AREA OZONE HOLES OVER ANTARCTICA IN THE LAST THREE YEARS: MORPHOLOGY AND POSSIBLE CAUSES

***A. Grytsai*[1], *G. Milinevsky*[1,2,3], *O. Ivaniha*[2]**

[1]*Physics Faculty, Taras Shevchenko National University of Kyiv, Kyiv, Ukraine; asengrytsai@knu.ua*

[2]*State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine;*

[3]*College of Physics, ICFS, Jilin University, Changchun, China*

The state of the ozone hole is dependent on various factors of both chemical and dynamical origin. After the ozone hole strengthening during the late 1990s – early 2000s, its parameters levelled off, but interannual changes have remained

significant. In particular, sudden stratospheric warmings influenced the stratospheric polar vortex with increase in total ozone column (TOC) in 1988, 2002, 2017 and 2019 in austral spring. These phenomena are caused by the activity of planetary waves propagating from the troposphere to the stratosphere. Nevertheless, large ozone losses were observed in the three consecutive austral springs, in September–November of 2020, 2021 and 2022. These years were characterized by low total ozone column inside the polar vortex, large ozone hole area and its long existence. For example, TOC minimum values over Antarctica in early October of 2020–2022 were slightly below 100 Dobson Units. The maximum ozone hole area during the mentioned springs was close to 25 million km^2 in comparison with 16 million km^2 in 2019.

Total ozone column is measured by both satellite and ground-based methods. Satellite observations allow obtaining almost global coverage, which is necessary for calculation of the ozone distribution integral characteristics including parameters of the ozone hole. Ground-based observations are useful to determine TOC time variations. We have considered the multi-year ozone hole metrics and data of satellite measurements (TOMS/Nimbus-7, TOMS / Earth Probe, OMI/Aura) from https://ozonewatch.gsfc.nasa.gov/ as well as results of TOC measurements at Vernadsky station.

We have analyzed planetary wave parameters obtained from TOC observations. The moderate and high latitudes of the Southern Hemisphere have been considered. We compare total disturbance and quasi-stationary wave in the years with small and large ozone hole. Spatial and time features of the TOC distributions are studied. Besides dynamical factors, natural and anthropogenic impacts on the stratosphere are important. One of them is volcanic activity, and the Hunga Tonga – Hunga Ha‘apai explosive eruption in January 2022 resulted in the appearance of a volcanic plume reaching the stratosphere. Taking into account this event, we pay an attention to the comparison between the ozone hole development in 2022 and during the two previous springs.

COMPARISON OF THE DYNAMICS AND MANIFESTATION OF THE WEEKEND EFFECT OF ATMOSPHERIC AEROSOLS IN INDUSTRIALLY DEVELOPED REGIONS AND IN THE ANTARCTIC

***A. V. Soina*[1], *Yu. M. Yampolski*[1], *G. P. Milinevsky*[2,3], *A. V. Zalizovski*[1,4,5]**
[1]*Institute of Radio Astronomy, National Academy of Sciences of Ukraine, Kharkiv, Ukraine; adituanna@gmail.com*
[2] *Taras Shevchenko National University of Kyiv, Kyiv, Ukraine;*
[3] *Main Astronomical Observatory National Academy of Sciences of Ukraine, Kyiv, Ukraine;*
[4] *State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine;*
[5] *Space Research Centre of Polish Academy of Sciences, Warsaw, Poland*

Atmospheric aerosols significantly affect the condition of the lower layers of the atmosphere [1]. In connection with the intensive development of industry and the increase of anthropogenic load on the geosphere, the number of artificial aerosols has increased significantly, leading to various manifestations of a local and global nature. The occurrence of a seven-day cycle, especially in aerosol parameters, is a consequence of human activity and can be an indicator of anthropogenic influence, even in regions that have the status of national and international reserves and are free from industrial activity. The search for the phenomenon of the weekend effect in the behavior of aerosols was conducted by various authors, including the authors of this paper [2–4]. Our research aims to further analyze in more detail the seven-day periodicity in aerosol parameters in the Antarctic compared with the planet's industrially developed regions. The work uses observation data from the international monitoring sunphotometers the AERONET network stations in Antarctica, Europe, and North America for the 2009–2021 time interval. Thirteen-year set of data was subject to processing: aerosol optical thickness (AOT) measured in two spectral channels of 440 and 870 nm; Angstrom exponent calculated from these two wavelengths; and data on the content of deposited water vapor based on calculations in the 936 and 870 nm sun photometer spectral channels. The "method of superimposing epochs" was chosen for the data processing. This choice was made because the effective functioning of the photometers is possible only during the daytime and the obtained time series of observations are discrete. A time series of observations is divided into seven-day intervals. Then the arithmetic mean values of the measurement data and root mean square deviation (MSD) are calculated for each day of the week, and the dependencies of the selected parameters are plotted. Statistical processing was performed using the Grapher 8 program (http://www.goldensoftware.com/products/grapher). As a result of data processing, the seven-day cycle in the concentration of suspended particle variations in the Antarctic region is not detected in contrast to the industrialized regions.

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THE STUDY OF THE ROLE OF THE ELECTRIC PHENOMENA IN THE INITIATION OF THE FREE-RADICAL REACTION OF TOLUENE BROMINATION AT THE SNOW/AIR INTERFACE

K. Yu. Tkachenko*, *D. V. Oranskii*, *S. G. Shcheholiev
Institute of Geological Sciences, National Academy of Sciences of Ukraine, Kyiv, Ukraine; tkachenko.katya@gmail.com

Changes in the chemical composition of snow under the influence of wind have been documented by many authors. Some poorly understood microphysical processes become most intensive both during blizzards, as well as during the metamorphism of fresh snow, but the mechanisms of free radical reactions responsible for these changes and what factors are critically important are still not clear and are still debated. According to the authors' concept, the electrification of snow is not considered yet but it can be critically important factor influence of which is determined by whether or not the threshold value of corona discharge can be achieved at the snow-air interface to form active species that can act as the seeds of free-radical processes.

