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NATIONAL ACADEMY OF SCIENCES OF UKRAINE
STATE INSTITUTION NATIONAL ANTARCTIC SCIENTIFIC CENTER

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Ambassador Extraordinary and Plenipotentiary of Ukraine to the Great Britain Academician Professor Sergiy Komisarenko and Minister of State of the United Kingdom of Great Britain and Northern Ireland Mr David Davis sign the Exchange of intergovernmental Notes regarding the transfer of Faraday research station to Ukraine (London, 20 July 1995)

Director of the Antarctic Research Center, corresponding member of NAS of Ukraine Petro Gozhik and Director British Antarctic Survay Mr Berry Haywood sign the Memorandum of Understanding regarding the transfer of Faraday research station in Antarctica (London, 20 July 1995)

The first raising of the National Flag of Ukraine at Ukrainian Antarctic Akademik Vernadsky station (06 February 1996). (All photos from NASC archive)

Ukrainian Antarctic Akademik Vernadsky station, 2020 (Photo by Yevhenii Prokopchuk)

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This paper outlines the development of the Malaysian Antarctic Research Programme with emphasis on its strategies and the role of the Sultan Mizan Antarctic Research Foundation (Foundation). The Polar Regions may seem remote to Malaysian, yet environment changes there have potential effects on our tropical regions particularly due to climate change and elevated sea levels. As such scientific knowledge is a vital tool in tackling and resolving problems besetting the Polar Regions and their global implications. Malaysia as a tropical country in the Asian continent has always played an active role in scientific initiatives in Polar Regions via the Malaysian Antarctic Research Programme and its extensive international collaboration networks. A few strategies have been identified towards sustaining Malaysian polar research activities, both at the national and international levels. These include provision of research support, strengthening international collaboration (bilateral and multilateral), creating polar research eco-system in the country; and undertaking communication and education activities. In 2012, the Malaysian Government has established the Foundation with the mission of sustaining Malaysia's presence in polar research. The Foundation has carried out various programmes and activities to support the development of the Malaysian Antarctic Research Programme. These include providing research grants, fellowship schemes and berth support. To enhance research framework in the country, the Foundation has signed Memorandums of Understanding (MOUs) on Smart Partnership Initiatives with eight local universities to collaborate in polar research. The Foundation is also planning to establish a Chair in Antarctic Science and to streamline the management of polar research in the country, the Foundation will formalise its relationship with the National Antarctic Research Centre (NARC). Malaysia will continue to play active role in SCAR and Malaysian researcher continued to lead SCAR Action Group on Tropic Antarctic Teleconnections aims to examine climate processes linking the tropics to Antarctica. Another main area of research being undertaken by Malaysian researchers is on the climate change impacts on microbial diversity. At the regional level, Malaysia is a member and the current Chairman of the Asian regional grouping on polar sciences. The Foundation has also signed an MOU with the British Antarctic Survey (BAS) to secure Antarctic berth for Malaysian researchers. To promote and share Malaysian research findings with the public, the Foundation in collaboration with the NARC organises a biennial Antarctic seminar of which the Ninth seminar will be held in October 2021. The Malaysian Antarctic Research Programme is progressing well but more needs to be done to develop the national capacity and experience in strategizing the development of the Programme. It is therefore crucial for Malaysia to collaborate with many more countries and we would welcome the opportunity to work with Ukraine through the National Antarctic Scientific Centre.

ISLANDS IN THE ICE: THE PAST, PRESENT AND FUTURE OF ANTARCTICA'S UNIQUE TERRESTRIAL BIODIVERSITY

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Terrestrial and freshwater life in Antarctica is surprisingly poorly appreciated. Today it is dominated by lower plants and lichens, micro-arthropods and other micro-invertebrates, and microbial groups, although that has not always been the case. Most currently ice-free ground in Antarctica and on at least some of the surrounding sub-Antarctic islands would have been covered and scoured by glacial advances at the Last Glacial Maximum and previous maxima. However, as new baseline survey data become available, combined with modern molecular biological analysis, it has become clear that isolation, long-term persistence, and regionalisation are general features of the Antarctic terrestrial and freshwater biota. It is also increasingly clear that endemism, even at remarkably small regional scales within Antarctica, is the norm for much of this biota. As well as creating a new paradigm in which to consider the evolution and adaptation of Antarctic terrestrial and freshwater biota, important new cross-disciplinary linkages have opened in the fields of understanding the geological and glaciological history of the continent itself and its neighbouring landmasses, and of the climatic and oceanographic process that can both lead to isolation and support colonisation processes. This new and more complex understanding of Antarctic biogeography also provides important practical challenges for management and conservation in the region as is required under the Antarctic Treaty System, in the face of growing human activity, connectivity and impacts, and of considerable regional climate change.

LONG-TERM INVESTIGATIONS OF GLOBAL LIGHTNING ACTIVITY FROM THE UKRAINIAN ANTARCTIC STATION (REVIEW)

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Why is the problem of studying the dynamics of global lightning activity (GLA), despite its long history, becoming more and more relevant? In our opinion, there are several reasons. First, thunderstorm activity is the main source of the electromagnetic background at the low altitudes of atmosphere. The spectrum of a lightning discharge extends from zero frequency ("fair weather field") to gamma frequencies, while the main energy is concentrated in the low-frequency range. It is obvious that development and existence of life on the planet took place in particular under the influence of the electromagnetic background. At present, the understanding of the mechanisms of the influence of GLA radiation on living organisms is still in its initial stage. Secondly, thunderstorm activity is an important structural component of the weather and climate on the planet. The formation of thunderstorm clouds is directly related to the process of moisture evaporation, which directly depends on the heating of the surface. As a result, planetary thunderstorm activity can be used as a global thermometer. And finally, thirdly, many modern

technological processes and systems that provide civilization with the power generation and transport of electricity, communication services, navigation, access to computer networks, and so on are subject to the destructive effect of lightning discharges. In addition, GLA poses an immediate fire hazard. For example, in the United States alone, lightning leads to tens of thousands of fires. The importance of this issue is evidenced by the large number of modern expensive ground-space monitoring systems of the GLA.