Electrification of the phase boundary of ice crystals is studied intensively by specialists in atmospheric electricity. Some of mechanisms that lead to electrification in ice particles in clouds can be also relevant on the Earth's surface. The front of growing ice crystal becomes positively charged during its growth, and negatively charged during sublimation. The detached fragment of growing ice crystal is charged also. Cracking, collision and friction of ice crystals also create high gradients of the electric field, but these hotspots occur in a fraction of a second and quickly dissipate.

According to the literature data, maximum electrification level can be achieved as result of combined effect of different factors mentioned above. But it is necessary to consider that high levels of energy are concentrated rather pointwise. Appearance of these microscopic "points of flame" in a cold icy substance can lead to formation of active species.

We conducted the laboratory experiment with the aim to verify this hypothesis. Our first task was to use such experimental conditions under which electrification of ice crystals can occur under the influence of several factors at once, such as: intense friction (tribochemical processes), cracking, condensation growth sublimation processes (metamorphism). Since the energy sufficient for the formation of a free radical occurs pointwise in a fraction of a second, the quantity of product of free radical reaction is too low, and it can be a problem to detect them, so the second task was to choose an appropriate free radical reaction that would allow us to "catch" the effect. In this case the first radicals become a "seed" that initiate the development of free radical processes, and subsequent reactions multiply the amount of the resulting product, so it can be seen by the chromatographic method. Well known "bromine explosions", which destroy tropospheric ozone in the polar marine zone in the spring, go by similar scenario.

We focused on the reaction of the interaction of toluene with bromine. This reaction can proceed by two ways: as an electrophilic substitution into the ring, or as a free-radical substitution of a hydrogen atom in the side chain (CH_3 group).

Experiments were conducted using refrigeration equipment (cryostats) and artificial snow (ice). Ice crystals were electrified and recrystallized as a result of tribochemical processes. We have shown that control of the factors that stimulate the electrification of ice makes gives possiblity to control the initiation and direction of the chemical reaction on ice surface. It has been shown that the presence of ice directs the reaction of bromination of toluene by a free-radical pathway with the formation of benzyl bromide. If there is no ice, the reaction proceeds "traditionally" with bromination into the benzoic ring. Stirring of ice and electric field influence increases the yield of the reaction.

ARCTIC AND ANTARCTIC PARALLEL FIELD EXPERIMENT TO CHECK THE ROLE OF ELECTRIC PHENOMENA IN SNOW-AIR INTERACTIONS

K. Tkachenko [1]***, D. Pishniak*** [2]***, S. Razumnyi*** [2]***, H.-W. Jacobi*** [3]
[1]*Institute of Geological Sciences, National Academy of Sciences of Ukraine, Kyiv, Ukraine;*
[2]*State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine; tkachenko.katya@gmail.com*
[3]*Institute for Geosciences and Environmental Research (IGE), Université Grenoble Alpes / CNRS / Grenoble INP / INRAE / IRD, France*

Polar near-surface snow can act as a chemical reactor that alters the composition and chemistry of snow and the overlying air. But mechanisms and driving forces of these reactions are still debated, because existing models cannot explain all field data. The role of electrical phenomena, well studied by physicists and meteorologists, has not yet been taken into account in snow chemistry. Electric phenomena arise as a result of the combined effect of various meteorological factors, cosmic influences and microphysical processes, but the most visible of their manifestation is the increase of the electric field as a result of electrification during blizzards. It has been shown already that strong winds and blizzards lead to charging of snow particles. At the same time, other studies have shown the possibility of changes in the ionic composition of snow under the influence of strong winds. The aim of present work is to check by field experiment if there is any relation between these processes.

Field experiment includes the collection of differently charged fractions of snow during blowing snow events for their subsequent analysis by means of ion chromatography.

To achieve this goal, the following tasks must be accomplished: 1) design of special instrument for separation of charged snow fractions; 2) installation of the instrument in the field and sampling methodology development, 3) year-round collection of snow samples during blowing snow events; 4) transport of samples and their analysis.

The special instrument for separation of blizzard snow into positively and negatively charged fractions has been designed. The instrument contains a box like housing with plane negative and positive electrodes inside and an opening on the front side. Snow particles charged during blizzards enter the instrument through the front opening and supposed to be attracted by charged electrodes. Positively charged snow will be collected by negatively charged electrode, and vice versa. Electrodes are powered due to voltage converter (converts 5 V to 7.3 kV) that is situated on the cover of the instrument. The trap can rotate due to bearing, so it stays all the time along the wind because of an attached tail.

Installation of the instrument in the field have been conducted parallel at two location. First one is Akademik Vernadsky station (West Antarctica), and second one is AWIPEV station (Ny-Alesund, Svalbard, Arctic). Year-round collection is

over at Akademik Vernadsky station (samples have been collected during 11 blowing snow events). AWIPEV experiment is in progress. The analyses of all samples is supposed to be conducted in the Institute of Geoscience of Environment, university of Grenoble Alp, France.

ON THE STATE OF THE OCEAN-ATMOSPHERE SYSTEM AND REGIONAL CLIMATE CHANGE AT THE ANTARCTIC PENINSULA

V. E. Tymofeyev, S. V. Klok
Ukrainian Hydrometeorological Institute of the State Emergency Service of Ukraine and National Academy of Sciences of Ukraine, Kyiv, Ukraine; tvvladys@gmail.com

Regional climate the Antarctic Peninsula (AP) can be quite simply explained by the State of the Ocean-Atmosphere interaction, with the most important El Nino-Southern Oscillation (ENSO), which generates low-frequency variability and can be used for the long-range weather forecasts. Greater Austral Ocean determine strong eastward air flows which oscillate in phase with the ENSO intensity and form the general circumpolarity of air motions in the atmosphere and ocean.