The report provides a review of the results of long-term systematic studies of global ELF thunderstorms in the Antarctic (since 2002) and synchronously in the Arctic (since 2013), which have made it possible to clarify a number of important scientific and applied questions. These include:

1. Does the 11-year cycle of solar activity affect the state of the lower ionosphere, atmospheric weather and global thunderstorm activity?
2. Reconstruction of daily and seasonal behaviors of three equatorial centers of thunderstorms located in Asia, Africa and America.
3. Estimation of the annual dependences of continental temperatures based on the ELF monitoring of Schumann resonance parameters.
4. Use of the global Earth - ionosphere resonator (Schumann resonator) as an indicator of geospace storms and earthquakes.
5. Detection, counting and geolocation of super-powerful lightning discharges on the planet.
6. Monitoring of power line radiations from industrial regions and studying the mechanisms of "electromagnetic smog" transportation to Antarctica.

In conclusion, further promising tasks for the elaboration of ELF studies of the planetary thunderstorm activity in Antarctic at the Ukrainian Antarctic Akademik Vernadsky station and in the Arctic on the Spitsbergen archipelago are formulated. The report will also mention domestic and foreign scientific groups with whom joint research is being carried out.

CURRENT STATE AND PERSPECTIVE ON ANTARCTIC RESEARCH

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In January 2021, Ukraine adopted an updated version of the State Special-Purpose Program of Research in Antarctica for 2011-2023 (https://zakon.rada.gov.ua/laws/show/1002-2010-%D0%BF#Text). In preparation of this document, the Scientific and technical council of the State Institution National Antarctic Scientific Center of the Ministry of Education and Science of Ukraine (SI NASC) was guided in part by the precepts and provisions of the Scientific Committee on Antarctic Research (SCAR).

Nowadays, SCAR focuses its research efforts on high-priority topical areas through its Scientific Research Programs (SRPs). Three such projects began officially in January 2021. One is AntClim^{now} (Near-term Variability and Prediction of the Antarctic Climate System), launched to answer fundamental questions (as identified by the SCAR Horizon Scan) relating to climate dynamics. The program aims to take a regional approach to observing and modeling the environment, with an integrated view that will consider the Antarctic as a whole (https://www.scar.org/science/antclimnow/home/). The second program is INStabilities & Thresholds in ANTarctica (INSTANT), which will address first-order question about

Antarctica's contribution to sea level. It encompasses geoscience, physical sciences and biological sciences to trace how ocean, atmosphere and cryosphere have influenced ice-sheets in the past and what to expect in the future with a special focus on quantifying the contributions to global sea level change (https://www.scar.org/science/instant/home/). The third one is Integrated Science to Inform Antarctic and Southern Ocean conservation (ANT-ICON), which also is designed to answer fundamental science questions (as identified by the SCAR Horizon Scan) and emerging issues relating to the conservation and management of Antarctica and the Southern Ocean. It will focus on research to drive and inform international decision-making and policy change (https://www.scar.org/science/ant-icon/home/).

Scientific Research Programs are developed and proposed by Program Planning Groups (PPGs) through wide consultation within the community. SRPs address major-priority, scientific issues of global or fundamental importance, at the cutting edge of the science, requiring substantial fieldwork and/or observations in the Antarctic. The latest suite of SRPs has just been approved to begin work, and more PPGs will be developed over coming months and years.

In recent years Ukraine has significantly enhanced scientific integration with the international research community, as evidenced by publications and international projects and Fellowships projects in which Ukrainian scientists take part. Efficient implementation of up-to-date methods and approaches in Antarctic research in collaboration with the leading world specialists will let us build on and accumulate the accomplishments of the last three years in Ukraine's research of the sixth continent. To increase the gains of this enterprise Ukraine needs a new 10 year-long State Special-Purpose Program of Research in Antarctic.

As before, Ukrainian research in the Antarctic should be involved in the international effort according to SCAR-defined science groups, e.g. life sciences, physical sciences, and geosciences.

THE ROLE OF AKADEMIK VERNADSKY STATION IN THE DEVELOPMENT OF UKRAINE IN THE ANTARCTIC TREATY SYSTEM

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Basic and applied research as well as the international scientific and technical cooperation are the main elements of public policy in Antarctica. The establishment in 1996 of Ukraine's own research station Akademik Vernadsky and the introduction of long-term research there were crucial not only for the approval of the State Special-Purpose Research Program in Antarctica, formation of our own school of researchers and growth of their publication activity, but also for membership in international organizations in the Antarctic Treaty System (Scientific Committee on Antarctic Research and the Council of Managers of National Antarctic Programs), and most importantly, Ukraine's acquisition of the higher status of the Consultative Party to the Antarctic Treaty in 2004.

This status gives our country the right to participate in decision-making related to the management and use of the Antarctic region within the framework of the highest collegiate body - the Antarctic Treaty Consultative Meeting. For the period of 2000-2020, the Ukrainian delegation submitted 55 information and working papers, which were considered at the meetings of two permanent working groups (scientific cooperation and operational issues 28 papers; legal and institutional issues 8 papers) and at the meetings of the Committee on Environmental Protection, the main deliberative body (19 papers). Most of the documents provided are mainly

of a reporting or program nature and cover the main results of research carried out at Akademik Vernadsky station, as well as measures to modernize the infrastructure and hardware system of the station itself.

At the same time, the analysis of the submitted documents indicates a consistent and systematic aspiration of Ukraine to institutionalize the so-called area of scientific interests of Ukraine in Antarctica (the area around Akademik Vernadsky station within a radius of 30-35 km and a total area of about 1800 km^2), taking into account the general logic of the development of the international legal regime in Antarctica.

So, on the basis of scientifically grounded data, Ukraine under its management is trying to ensure further expansion of the system of regions (including maritime ones) with special environmental status in order to consolidate the presence of Ukraine in the outlined region and provide a strategic vision for the development of diverse activities in large areas around the station, where there are representative sites for long-term monitoring of environmental changes.

In addition, the favorable geographical location and scientific potential of Akademik Vernadsky station contributes to the expansion of international scientific cooperation, mainly with countries that currently do not have their own infrastructure in Antarctica, but seek to carry out research activities, which is a prerequisite for obtaining the status of a Consultative Party to the Antarctic Treaty (Turkey, Latvia).