Regional modifications are also well-known; The climate of Graham Land is characterized as temperate (with regard to Antarctic), with features of mild maritime in summer months, and predominantly moderate winds and cloudy and wet weather and precipitation due to a series of cyclones intensifying at windward slopes. Uneven topography of the Antarctic Peninsula is responsible for the formation of regional climates and meridional climatic front between the western (warmer) and eastern (colder with glaciers) coasts of the AP. An increase in the near-surface air temperature has been peaked at the western coast of AP and Akademik Vernadsky station in 1986–2005, during the warm ENSO phase. The recent warming period is characterized by intensified westerlies and prevailing cyclogenesis in the Bellingshausen Sea

In the centenary course of ENSO, several regime shifts (changes in the trend sign) have been registered, followed by global changes. As a result of this shift in mid-1970s, warm episodes El Nino predominates, and the period of accelerated warming actually began. Then the influence of El Niño expanded in all regions of Earth, and especially in western Antarctica. A new shift towards cold episodes La Nina occurred in 2005–2006, and then a period of instabilities and fluctuations in weather conditions began (in the west Antarctica and Ukraine as well), in 2016 -a super-warm El Niño was registered, and a uniquely stable La Niña is kept for 3 consecutive years. Correspondingly Significant inter-annual weather fluctuations were observed in the western sector of Antarctica, including Vernadsky station, 2015 was the coldest in the last 30 years, and 2022 was the warmest. A record warm 2022 year showed some different atmospheric circulation pattern, with typical cyclones in the Bellingshausen Sea but the simultaneous intensifying anticyclones in the western sector of the Antarctic, during most seasons (October–

April), although in the peak of the winter (June–September), cyclogenesis prevails anyway. If early The El Niño warm phase was responsible for the increase in anticyclogenesis and synoptic blocking in the Pacific extratropics, causing colder years on the AP, a particularly large blocking intensification is observed in the last decade at the South Atlantic sector.

It is shown how the large-scale atmospheric circulation in the West Antarctic sector varies depending on the ENSO episode; the ENSO signal is traced to the lower stratosphere. Atmosphere and ocean teleconnections as well as transitions between scales, from synoptic to regional.

Some preliminary Conclusions are made on influence the ENSO and Ozone anomaly – Colder episodes La Nina suggest a longer period of ozone hole and Circumpolar vortex (CPV) persistence; On the background El-Nino – weakened ozone hole and early filling of the vortex. Significant variability detected in recent years indicates an uneven process of ozone replenishment, accompanying by large fluctuations in the leading indices. Some peculiarities in the CPV shape during the recent decades have been the noted, with division of CPV into several centers and/or displacement to the east Antarctic sector, especially close to the end of ozone anomaly; The recent strong anomaly in 2020–2021 season persisted until December on the background of the late CPV filling-in. Circumpolar circulation has been found strengthened during the development of the seasonal ozone hole; currently it shows no further deepening. Role of the earth´s rotation as an external climate-making factor is also shown. Despite on the some interannual variability, current regional weather and climate is more stable than in colder epoch in the mid-20th century, however, it is under great influence of the ocean expecting new shifts.

CASE STUDY OF THE EXTRAORDINARY MARCH 2022 EAST ANTARCTIC HEAT WAVE

J. Wille, and The East Antarctic Heatwave Team
ETH Zürich, Institute for Atmospheric and Climate Science, Zürich, Switzerland; jonathan.wille@env.ethz.ch

Between March 15–19th 2022, East Antarctica experienced an unprecedented heatwave with widespread 30–45° C temperature anomalies across the ice sheet. This record-shattering event saw numerous monthly temperature records being broken including a new all-time temperature record of −9.4 °C on March 18th at Concordia station despite March typically being a transition month to the Antarctic coreless winter. The driver for these temperature extremes was an unprecedently intense atmospheric river (AR) advecting heat and moisture deep into the Antarctic interior. The scope of the temperature records spurred a large, diverse collaborative effort to study the heatwave's meteorological drivers, impacts, and historical climate context using an array of observations, models, and analysis techniques.

From these efforts, we present the following

- Temperature observations and records
- Meteorological drivers including tropically forced Rossby wave activity along with AR and warm conveyor belt dynamics
- Radiative forcing impacts on surface temperatures and inversions
- Surface mass balance impacts
- Discussion of the AR impacts on isotope and cosmic ray measurements from Concordia station
- AR influence on the Conger Ice Shelf disintegration
- Event return time analysis
- Implications on past climate reconstructions
- Future event likelihood from IPSL-CM6 simulations

AN EXTRAORDINARY DEEP SYNOPTIC-SCALE CYCLONE AFFECTED THE BELLINGSHAUSEN SEA SECTOR, WEST OF THE ANTARCTIC PENINSULA

***J. F. Carrasco*[1], *R. R. Cordero*[2]**

[1]*Gaia Antarctic Research Center, Universidad de Magallanes, Punta Arenas, Chile; Jorge.carrasco@umag.cl*

[2]*Universidad de Santiago, Estación Central, Santiago, Chile*

An extremely strong synoptic-scale extratropical cyclone reached a minimum sea-level pressure of 902 hPa around 3–6 UTC on 17 October 2022. The satellite images and the high-resolution numerical model (Antarctic Mesoscale Prediction System: AMPS) resolved a low frontal system that developed over the southwestern Pacific Ocean and moved towards the Bellingshausen-Amundsen Seas region, where it weakened. The initial low-pressure center was 961 hPa at 21 UTC on 16 October; this reveals a rapid deepening of about 2 hPa h^{-1}, in other words, explosive cyclogenesis southern of 60ºS near Antarctica. The AMPS resolved wind speed of 30–34 m s^{-1} (110–125 km h^{-1}) around the low pressure and even 35 m s^{-1} (126 km h^{-1}) on the northeast coast of the Antarctic Peninsula. The near-surface air temperature increased during this event, as registered by the weather stations deployed in the Antarctic Peninsula. The near-surface northernly (southernly) winds that prevailed eastward (westward) from the pressure center favored the retreat (advance) of the sea-ice formation in the Bellingshausen Sea (Amundsen Sea).