Therefore, conducting promising and internationally significant research at the modernized Akademik Vernadsky station as well as the acquisition of its own ice-class research vessel will not only significantly expand the scope of Ukrainian Antarctic expeditions, but will also contribute to further strengthening of Ukraine's role in the Antarctic Treaty System for the current decade and beyond.

SYSTEMATIC CONSERVATION PLANNING FOR THE NEW PROPOSED ANTARCTIC SPECIALLY PROTECTED AREA "ARGENTINE ISLANDS AND KYIV PENINSULA REGION"

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As human activity and the influence of climate change increase across the Antarctic, it becomes more important to define how to best conserve its biodiversity and habitats. To protect areas with significant environmental, scientific, historic or aesthetic values, the Antarctic Treaty (AT) Parties have declared a number of Antarctic Specially Protected Areas (ASPAs). Despite the fact the AT requires the proponents to define reasons for ASPA designation, many ASPA Management Plans do not state clearly the priority objective for such designation, which sometimes becomes a problem as conservation, tourism and science often have conflicting management requirements. The protected area conservation tool has been widely used to protect biodiversity. However, there were two negative outcomes of its misuse in the past that are particularly relevant for conservation of the environment of Antarctica that does not belong to any country. The first is that there is a huge competition between conservational needs and needs

of other stakeholders, i.e. tourist operators, scientists and policy makers. The second is that there are limited resources for studying, designation and further managing many small and isolated protected areas. The scoring approach that selected sites for protection primarily based on their values in isolation, turned out to be not effective as those ASPA are often non-representative and too fragmentated. Unlike this, Systematic Conservation Planning (SCP) is an approach that chooses areas based on their being different from those already designed and on them being representative of the whole set of species, ecosystems and habitats in a region. SCP helps decision makers in sustainable managing the protected areas as it can identify sites that should be conserved and sites that may be used for tourism with minimum loss for all stakeholders. While developing this new proposed ASPA, our working team used the long-term observational data on the biodiversity, landing sites and scientific plots in the region and aimed to incorporate the SCP approach into this process in order to balance often conflicting needs and requirements of different stakeholders. We show that the proposed ASPA with its total area about 50 km^2 and small marine protected sites (0.3% of total proposed ASPA) is a good example of improved type of representative Antarctic protected area. First of all, it is continual and non-fragmentated which is important for conserving the whole ecosystem and differs it from many other ASPAs. Second, it includes many unique biotopes (diverse vegetation, marine animals and seabirds biotopes and colonies), species on the edge of their distribution (*Pygoscelis papua, P. antarctica, Catharacta lonnbergi*) and declining species (*P.adeliae*); endemic flightless mite *Belgica antarctica,* and key monitoring sites for comparative studies (colonial birds, seals, vascular plants) that together occupy less area and thus minimize efforts for its study and management. And finally, it leaves the whole area open for scientific research, and the most interesting tourist landing sites are excluded from ASPA and are open for visits that meets the interests of other stakeholders.

BIBLIOMETRIC ANALYSIS OF UKRAINIAN ANTARCTIC RESEARCH PROGRAM 2011-2020

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Scientific-driven goals were always the major priorities of Ukrainian Antarctic activity, which required long-term period planning and budgeting within the Government research programs.

Since 1996 Ukraine had three Antarctic Programs. Although the first one (1996-2000) was only a part of Marine Research Program of National Academy of Science, next two Antarctic Programs (2002-2010 and 2011-2020) were adopted by the Decree of the Government of Ukraine.

All Ukrainian Governments and Presidents of Ukraine had strong commitments to Antarctic Programs even in very difficult periods. The last two Programs were financed on 100 per cent of demand. Budget allocations have never been sequestered.

Despite Ukrainian Antarctic annual budget is quite strapped in comparison with other ATCM-countries, it is crucial to demonstrate visible scientific outputs. Moreover, deep changes in management and research stuff of the National Antarctic Scientific Center in 2018 have fostered international research collaborations and publications, in particular in biology and connected areas. First results of these changes need to be evaluated as well.

A comprehensive bibliometric analysis was applied to evaluate the visibility of the results of ongoing Government Program (2011-2023) on Scopus database. Since the Government Antarctic Research Programs were the only source of national financial support of Antarctic research in Ukraine in this analysis we consider all Antarctic publications, originated from Ukraine, as a cumulative results of Government Antarctic Research Programs.

We compiled our bibliometric database on 16.04.2021 in Scopus. "Antarctic*" and 58 the most mentioned geographical names in Antarctic were selected as a search words in topics, key words and annotations for the period 2010-2020. 32283 publications were identified as Antarctic related papers and were analyzed upon categories of affiliation (Worldwide, Ukrainian, National Antarctic Scientific Center).

The analysis detected 112 Antarctic related publications (NASC affiliated – 8), originated from Ukraine for 2010-2018 (12,4 publication per year). Regarding global Antarctic publication output this put Ukraine in the 34th position. For the next two years Ukrainian scientists demonstrated rapid increase of publication activity (2019 – 21, 2020 – 29), which raised Ukraine in 31-32 position in global Antarctic publication output (Ukraine – 50, Taiwan – 51) in the period 2019-2020, accounting 0,9% of total number of Antarctic related publications worldwide. The major input in this boost was performed by NASC (26 papers). To enter TOP-30 countries Ukraine needs to demonstrate publication output over 35-40 papers annually.

To evaluate efficiency of Ukrainian Antarctic Programs the positions of Ukraine in global Antarctic publication output need to be compared with Ukraine's position in SCImago country ranking, where Ukraine had only 42th position in 2019 with 0,38% of total number of publications worldwide.

The percentage of international collaboration for Ukrainian Antarctic related publications (2010-2019 – 50%, 2020 – 59%) also is much higher than for all publications, originated from Ukraine (2010-2019 – 37-38%). Moreover, this index is even higher than average percentage of international collaborations in Antarctic related publications worldwide (2010-2019 – 42%).

The landscape of institutions, contributed to Ukrainian Antarctic publication output consists more over 40 organizations. But the most involved are Taras Shevchenko National University of Kyiv – 49, National Antarctic Scientific Center of Ukraine – 34, Institute of Molecular Biology and Genetics National Academy of Sciences of Ukraine – 23, Institute of Geophysics National Academy of Sciences of the Ukraine – 21, Institute of Radio Astronomy National Academy of Sciences of Ukraine – 14.