CHARACTERISTICS OF SURFACE "MELT POTENTIAL" OVER ANTARCTIC ICE SHELVES BASED ON REGIONAL ATMOSPHERIC MODEL SIMULATIONS OF SUMMER AIR TEMPERATURE EXTREMES FROM 1979/80 TO 2018/19

A. Orr[1]; P. Deb[2], K. R. Clem[3], E. Gilbert[1], D. H. Bromwich[4], F. Boberg[5], S. Colwell[1], N. Hansen[5, 6], M. A. Lazzara[7,8], P. A. Mooney[9], R. Mottram[5], M. Niwano[10], T. Phillips[1], D. Pishniak[11], C. H. Reijmer[12], W. Jan van de Berg[12], S. Webster[13], X. Zou[4,14]

[1]*British Antarctic Survey, Cambridge, UK; anmcr@bas.ac.uk*
[2]*Indian Institute of Technology, Kharagpur, India;*
[3]*Victoria University of Wellington, Wellington, New Zealand;*
[4]*Byrd Polar and Climate Research Center, The Ohio State University, Columbus, USA;*
[5]*Danish Meteorological Institute, Copenhagen, Denmark;*
[6]*Geodesy and Earth Observation, DTU-Space, Technical University of Denmark, Lyngby, Denmark;*
[7]*University of Wisconsin-Madison, Madison, USA;*
[8]*Madison Area Technical College, Madison, USA;*
[9]*NORCE Norwegian Research Centre, Bjerknes Centre for Climate Research, Bergen, Norway;*
[10]*Meteorological Research Institute, Japan Meteorological Agency, Tsukuba, Japan;*
[11]*State Institution National Antarctic Scientific Center, Kyiv, Ukraine;*
[12]*Utrecht University, Utrecht, The Netherlands;*
[13]*Met Office, Exeter, UK;*
[14]*Scripps Institution of Oceanography, La Jolla, USA*

We calculate a regional surface "melt potential" index (MPI) over Antarctic ice shelves that describes the frequency (MPI-freq, %) and intensity (MPI-int, K) of daily maximum summer temperatures exceeding a melt threshold of 273.15 K. This is used to determine which ice shelves are vulnerable to melt-induced hydrofracture and is calculated using near-surface temperature output for each summer from 1979/80 to 2018/19 from two high-resolution regional atmospheric model hindcasts (using the MetUM and HIRHAM5). MPI is highest for Antarctic Peninsula ice shelves (MPI-freq 23–35%, MPI-int 1.2–2.1 K), lowest (2–3%, < 0 K) for Ronne-Filchner and Ross ice shelves, and around 10–24% and 0.6–1.7 K for the other West and East Antarctic ice shelves. Hotspots of MPI are apparent over many ice shelves, and they also show a decreasing trend in MPI-freq. The regional circulation patterns associated with high MPI values over West and East Antarctic ice shelves are remarkably consistent for their respective region but tied to different large-scale climate forcings. The West Antarctic circulation resembles the central Pacific El Niño pattern with a stationary Rossby wave and a strong anticyclone over the high-latitude South Pacific. By contrast, the East Antarctic circulation comprises a zonally symmetric negative Southern Annular Mode

pattern with a strong regional anticyclone on the plateau and enhanced coastal easterlies/weakened Southern Ocean westerlies. Values of MPI are 3–4 times larger for a lower temperature/melt threshold of 271.15 K used in a sensitivity test, as melting can occur at temperatures lower than 273.15 K depending on snowpack properties.

SIMULATING THE IMPACT OR ATMOSPHERIC RIVER ON THE CLOUDS AND METEOROLOGY OF COASTAL ANTARCTICA

K. M. Hines, D. H. Bromwich, M. F. Litell, S.-H. Wang
Polar Meteorology Group, Byrd Polar and Climate Research Center, The Ohio State University, Columbus, USA; khines1@columbus.rr.com

As part of the Southern Hemisphere component to the international Year of Polar Prediction (YOPP-SH), a modeling and observational study aims to improve Antarctic weather forecasting. This effort includes the representation by global and regional models of the weather and clouds over coastal Antarctica. Atmospheric river events are emphasized, and Targeted Observing Periods (TOPs) have been organized for YOPP-SH. Enhanced observations for YOPP-SH along the Antarctic Peninsula at Vernadsky, Escudero, and Rothera are especially being applied. At The Ohio State University, the meteorological fields in reanalyses with global forecast models are being analyzed in comparison to YOPP-SH observations. Also, simulations of the polar-optimized version of the Weather Research and Forecasting model (Polar WRF) are being performed to improve the simulation of relatively warm Antarctic clouds. Work on the project shows the impact of an Antarctic River during May 2022. A surprise finding is the intrusion of stratospheric air into the middle troposphere during this event. The project is also studying the impact of secondary ice production on the resulting ice and liquid in Antarctic coastal clouds. It is anticipated that the Polar WRF model will be improved by resulting adjustments to the model microphysical schemes.

POSTERS

BIOFILM PRODUCTION BY ENDOPHYTIC BACTERIA ISOLATED FROM EXTREME ENVIRONMENTS

***O. Iungin*[1,2,4], *Ye. Prekrasna-Kviatkovska*[3], *O. Moshynets*[2], *M. Sidorenko*[4], *O. Kalinichenko*[1], *S. Mickevicius*[4]**

[1]*Kyiv National University of Technologies and Design, Kyiv, Ukraine;*
[2]*Institute of Molecular Biology and Genetics, National Academy of Sciences of Ukraine, Kyiv, Ukraine;*
[3]*State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine;*
[4]*Vytautas Magnus University, Kaunas, Lithuania; olgaungin@gmail.com*

Plants harbour a wide diversity of microorganisms, which play a crucial role in their growth, survival and establishment by conferring enhanced resistance to abiotic stress, allowing plants to grow in extreme conditions. The aim of our study was to estimate the biofilm formation of endophytic bacteria associated with *Deschampsia antarctica*.

12 endophytic bacterial cultures were isolated from *D. antarctica* sampled during the 25th Ukrainian Antarctic Expedition (January–April 2020) and identified by the molecular approach. Biofilm assay was performed in static microcosms at 4, 26, 37 and 42°C during 3 days. Fine biofilm structures were analyzed by CLSM using Leica TCS SPE Confocal system with a coded DMi8 inverted microscope (Leica, Germany) with recommended software using Ethidium bromide (ex/em 532/537–670 nm), AmyGreen (ex/em 488/510–605 nm) and Calcofluor White (ex/em 380/475 nm).

Some of the isolated strains belong to *Pseudomonas*, *Psychrobacter* and *Hafnia* genus. Six isolates were highly productive and formed liquid-surface and air-liquid-surface biofilms at 4°C, whereas others have the optimum biofilm formation at 26–42 °C. *Pseudomonas* spp. were able to form biofilms in studied temperature range producing amyloids and eDNA. Generally, all Gram-negative isolates have shown an amyloids/DNA ratio at least 10 times higher than Gram-positive isolates with the opposite tendency in polysaccharides/DNA ratio. That could describe different mechanisms of biofilm formation exploited by bacterial isolates in harsh environments.