International collaborations in Ukrainian Antarctic related publications involved partners from 44 countries (USA – 23, Russia – 21, Germany – 16, UK – 16, Poland – 15, Australia – 14).

This analysis demonstrated qualitative changes in Ukrainian Antarctic research since 2019. The pace of publication activity foster gives optimistic expectations for Ukraine to enter TOP-30 Antarctic publication output countries, accounting 1% of Antarctic publications worldwide annually during next two years.

OPTIMIZATION OF EDITORIAL AND PUBLISHING PROCESS OF SCIENTIFIC PROFESSIONAL EDITION "UKRAINIAN ANTARCTIC JOURNAL"

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The Ukrainian Antarctic Journal (UAJ) is a scientific professional edition that for 2 decades has been publishing the achievements of Ukrainian and foreign scientists related to

Antarctic research, in particular in the area of Ukrainian Antarctic Akademik Vernadsky station and in the Southern Ocean. Scientific publications in the UAJ are related to such fields of science as geology, geography, biology, physics and mathematics.

To ensure a steady increase of the level of scientific publications, their availability in the world of scientific area, and to fulfill the tasks defined in the Procedure for forming the List of scientific professional publications of Ukraine, the UAJ editorial board has implemented a number of measures and introduced changes in this regard since 2018. The scale and frequency of the publication have been expanded; the number of English-language articles has increased to 80%. The double blind peer review has been implemented for all types of publications.

In order to adhere to the principles of objectivity and impartiality in the section of scientific material for publication, the Publication Ethics has been developed and the obligations of the editorial board, reviewers and authors are regulated. Due to the need to increase the presence of the UAJ in the scientific world, one of the key requirements of international scientometric databases has been implemented, namely: the geography of the editorial board has been expanded (now it includes editors from nine countries). The work on extension of the authors' geography continues. For the last three years, in addition to Ukrainian scientists, authors from Italy, Latvia, Poland, Belarus, the USA, China, and Australia have published papers in the UAJ.

Since 2019, the UAJ website (http://uaj.uac.gov.ua) has been transferred to the OJS 3.0 platform (Open Journal Systems) that provides an opportunity to implement all stages of the editorial and publishing process at the level of international standards. The same year, scientific publications in the UAJ were assigned digital object identifiers (DOIs) that allowed the journal to move to an international references model and make scientific materials more accessible.

As the UAJ supports the Budapest Open Access Initiative that aims to distribute scientific knowledge fluently and free of charge, the publication of scientific materials for authors and access to them for readers is free.

Due to the use of innovations introduced in the scientific world and services that improve the work of the journal, the publication has been present in the Directory of Open Access Journals (DOAJ), WordCat, Google Scholar since 2020, and is included in category B of the Register of Scientific Professional Journals of Ukraine in the fields of specialties: biology, ecology, Earth sciences, physics and astronomy.

For the further promotion of the UAJ in the scientific world it is planned to distribute information about the journal through its presence in international abstracts and scientometric databases, at scientific events in Ukraine and abroad, to present the journal in the scientific organizations related to the study of the polar regions, to use Internet facilities including social networks, to announce new issues, as well as popular research articles.

Further work in this direction opens the prospect for UAJ to enter Scopus and Web of Science scientometric databases and the formation of a positive image of Ukrainian science in Antarctic research throughout the world.

GEOSPACE IMPACT OF THE 2021 SOLAR ECLIPSES IN POLAR REGIONS

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Solar eclipses are a natural phenomenon that demonstrate the substantial influence of the Moon's motion on the omnipresent Sun-Earth connection. The Sun provides the ultimate electromagnetic energy, momentum, and to certain degree, energetic plasma inputs to the geospacer region that extends from several Re (Earth radius) to less than 100 km from the earth's surface. In particular, a sudden reduction in solar irradiation during a solar eclipse will result in sharp decreases of photo-absorption by neutral constituents in the thermosphere (the neutral component of the upper atmosphere) and of photo-ionization in the ionosphere (the plasma component of the upper atmosphere), among many other changes. Such changes are most prominent under the spatially localized eclipse umbral shadow. However, these change and other related processes can cause system wide geospace consequences, sometimes instantaneously. These include effects on system energy budget, thermal dynamics, plasma chemistry, transport, and electrodynamics. In general, Earth's polar regions exhibit fundamental magnetosphere-ionosphere-thermosphere (M-I-T) coupling which dominates regional and global geospace behavior. These changes occur most significantly during solar storm periods but also can occur under solar quiet conditions. Furthermore, key elements of high latitude electrodynamics linking the ionosphere and thermosphere up to the magnetosphere include electric currents and fields as well as magnetic fields. They are subject to dramatic changes during a solar eclipse above the polar regions and their vicinity, due to variations in conductivity (strongly correlated to ion production) and thermospheric winds (strongly correlated to neutral temperature or pressure gradients). Taken in aggregate, these factors are complex and interconnected enough that ionospheric and thermospheric effects of a solar eclipse remain poorly known for high latitudes and polar regions. However, advancing understanding of these effects is essential to gauge the potential for appreciable eclipse-associated magnetospheric changes at high latitudes. For all these reasons, high-latitude ionospheric, thermospheric, and magnetospheric responses to a solar eclipse are the main targets of the study described here. In 2021, two polar eclipses will occur in June and December solstices, respectively, providing rarely available comparable conditions for the study of M-I-T coupling under a solar eclipse as outlined above. International observational campaigns in both Antarctic and Arctic regions as well as in other surrounding regions along the eclipse path and along its magnetic conjugate path are being planned. Analyses of the comprehensive observational dataset as well as the theoretical M-I-T simulations will be conducted.

FORAGING ECOLOGY AND POPULATION DEMOGRAPHY OF RECOVERING HUMPBACK WHALES AROUND THE ANTARCTIC PENINSULA: A MULTI-NATIONAL, COLLABORATIVE RESEARCH PROGRAM

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Since 2009, dedicated cetacean research has been conducted in the nearshore waters around the Antarctic Peninsula with the general aim to better understand the behavior of baleen whales, how their populations are changing, and how this is impacted by climate change and other human activities. Our research team includes scientists from the many countries around

the world including the United States and Ukraine. Together, a collaborative partnership has been developed to help support long-term whale research by taking advantage of opportunities for data collection. In this talk, I will present a series of our major findings regarding: the foraging behavior of humpback whales throughout the feeding season and how this is affected by changes in their prey, how the body condition of humpback whales changes throughout the feeding season, inter-annual pregnancy rates that indicate variation in calf production but overall quickly growing populations, the genetic structure of the population of whales that forage on the western side of the Antarctic Peninsula, and the migratory behavior of these whales from Antarctic to their South/Central American breeding grounds. This research would not be possible without the partnerships that have be developed to bring researchers from many countries together to share in a common scientific goal and without the support of international governments and Antarctic programs to provide the opportunities for our science.

AN OVERVIEW OF THE YEAR OF POLAR PREDICTION IN THE SOUTHERN HEMISPHERE (YOPP-SH) AND ITS ACHIEVEMENTS

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YOPP-SH is an initiative of the World Weather Research Programme of the World Meteorological Organization (WMO) and is endorsed by the Scientific Committee on Antarctic Research (SCAR). It had a special observing period (SOP) from 16 November 2018 to 15 February 2019, chosen to bracket the austral summer months of primary operational activity in the Antarctic. 2,200 additional radiosondes were launched by 17 nations during the 3-month SOP, roughly doubling the routine program, and additional drifting buoys were deployed in the Southern Ocean. An evaluation of global model forecasts during the SOP confirmed that extratropical Southern Hemisphere forecast skill is lower than in the Northern Hemisphere with the contrast being greatest between the Antarctic and Arctic. Observing system experiments show that the additional radiosondes yield a better description of atmospheric conditions over Antarctica and as a result improve the forecasts of strong cyclones impacting the Antarctic coast. SOP data have been applied to study an atmospheric river event that was challenging to forecast and that impacted southern South America and the Antarctic Peninsula. Seasonal predictions by coupled atmosphere–ocean–sea ice models struggle to capture the spatial and temporal characteristics of the Antarctic sea ice minimum. Education, outreach, and communication activities will be summarized as well.

YOPP-SH is currently planning a second SOP, mid-April to mid-July 2022, coinciding with the rapid expansion of the sea ice cover. The project goal is to improve forecasts during the non-summer months as nations contemplate expanding to year-round scientific field investigations. In recognition of limited personnel and resources at this time of year, the Targeted Observing Periods (TOPs) approach is being adopted. Four TOPs of ~5 days duration each will be scheduled during the SOP with the focus on major oceanic cyclones, atmospheric rivers, and related events. The primary additional observations will be additional radiosonde ascents from Antarctica and lower latitude sites. Expanded oceanic observations are also planned. Two broad regions of particular emphasis are the Antarctic Peninsula and Weddell Sea along with the greater Ross Sea region. The scientific community is showing great enthusiasm for this new effort with about 30 participants joining the monthly online planning sessions.

SECTIONAL REPORTS

THE APPLICATION OF ANTARCTIC MICROORGANISM ON HYDROCARBON BIOREMEDIATION PROCESS

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There has always been a demand for petroleum products to cater to the consumption of daily human activities all over the world more so in Antarctica where diesel is the fuel of choice for transportation, heating and electricity. Many reports have established time and time again that Antarctic soil and its water are exceptionally high in diesel hydrocarbons. The bactericidal effects of some polyaromatic species in diesel and the severe climate conditions in Antarctica such as low temperature and poor soil nutrients have caused bioremediation approaches to be largely inefficient. Diesel-degrading bacteria and algae have been isolated from soils and water in Antarctica. The growth and degradation optimisations of diesel-degrading bacteria have been carried out using the conventional one-factor-at-a-time (OFAT) and statistical response-surface methodology (RSM) approaches. The RSM approach gave a better performance than OFAT. Based on the optimised parameters from *in vitro* RSM, the data were used to set up a bioreactor-based bioremediation as an *ex situ* approach to clean up both soil and water which are contaminated with petrogenic hydrocarbons. In this study, bacterial community isolated from soil successfully degrades up to 95% of 1.75% diesel, while marine bacterial community is able to degrade up to 80% of 1% diesel. The data obtained suggest the potential of Antarctic bacterial community in bioremediation applications in low-temperature diesel-polluted environments.

ANTARCTIC CYANOBACTERIA RESPONSE TO SALT STRESS

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Cyanobacteria are among the dominant microbial organisms in extreme Antarctic ecosystems. Their success in extreme Antarctic environment is largely due to their ability to adapt to a wide range of environmental conditions. In Antarctica, salinity has been reported as an important factor affecting cyanobacterial community structure. Cyanobacteria experiences salinity fluctuations during the winter and summer seasons. Freshwater becomes saline as a result of excessive evaporation over precipitation and mostly forms a thin layer of hypersaline brine below ice. Despite the presence of cyanobacteria in these changing saline environments, there is limited information about their physiological response to salt stress. Therefore, this study

will investigate the impact of salinity increase on Antarctic cyanobacteria, focussing on salinity tolerance and accumulation of compatible solutes. Cyanobacteria were isolated from deep freeze mats samples collected from various meltwater ponds, lakes and hydro-terrestrial environments in Cape Royds, Scott Base, Victoria Valley and McMurdo Ice Shelf. Seventeen (17) morphospecies belong to eight (8) genera. *Phormidium, Microcoleus, Wilmottia, Leptolyngbya, Phormidesmis, Leptolyngbya, Nodosilinea and Nostoc* were recorded. All the strains were successfully established as unialgal cultures, and the morphospecies identification was based on major phenotypic features observed in culture. Molecular analysis of 16S rRNA genes revealed complementary information from morphological identification. Salinity tolerance of all strains was tested in a culture dependent study, the strains were exposed to four growth media conditions, from freshwater (BG-11) to brackish (15‰) to marine (35‰) to hypersaline (65‰). The strains are grouped into three categories; a salt-sensitive strain that grew only at the control medium (BG-11); 5 low salt-tolerant strains (grew at 15‰ and 35‰) and the third group are 11 moderate salt-tolerant strains (65‰). Although the strains did grow at various salinity values, as it increased, reduced biomass and chlorosis were observed except for *Phormidesmis priestley* strain which showed consistent biomass concentration across all salinities tested. Currently, we employ the use of Nuclear Magnetic Resonance Spectroscopy (NMR) to characterise and determine the concentration of compatible solute accumulated by all the strains in all the salinities they survived. This study will increase our understanding of cyanobacterial adaptive strategy to salinities in Antarctic ecosystem.