All studied isolates proved to be biofilm formers with different components which might be a strategy to reside in extreme environments.

PRIMARY SCREENING OF BIOACTIVE COMPOUNDS FROM PLANTS OF TWO SPECIES OF THE GENUS *DESCHAMPSIA*

R. Ivannikov[1], O. Poronnik[2,3], I. Parnikoza[3,2,6], I. Laguta[4], V. Anishchenko[5], P. Kuzema[4], O. Stavinskaya[4], G. Myryuta[2,3], A. Balanda[2], V. Kunakh[2]

[1]M.M. Gryshko National Botanic Garden, National Academy of Sciences of Ukraine, Kyiv, Ukraine;

[2]Institute of Molecular Biology and Genetics, National Academy of Sciences of Ukraine, Kyiv, Ukraine; oksana_poronnik@ukr.net

[3]State Institution National Antarctic Scientific Center, Ministry of Education and Science of Ukraine, Kyiv, Ukraine;

[4]Chuiko Institute of Surface Chemistry of National Academy of Sciences of Ukraine, Kyiv, Ukraine;

[5]L.M. Litvinenko Institute of Physical-Organic Chemistry and Coal Chemistry of National Academy of Sciences of Ukraine, Kyiv, Ukraine;

[6]National University of Kyiv-Mohyla Academy, Kyiv, Ukraine

In response to abiotic and biotic stresses, plants accumulate bioactive compounds such as phenols and carotenoids, which are valuable secondary metabolites for wide applications. Extremophile plants are promising potential producers of these compounds. The study aimed to carry out a primary screening of phenolic compounds and photosynthetic pigments in plants of two species of the *Deschampsia* genus: *Deschampsia antarctica* É. Desv. from the Antarctic, and *Deschampsia cespitosa* (L.) P. Beauv. from Alaska (USA), Iceland and Ukraine. The plants studied were obtained from seeds and grown under standard laboratory conditions: plants of *D. antarctica* were grown on nutrient media and *D. cespitosa* was grown in soil. The composition of extracts was investigated using HPLC and MALDI MS methods. The heterogeneity of the extracts was revealed both between the studied plants of *D. antarctica* and different variants of *D. cespitosa*. A comparison of extracts from *D. antarctica* with extracts from different variants of *D. cespitosa* showed that all *D. antarctica* plants had a significantly higher content of flavonoids (~2.5–8 mg/g of dry mass) than *D. cespitosa* plants regardless of the origin (0.4–0.8 mg/g of dry mass). At the same time, the content of oxycinnamic acid derivatives in all *D. cespitosa* variants was 2–3 times higher than in *D. antarctica'* plants. *D. cespitosa* plants of different origins had specific flavonoid composition. The luteolin content in *D. antarctica* samples exceeded 90% of the total content of flavonoids, while apigenin reached up to 80% of the total amount of flavonoids in *D. cespitosa* plants regardless of their origin. The high content of simple phenols, oxybenzoic and carboxylic acids (2–3.6 mg/g of dry mass) was typical for the samples of *D. cespitosa* from Iceland and Alaska, while the sample from Iceland had a high content of terpenoids and sterols as well. Luteolin glycosides (1.3–3.9 mg/g of dry mass) dominated in *D. antarctica* plants, and oxycinnamic acids (1.9–2.8 mg/g of dry mass) or carotenoids dominated in *D. cespitosa* plants depending on the origin. *D. cespitosa* plants from Alaska or Iceland had higher contents of simple phenols, oxybenzoic and carboxylic acids

(2–3.6 mg/g of dry mass), terpenoids, styrenes, carotenoids and chlorophyll catabolites. Plant samples from Alaska and Iceland had carotenoid content up to 6.5 times higher than samples of *D. antarctica*. Hence, it was shown that, both types of cultivated plants can be used as a primary source of secondary metabolites. *D. antarctica* can be a source of flavonoids and their glycosides, while *D. cespitosa* plants can be a source of simple phenols, phenolic acids and carotenoids.

GEOSCIENCES

PRELIMINARY STUDY OF FRESHWATER LAKE AND SHALLOW POND SEDIMENTS OF THE ISLANDS OF MARITIME ANTARCTICA AND WESTERN COAST OF ANTARCTIC PENINSULA

***S. M. Stadnichenko*, V. V. Permiakov, V. I. Bogillo, M. S. Bazylevska**
Institute of Geological Sciences, National Academy of Sciences of Ukraine, Kyiv, Ukraine; stadnik_sm@ukr.net

The peculiarities of particle size distribution, mineral, and chemical composition were established for bottom sediments of freshwater lakes and shallow ponds of the Argentine Islands (Wilhelm Archipelago) (Galindez I., Winter I., Barchans Is., Skua I.), Petermann I., King George I., and the western coast of the Antarctic Peninsula (Cape Tuxen and Cape Rasmussen). The studies were carried out in the Center for shared use of scientific equipment of the Institute of Geological Sciences, NAS of Ukraine with the use of a laser sedimentograph and a scanning electron microscope with an X-ray microanalysis system. The studied samples are represented from light brown pelitic silt (Barchans Is., Galindez I., Cape Tuxen, Cape Rasmussen), light brown fine-grained sand (Petermann I.) to dark brown with a brown tint: sandy silt (Skua I.), fine-grained silty sand (Cape Rasmussen), coarse-grained sand (King George I.). Also, the samples are represented by gray with a brown shade coarse-grained sand (Petermann I., Galindez I.) and dark gray to black fine-grained sand (Winter I.). Almost all studied samples are characterized by the presence of fragments of igneous rocks of psephytic size, which are from 2 to 32%. In the samples, organic residues (diatom frustules, sponge fragments – Barchans Is., Cape Rasmussen, King George I.) of varying degrees of preservation were found, and samples with a significant content of plant detritus from coarse-psammitic to psephytic sizes were noted (Skua I., Petermann I., Winter I., Cape Rasmussen). The smallest silt-pelitic sediments were found for samples from Cape Rasmussen, Barchans Is., Galindez I., and Cape Tuxen. The largest formations in terms of particle size – coarse-grained sands with an admixture of psephitic fraction were observed for Petermann I. and Galindez I. samples.