STATISTICAL OPTIMISATION OF MOLYBDENUM REDUCTION USING PSYCHROTOLERANT MARINE BACTERIA ISOLATED FROM ANTARCTICA

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The release of industrial waste containing heavy metals into the environment has led to an emerging global pollution. Several studies have revealed rare heavy metal molybdenum (Mo) deposits in Antarctic environment. One of the alternatives to clean Mo from soil and water is bacterial remediation, which is described as the process of using bacteria to reduce hexamolybdate, Mo^{6+}, to a less toxic form, Mo-blue. The aim of this study was to investigate the reduction of Mo by a psychrotolerant Antarctic marine bacterium, *Marinomonas* sp. strain AQ5-A9. Mo reduction was optimised using conventional One-Factor-At-a-Time (OFAT) and Response Surface Methodology (RSM) approaches. Optimisation using OFAT was carried out based on selected parameters, namely salinity, temperature, carbon sources and its concentration, nitrogen source, nitrogen concentration, molybdate concentration and pH. Further optimization using RSM with Central Composite Design (CCD) identified optimum Mo reduction conditions

of pH 6.0 and 47 ppt salinity at 16 °C, with initial sucrose, nitrogen and molybdate concentrations of 1.8%, 2.25 g/L and 16 mM, respectively. The data obtained support the potential use of marine bacteria *Marinomonas* sp. strain AQ5-A9 on the bioremediation of Mo in cold regions.

DIVERSITY OF TERRESTRIAL CYANOBACTERIA FROM SELECTED HABITATS ON SIGNY ISLAND, SOUTH ORKNEY ISLANDS, ANTARCTICA

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A study was conducted to investigate the diversity of cyanobacteria from terrestrial habitats in Signy Island, South Orkney Islands during the expedition of British Antarctic Survey in austral summer of 2015/2016. Samples were collected following the previous locations that was provided by Broady in 1979. 37 out of 120 collection sites established by Broady (1979) were successfully acquired for this study. Seventeen morphospecies belonging to 14 genera; *Chamaesiphon*, *Cyanosarcina*, *Desmonostoc*, *Leptolyngbya*, *Microcoleus*, *Nodosilinea*, *Nostoc*, *Oscillatoria*, *Phormidium*, *Phormidesmis*, *Pseudanabaena*, *Synechocystis*, *Trichocoleus* and *Wilmottia* have been recorded. A novel species of *Nodosilinea*, *Nodosilinea signiensis* sp. nov. has been identified using a polyphasic approach. This strain has been characterized by its separation position in 16S rDNA phylogenetic tree. Morphologically, differences were apparent in cell size, cell shape, filament attenuation, sheath morphology and granulation to previously recorded members of the genus. The D1-D1' helix of the 16S – 23S ITS region analyses showed that *N. signiensis* is genetically distinct from other recorded species of *Nodosilinea*. Similar approach was carried out on two strains of filamentous cyanobacteria that resemble members from the genus *Phormidium* specifically the ones with narrow trichomes. However, the 16S rDNA phylogenetic analyses showed that both morphotypes were clustered within the major clade of the *Wilmottia murrayi*. To date, this genus at present contains only two species, *W. murrayi* and *W. stricta*. In this study, the occurrence of both *W. murrayi* USMFMS1 and *W. murrayi* USMFMS2 were first described from Signy Island.

GROWTH OPTIMISATION AND KINETIC PROFILING OF DIESEL BIODEGRADATION BY A COLD–ADAPTED BACTERIAL CONSORTIUM ISOLATED FROM TRINITY PENINSULA, ANTARCTICA

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The use of diesel fuel is crucial in human activities in Antarctica, leading to inevitable risks of spillage during transportation, storage and disposal processes. The multiple harsh environmental conditions of Antarctica heavily restrict the natural attenuation of petrogenic hydrocarbons which, therefore, show high persistence in the natural environment. The current study focuses on the ability of a cold-adapted crude bacterial consortium (BS24), isolated from soil on the north-west Antarctic Peninsula, to metabolise diesel fuel as the sole carbon source in a shake-flask setting. Factors expected to influence the efficiency of diesel biodegradation, namely temperature, initial diesel concentration, nitrogen source type and concentration, salinity and pH were manipulated using the Response Surface Methodology (RSM) approach. In RSM-optimised conditions (1.0% NaCl, pH 7.25, 0.75 g/L NH4Cl and 1.75% v/v initial diesel concentration), the highest total petroleum hydrocarbons (TPH) mineralisation was boosted to 95% over a 7 d incubation. The consortium was psychrotolerant based on its optimum growth temperature of 12.5°C. The kinetics of BS24 grown in diesel-enriched medium were shown to fit a Tessier secondary model with maximum specific growth rate, μmax, substrate inhibition constant, Ki and half saturation constant, Ks, being 0.9996 h-1, 1.356% v/v and 1.238% v/v, respectively. The data obtained suggest the potential of bacterial consortia such as BS24 in bioremediation applications diesel-polluted soils at low temperature.

ISOLATION OF POLYLACTIC ACID (PLA)-DEGRADING BACTERIUM FROM ANTARCTIC SOIL

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Plastic is widely used in our daily life. However, it is hard to be degraded in the natural environment and remains persistent for extended period of time. In order to solve this plastic pollution problem, environmentally friendly bioplastics have been attracting a lot of attention as these plastics can be degraded by microorganisms. Polylactic acid (PLA) is a type of bioplastic, which is synthesized from biological resources. In addition, several strains of psychrophilic bacteria had been reported to possess the ability to degrade plastics. The objective of this study is to isolate bacterial strains capable of degrading PLA from Antarctic soil and to determine its properties and its ability to degrade PLA films. Antarctic soil was added to a medium containing inorganic salts and PLA and incubated by shaking. As a result of enrichment culture, Gram-negative rod-shaped bacterium with catalase activity was successfully isolated. To estimate the biodegradation rate of PLA, isolates were added to a medium containing only inorganic salts and PLA film and incubated for 4 weeks. The number of bacteria increased after the incubation, as shown by the CFU counting method and the measurement of protein concentration. In addition, the weight of the film decreased by 6.4% compared to that before incubation. These results indicate that these isolates in the Antarctic soil have the ability to degrade PLA.

BIODEGRADATION OF WASTE CANOLA OIL (WCO) AND PURE CANOLA OIL (PCO) BY AN ANTARCTIC BACTERIAL COMMUNITY

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The use of edible oils, particularly different types of vegetable oil, has increased by at least a million metric tonnes per year worldwide in the last decade. Disposal of waste cooking oils into the sewage system and natural environment has become routine. Canola oil is the most common and widely used dietary fat in most Antarctic research stations. It is impossible to avoid some waste oil entering the Antarctic environment with the permitted release of 'grey water' from research stations and ships, while the risk of spillage events remains during storage and transport of oils to, from and within the continent. In this study, using native Antarctic bacterial communities, key environmental factors influencing biodegradation of waste canola oil (WCO) and pure canola oil (PCO) were optimised using one-factor-at-a-time (OFAT) and response surface methodology (RSM) approaches. Through OFAT, the most effective community trialled was able to degrade 94.42% and 86.83% from initial concentrations of 0.5% of WCO and PCO, respectively, within seven days. Using RSM, 94.99% and 79.77% degradation of WCO and PCO, respectively, was achieved in six days. The efficiency of canola oil biodegradation achieved in this study provides a support for the development of practical strategies for effective bioremediation in the Antarctic environment.

HYDROCARBON-DEGRADING BACTERIAL COMMUNITY PRESENT IN NON-CONTAMINATED ANTARCTIC SEAWATER

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Bioremediation of hydrocarbons has received increasing interest in recent decades, extending even to the harsh, isolated, continent of Antarctica. Antarctica faces chronically cold, often sub-zero, temperatures which reduce rates of biodegradation. However, it holds a natural reservoir of cold-adapted microorganisms, some with the ability to degrade hydrocarbons and other pollutants. Diesel is commonly used as a source of energy in Antarctica, and spills of various magnitude have occurred throughout the history of human presence on the continent, to the present day. This study evaluated the hydrocarbon-degrading ability of a bacterial consortium obtained from freshly-collected uncontaminated Antarctic seawater to utilise diesel fuel as a carbon source. Growth conditions for the consortium were optimised through both one-factor-at-a-time (OFAT) and statistical response surface methodology (RSM) approaches. RSM confirmed that salinity, nitrogen availability, temperature and initial diesel concentration all play significant roles influencing how the bacterial community utilises the carbon source. During a 6 d *ex-situ* experiment, fresh diesel of 4% initial concentration was reduced by up to 40% by the bacterial consortium in growth conditions of 1.5 g/L NH_4NO_3 25.0 ppt salinity at 10℃. This study confirms the presence of hydrocarbon-degrading bacteria in the largely pristine marine environment of Antarctica.

THE FIRST DISCOVERY OF TOXIN PRODUCING *WILMOTTIA MURRAYI* FROM CRYOPRESERVED ANTARCTIC CYANOBACTERIAL MATS

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A new microcystin producing benthic cyanobacteria, *Wilmottia murrayi* was isolated from 36 years old deep-frozen (-15^{o}C) cyanobacterial mat samples collected from Northern Victoria Land, Antarctica. Two strains from two different sites, 81 and 95 were successfully isolated and characterized using both morphological and molecular analysis. Morphologically, both strains resemble members of *Phormidium* Kützing ex Gomont (1892). However, phylogenetic analysis using partial 16S rRNA sequences of the two strains showed that they both formed a well-supported monophyletic clade with other *Wilmottia murrayi* and are well separated from the *Phormidium* clade. Amplification of a fragment of the *mcyE* gene involved in microcystin biosynthesis from both *Wilmottia murrayi* strains confirmed that they have this genetic determinant. Analysis of the extracts from these strains were further confirmed by Microcystin Enzyme-Linked Immunosorbent Assay (ELISA) kits for the presence of microcystin concentrations. This is a new discovery of microcystin synthesis from the cyanobacteria species *Wilmottia murrayi* both in Antarctica and worldwide.

DEVELOPMENT OF A DEFINED MIXED CULTURE (DMC) SYSTEM FOR EFFECTIVE REMEDIATION OF PHENOL AT LOW TEMPERATURE

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Biodegradation is one of the most effective and cost-effective methods for the mitigation of toxic phenol contamination from the Antarctic environment. Increasing levels of phenol contamination in the Antarctic environment, from human sources such as oil spills and wastewater discharge from vessels and research stations, bring significant risks to aquatic terrestrial ecosystems due to the compounds' highly toxic properties and persistence. Studies have reported the ability of specific Antarctic bacterial taxa to degrade phenol. More recently, the use of mixed microbial cultures has received research attention, based on the potential synergies resulting from the activity of different complementary biochemical degradation pathways in the strains present. In this study, a defined mixed culture (DMC) was developed using the native Antarctic bacterial strains *Arthrobacter* sp. strain AQ5-06, *Rhodococcus* sp. strain AQ5-07 and *Arthrobacter* sp. strain AQ5-15 in a 1:1:1 ratio and applied to aerobic phenol degradation at low temperature. Biostimulation of this DMC was evaluated by optimising its culture conditions using Response Surface Methodology (RSM). The identified that the DMC perform optimally in the presence of 0.4 g/L $(NH_4)_2SO_4$ and 0.13 g/L NaCl at pH 7.25 and temperature 12.5°C, with $(NH_4)_2SO_4$ concentration, NaCl concentration and temperature being significant factors. Under these optimised conditions, this DMC could completely degrade phenol up to an initial concentration of 1.9 g/L within 192 h. The efficiency of phenol biodegradation achieved in this study provides key information that will support the development of practical bioremediation strategies in the Antarctic environment. This study provides the first report of the effectiveness of DMC using Antarctic bacteria in degrading high concentrations of phenol at low temperature.