The chemical composition of the samples is dominated by silica from 68 % (Galindez I.) to 53% (King George I.) and decreases to 2–14% in samples, the composition of which predominates in ornithogenically derived phosphate. Such samples include the sediment of Cape Rasmussen, for which the maximum value of PO_4^{3-} was established (39%), as well as the sediments of Barchans Is., Galindez I., Petermann I., and Cape Tuxen. The fluorine content ranges from 1 to 14% (Petermann I., Cape Rasmussen). A significant sulfur content from 0.2 to 5% was observed. Traces of Cu (up to 0.2%), Zn (up to 0.3%), and Pb (up to 1%) were also detected in the samples. The established mineral composition of the sediments is

represented by quartz, albite, anorthite, hydroxyapatite, fluorapatite, finely dispersed muscovite, chlorite, mixed-layer formations of illite-montmorillonite and amphibole (hornblende). Among the terrigenous minerals of the heavy fraction, fragments of iron oxide grains, iron sulfide, barite, zircon, and ilmenite were determined.

A significant number of formations with a Pb high content (up to 47–62 %) were revealed for the sample of coarse-grained sand (Galindez I.), the content of which is high enough that it was reflected in the general chemical composition of the sample with more than 1% (PbO from 0.2 to 2%). Lead compounds are represented by formations of irregular shape with a size of 5–20 μm, sometimes as an impurity, probably adsorbed on the surface of ilmenite (Pb content – 8%), and sometimes represented by inclusions in aluminosilicate grains, up to 5 μm in size. Such results were obtained for the first time; no other sample of the sediments of the studied islands is characterized by a similar find. Therefore, given that in the studied samples, lead, together with the presence of copper and zinc, was found only on Galindez I., we can assume the anthropogenic source of these compounds. Undoubtedly, this issue requires further detailed research to confirm or disprove anthropogenic pollution on the island.

FORMATION OF TRACE GASES IN POLYTHERMAL GLACIER (GALINDEZ ISLAND, MARITIME WEST ANTARCTICA) AND THEIR EMISSION UNDER ACTION OF CURRENT GLOBAL WARMING

M. S. Bazylevska, V. I. Bogillo
Institute of Geological Sciences, National Academy of Sciences of Ukraine, Kyiv, Ukraine; bazilevskaya1955@gmail.com

Polythermal glaciers are the most sensitive indicators of climate change and ideal regions for studying the chemical composition of the atmosphere, snow, firn and ice under the influence of current climate warming. This study is the first attempt to assess concentration range of a large number of trace gases (except the previously studied O_2, N_2, Ar and CO_2) in polythermal and temperate glaciers, which widespread in Greenland, Svalbard, Canadian Arctica, Alaska, Alps, Andes, Tibet, Altai, and Maritime Antarctica. The changes in average annual and monthly air temperatures, and wet precipitations from 1947 to 2019 at the Faraday/Vernadsky station were compared with the glaciological parameters of polythermal glacier on Galindez I. (accumulation and ablation), and linear trends were found between ablation parameters, amount of wet precipitation and air temperature during this time.

Qualitative analysis by GC-MS was carried out for more than 200 organic and inorganic trace gases in the composition of this glacier. A quantitative analysis of 20 compounds was performed along the vertical profile of the glacier, including greenhouse gases CO_2 and N_2O, freons, chlorine-based solvents that are prohibited

by the Montreal Protocol, F-, Cl-, Br- and I-containing halocarbons, COS, CS_2, CH_3SCH_3, CH_3SSCH_3, and propylene.

Statistical data were calculated for their mixing ratios compared to background air (minimum, maximum values, their averages, root mean square deviations and median values), the relative parameters (purely anthropogenic CF_2CCl_2 was chosen as the standard), taking into account for their possible solubility in the quasi-liquid layer on the ice surface. Most of the halocarbons, sulfur-containing compounds and propylene are characterized by high enrichment factors and the relative parameters. This suggests that the species can be formed in the snowpack and firn of the glacier or in its deep bubbling superimposed and bare ice.

We can assume following abiotic pathways for the formation of the compounds:

(a) Direct and indirect photochemical reactions of triplet state dissolved organic matter (DOM) without (C_3H_6, COS, CS_2), or in presence of X^- ions (X = Cl, Br, I): RX (R = CH_3, C_2H_5, CH_2=CH).

(b) Redox reactions of Fe^{3+}, Mn^{4+}, Cu^{2+}, O_3, H_2O_2 or HO radicals (assisted by Fe^{2+} and TiO_2) with the DOM in presence of X^- ions: RX.

(c) Reactions of HOX with DOM (with participation of HO, HO_2, H_2O_2 or O_3): CH_2Br_2, $CHBr_3$.

(d) Free radical reactions of Cl, ClO, Br, BrO, I and IO with alkenes, alkynes and alkyl radicals.

(e) Decomposition of methylmethionine or S-containing peptides: CH_3SCH_3 and CH_3SSCH_3.

These reactions can be greatly accelerated in quasi-liquid layers on the grain surface of ice in the microcavities and trenches of snow and firn due to concentration freezing and cage effects, variations of pH values, freezing potential and strong electric field in the thinner layers. They can be even more accelerated by the repetition of freeze-thaw cycles typical for polythermal glaciers.

Based on the ranges of mixing ratios of the trace gases in the glacier, the ablation rate of Antarctic coastal glaciers and the mass of calved icebergs, preliminary estimates of their secondary emission into the environment were made. Although this emission does not exceed 1% of the total emission of these gases from all sources, it can certainly affect the biota of the ocean and land as well as the formation of clouds over the coastal regions of Antarctica.

POSSIBLE IMPACT OF VOLCANIC EMISSION ON THE LOCAL DEPLETION OF OZONE LAYER AND ANTARCTIC ENVIRONMENT

V. I. Bogillo, M. S. Bazylevska
Institute of Geological Sciences, National Academy of Sciences of Ukraine, Kyiv, Ukraine; bazilevskaya1955@gmail.com

Antarctica is one of the least volcanically active regions in the world. As a consequence, volcanism was important for the formation of both West and East Antarctica, and it was a driver of several global continental and oceanic biotic extinctions during the past 400 Ma and potentially driven Antarctica climatically. The large igneous provinces (LIPs) eruptions are implicated in environmental and climatic changes, including global warming, ozone layer depletion, acid rains, oceanic anoxia and/or increased oceanic fertilization, calcification crises, mass extinction, and potentially the release of gas hydrates. The mafic volcanism in Antarctica is known as the Ferrar Supergroup and the LIP had a total volume of more than 0.5×10^6 km^3, but it was emplaced in a very short time (~ 100 ka).

Apart from the ozone-depleting halocarbons of volcanic origin, such as CH_3X, C_2H_5X, CH_2X_2, CHX_3 (X = Cl, Br, and I), the main inorganic halogen-containing volcanic gases are the hydrogen halides HX, which in gas-phase reactions ($HX + OH \rightarrow X + H_2O$) release halogen atoms and subsequently deplete the stratospheric ozone ($X + O_3 \rightarrow XO + O_2$). Large ozone losses that occur over Antarctica result directly from heterogeneous reactions involving halogens from the halides on the surface of cold sulfate-water aerosols.

We calculated the injected Equivalent Effective Stratospheric Chlorine (EESC) (EESC = [Cl] + 60[Br] + 300[I]) values by using the Cl/S, Br/S, and I/S ratios, 25% release of HCl to the stratosphere, the S-volcanic flux from Tambora eruption (1815 CE), and petrological estimates of total SO_2 volcanic emission as well as the ratio of nss-SO_4^{2-} deposition fluxes in Antarctic ice cores between a volcano and Tambora volcano. Using the relationship between EESC and column ozone percentage change, $\Delta\%O_3$, we estimate the last values for 20 known volcanoes in the tropical belt and low latitudes. The estimates lead to more than 50% depletion of stratospheric ozone after the most powerful volcanic eruptions (Huaynaputina (1600 CE), Kuwae (1450 CE), Samalas (1257 CE), and Toba (73 – 71 ka)).

Taking the range of ejected magma volume for Deception Island's caldera collapse c. 4 ka, and amounts of released Cl, Br and I, suggesting 25% release of HCl into the stratosphere, we estimated the range of possible ozone depletion after the eruption, which is comparable with those from Krakatoa (1884 CE), Samalas (1257 CE) and Tambora (1815 CE) eruptions. A similar estimate for the 192 yrs series of Mt. Takahe halogen-rich volcanic eruptions at 17,7 ka presents extensive stratospheric ozone depletion over Antarctica. Crude estimates of $\Delta\%O_3$ after the Ferrar LIP (182 Ma) eruptions in Antarctica, considering the whole LIP volume of basaltic lavas, range from −49 to −83%. The ozone depletion on this scale (quadratic dependence of UV-B % on the $\Delta\%O_3$) would dramatically increase the

flux of harmful UV-B radiation to the surface, which could cause damage to animals and plants in the Southern Hemisphere and Antarctica.

Due to very the low emission rate of HCl from an unit non-eruptive degassing Erebus volcano, the volcanic emission of Erebus could not be an essential reason for modern springtime ozone hole formation over Antarctica.

However, the last "Big Five" mass extinctions were coincident with a major climatic warming. Then the increase in mid-latitude summer temperature leads to an increase in the convective injection of water vapor into the lower stratosphere. This increased water content then passes the threshold for an increased production of catalytically active ClO, BrO and IO radicals in the heterogeneous reactions with ensuing increased rate of ozone loss in low stratosphere.

POSSIBLE EFFECT OF ELECTRIC FIELD ON THE CHEMICAL REACTIONS AT AIR/WATER INTERFACE OF RESTRICTED SPACE IN SUPERIMPOSED ICE OF POLYTHERMAL ANTARCTIC GLACIERS

V. I. Bogillo, ***M. S. Bazylevska***
Institute of Geological Sciences, National Academy of Sciences of Ukraine, Kyiv, Ukraine; bazilevskaya1955@gmail.com

The ice caps of Argentine Islands (Maritime Antarctica) lie exclusively below the saturation line and that the facies present are: soaked, superimposed ice and ablation. The ice has been at least 300 m thicker then at present and during the maximum glaciation it was much more extensive. The ice samples consists of alternating layers of superimposed ice and normal glacier ice containing air bubbles. In contrast to cold glaciers, where density increases gradually down to 50–100 m, in the polythermal glaciers the density reaches 0.8–0.9 g cm^{-3} at 2–3 m depth. Natural ice mostly contains sea salts in coastal regions. When aqueous solution is frozen, dissolved salts are expelled from ice and are concentrated in an unfrozen liquid phase. The phase coexistent with ice has been regarded as an important medium for various reactions. Reactants are accumulated by freeze concentration and are aggregated in grain/boundry channels or near the ice surface. The freeze concentration of reactants into a small volume of the unfrozen liquid phase enhances the second order reactions rate.

We performed quantitative GC-MS analysis of 27 trace gases in ice samples taken along vertical profile of the glacier on Galindez I. (Argentine Islands, Maritime Antarctica) and obtained high enrichment factors in comparison with their content in background air over Antarctic Peninsula for such species as C_3H_6 (19680), COS (1158), CS_2 (1078), CH_3SCH_3 (12000), CH_3SSCH_3 (>15000), CH_3Cl (64), C_2H_5Cl (189), CH_2=CHCl (218), $CHCl_3$ (115), Cl_2C=CCl_2 (172), CH_3Br (46), CH_2Br_2 (25), $CHBr_3$ (360), CH_3I (380), C_2H_5I (3320) and CH_2=CHI (600). Such high enrichment of the gases in the ice samples is attributable to their immediate formation in the snowpack, firn and in the superimposed ice of the polythermal glacier.

From other side, we estimated porosity and electric conductivity (EC) along ice core (4 m) from top of the glacier. The ice porosity is varied from 0.55% to 6.98% which are unique to superimposed ice. The NaCl concentration in the melted ice samples ranges from 0.11 to 0.47 mmole L^{-1}. The concentration of dissolved organic carbon (DOC) in the snowpack of the region is varied from 0.3 to 1.3 mg L^{-1}. Then, the reactions of the trace gases formation occur in very restricted space consisting the quasi-liquid layer (QLL) of various salts and DOC solutions on the ice solid surface and air. The electrical conductivity of QLL is 6 times greater than that of water, its viscosity is significantly greater than supercooled water, and the hydrogen bonding network present there is different from that of liquid and solid water. In an aqueous NaCl solution, the calculated by using the classical MD simulations local electric field of O and H atoms had a mean value of 2 V/A.

One of the primary hypotheses about the interfacial features of the air-water interface is the presence of strong electric fields that can promote reactive chemistry. Estimates of required field strengths range from the order of tens of MV/cm for bond activation to several hundred MV/cm for making or breaking strong chemical bonds or to induce redox reactions. The ab initio MD computations show that the vapor-water interface has an average interfacial electric field strength of 150 MV/cm. For a pure water droplet, the surface O-H bonds are more destabilized due to a higher electric field of ~163 MV/cm compared to the interior bonds which experience small field strengths of ~131 MV/cm (ReaxFF/C-GeM model). Then, the strong electric fields in the restricted space of polythermal glacier can modify reaction pathways and transition states, and new molecular species may be stabilised due to the rearrangement of valence electrons.

THE PROPOSAL FOR A NEW SCAR PROGRAMME PLANNING GROUP: AGATA

***A. M. Gulisano*[1,2,3], *L. Alfonsi*[4], *N. Bergeot*[5]**
[1]*Instituto Antártico Argentino, Dirección Nacional del Antártico, Buenos Aires, Argentina;*
[2]*Instituto de Astronomía y Física del Espacio (UBA-CONICET), Argentina;*
[3]*Universidad de Buenos Aires, Facultad de Ciencias Exactas y Naturales, CABA, Argentina; adrianagulisano@gmail.com*
[4]*INGV, Italy;*
[5]*ROB, Belgium*

A concerted international effort is being made by The Antarctic Geospace and ATmosphere reseArch (AGATA) Programme Planning Group to monitor, research, and better understand the physics of the polar atmosphere and the effects of the Sun-Earth interactions on the polar areas. It has the support of SCAR (Scientific Committee on Antarctic Research). If the proposal is approved, AGATA will establish a brand-new Research Programme within SCAR to represent the geospace and polar atmospheric sciences (https://www.scar.org/science/agata/home/). The main reasearch questions can be defined as following:

1)How are different atmospheric layers in the polar regions related? AGATA hopes to contribute to the resolution of one of the most pressing scientific issues in atmospheric and space physics.

2)How does increased geomagnetic activity, as well as energy flow from space into the ionosphere, affect the upper polar atmosphere?

3)How may radio signals from the GNSS or other satellites, as well as from ground-based radars, be used to better comprehend the Antarctic atmosphere?

By utilizing both already-existing and future instrumentation in the Arctic and the Antarctic, as well as satellite-based observations, AGATA was proposed by specialists from 40 international institutions with the goal of coordinating research activities and data interchange. The study of major interhemispheric disparities in the atmospheric response seen in the polar regions is made possible by this bipolar perspective. This work will provide an overview of the effort to draw in new scientists, particularly students and early-career researchers, to assist the implementation of the new Research Programme.

LAGRANGIAN ANALYSIS OF CIRCULATION UNDER THE FILCHNER-RONNE ICE SHELF AND IN THE WEDDELL SEA

R. Bezhenar*, *V. Maderich
The Institute of Mathematical Machine and System Problems, National Academy of Science of Ukraine, Kyiv, Ukraine; romanbezhenar@gmail.com

The objective of the study is to construct Lagrangian pathways under the Filchner-Ronne ice shelf (FRIS) and in the Weddell Sea using the data of numerical simulation of currents, which were kindly provided by University of Helsinki, and Lagrangian numerical methods. The results of modeling for the circulation, temperature, and salinity in the Weddell Sea and the FRIS cavity from the Whole Antarctica Ocean Model were used to run the particle-tracking model (Parcels) for computing Lagrangian particle trajectories. The basic version of the Parcels model does not have an option for particle reflection from the solid boundaries including the ice shelf. Therefore, the corresponding kernel was used in the study. To avoid errors in interpolation near the solid boundary when the model algorithm cannot find enough grid nodes around the particle, the function of particle recovery was implemented. To analyze the variations of movement of the water masses under the FRIS, a set of particles was released in the Ronne Depression near the ice shelf front. Simulation continued for 20 years of particle movement. Particles were released at two depths: 350 m and 500 m every 4 hr within the first 365 days. To characterize the redistribution of water masses we calculated the 'visitation frequency' which was a percentage of the particles that visited each 2×2 km grid column at least once in a period of modeling. The mean age of visits was also calculated to characterize the age of water masses. The results of this analysis generally agreed with schemes based on water mass analysis. The released particles first move southward along the Ronne Trough. The flow then turns to the east reaching the passage between Berkner Island and Henry Rise after 3 years. After 10 years, the released particles reach the Filchner Trough through which water flows out to the shelf of the southern part of the Weddell Sea. Over time, the particles penetrate all parts of the cavity. The particles also cross the Ronne Shelf front, and then they are carried away by currents on the Weddell Sea shelf. In 20 years, almost the same number of particles left the cavity through the Ronne ice front (43%) and the Filchner ice front (37%) whereas the rest of the particles (20%) remained under FRIS.

CHARACTERISTICS OF EXTREME ACCUMULATION EVENTS IN WEST ANTARCTICA

E. Gilbert*, *A. Orr, D. Pishniak, K. Verro, W. Jan van de Berg, R. Mottram
British Antarctic Survey, Cambridge, United Kindom; ellgil82@bas.ac.uk

Glaciers in West Antarctica are accelerating extremely rapidly and discharging enormous quantities of ice into the ocean, adding to global sea level. However, while ice loss factors in this region are important to consider, the other side of the mass balance equation – accumulation – also has a strong bearing on overall ice mass. In this study, we examine extreme accumulation events over the West Antarctic region focusing on the Thwaites and Pine Island glaciers. Several regional climate models (MetUM, HCLIM and Polar-WRF) are used to dynamically downscale ERA5 reanalysis to 12 km, 3 km and 1 km resolution and we compare against AMIGOS snow accumulation data to validate and add value to the model simulations. In this work we will explore the characteristics of extreme precipitation events and evaluate how enhanced resolution impacts the quality of simulations.