TRANSCRIPTIONAL RESPONSE IN POLAR PSEUDOGYMNOASCUS SPP. SOIL FUNGI FOLLOWING THERMAL CHALLENGE

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Global temperatures are predicted to rise due to climate change, thus prompting much research towards linking shifting environmental parameters to physiological response in polar organisms. Nevertheless, these studies are lacking in soil fungi, even though they constitute a significant proportion of soil microbial diversity and biomass. *Pseudogymnoascus* fungi are commonly isolated from polar soils and have been shown to secrete high levels of extracellular hydrolase enzymes, suggesting a role as important decomposers. In this study, we sought to measure transcriptional changes in these fungi in response to a transient heat treatment. Strains of *Pseudogymnoascus spp.* isolated from Arctic and Antarctic soils were cultured at 15°C (ideal growth temperature) for 5 days to reach log-phase, then transferred to 25°C (heat challenge temperature) for 2 hours. Among available *Pseudogymnoascus* spp. protein predictions, putative homologs of *Saccharomyces cerevisiae* HSP70 and HSP90 genes were identified and their expression following heat treatment was measured by quantitative real-time PCR. Consistently across all strains, two HSP70 homologs and the HSP90 homolog were upregulated, of which two were statistically significant in polar strains. Conversely, one HSP70 homolog was downregulated in all strains, demonstrating functional differences of homologous genes in the HSP70 family. RNA sequencing analysis of one of the Arctic strains revealed 2,992 differentially expressed genes (DEGs) between heat-treated and control samples. KEGG analysis identified pathways involving ribosome, amino acid degradation and glycerophospholipid metabolism as significantly enriched in DEGs ($P < 0.05$). To determine whether these DEGs were among the suite of genes involved in the environmental stress response (ESR) that is extensively characterized in other fungi, a BLASTP search was done against ESR genes described in the yeasts *Saccharomyces cerevisiae* and *Lachancea kluyveri*. 175 out of these DEGs are ESR genes (FDR < 0.001), of which 111 were downregulated and 64 were upregulated following heat treatment. The downregulated ESR genes are involved in ribosomes and translation, whereas the upregulated genes function in metabolism of amino acids, carbohydrates and lipids. Our findings show that short-term exposure to thermal stress heat stress in polar *Pseudogymnoascus* spp. resulted in inhibition of protein translation along with induction of cellular processed important for generating metabolic energy, consistent with observations reported in other fungi. Taken together, our findings provide preliminary evidence of a similar ESR programme in *Pseudogymnoascus* spp., and it is crucial that future studies dive deeper to unravel the response and adaptation of this important fungal genus to environmental change.

MOLECULAR IDENTIFICATION OF *PSEUDOGYMNOASCUS* SPP. ISOLATED FROM ARCTIC AND ANTARCTIC REGIONS

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Soil microfungi play important role in the carbon and nutrient cycling in terrestrial ecosystems. They produce extracellular hydrolytic enzymes (EHEs) that breakdown complex organic material. Species of the fungal genus *Pseudogymnoascus* are frequently reported in different substrates, especially in soils from the temperate and both polar regions. Like other saprophytic fungi, *Pseudogymnoascus* spp. produce a large number of extracellular hydrolytic enzymes (EHEs) such as cellulase, protease, amylase, beta-glucosidase, chitinase and esterase, indicating their importance in nutrient and biogeochemical cycling in soil ecosystems. One species *Pseudogymnoascus destructans* is a known pathogen causing the white-nose syndrome in bats, whereas many others are yet to be formally described as species and their taxonomy positions are still unresolved. In this study, we identified *Pseudogymnoascus* isolates, obtained from Artic and Antarctic soils by using multiple genetic markers. DNA sequences of Internal Transcribed Spacers (ITS), 28S ribosomal RNA (LSU) and minichromosomal maintenance unit (MCM7) from 31 taxa were concatenated and analysed to provide higher resolution phylograms. Neighbour Joining (NJ), Maximum Likelihood (ML), Maximum Parsimony (MP) and Bayesian (BI) phylogenetic analyses on ITS, LSU and MCM7 sequences revealed similar topologies with separate seven distinct clades (A & C, B, E, G, H, J, and L), which corresponded to the clades designated by Minnis and Lindner (2013). However, in our study, clades A and C could not be separated into two distinct clades. All four isolates were phylogenetically confirmed as *Pseudogymnoascus* taxa. They were found in Clade B in the phylogram but were not associated with any described species within the clade. Our study suggests that the four isolates may be novel species, and resolution of the phylogenetic tree could be further improved with the addition of more genetic markers.

MOLECULAR CHAPERONES HELP ANTARCTIC PSYCHROPHILIC YEAST, *Glaciozyma antarctica* PI12 TO COPE WITH HEAT STRESS

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Yeasts living in the Antarctic are believed to have adopted many strategies to respond to cold stress. The warming of the Antarctic will soon expose some of the Antarctic yeasts to warmer temperatures. It will be interesting to find out how the Antarctic psychrophilic yeasts will respond to heat stress. Molecular chaperones have been one of the main protein groups helping microbes to cope with heat stress. It is not known whether molecular chaperones in Antarctic yeasts play similar roles to those from mesophilic yeasts when they are exposed to heat stress. Hence, this project was set out to determine the *Glaciozyma antarctica* PI12 molecular chaperone gene expression patterns when it was exposed to heat stress. *G. antarctica* PI12 was

grown at its optimal growth temperature of 12 ºC and later exposed to heat stresses at 16 ºC and 20 ºC for 6 hours. The mRNAs of those cells were extracted, sequenced, and analysed. Thirty-three molecular chaperone genes demonstrated differential expression of which 23 were up-regulated while 10 were down-regulated. The up-regulated molecular chaperone genes were involved in protein binding, response to a stimulus, chaperone binding, cellular response to stress, oxidation, and reduction, ATP binding, DNA-damage response, and regulation for cellular protein metabolic process. In contrast, the down-regulated molecular chaperone genes were involved in chaperone-mediated protein complex assembly, transcription, cellular macromolecule metabolic process, regulation of cell growth and ribosome biogenesis. The data generated from this work have increased our knowledge on how molecular chaperones work together in a complex network to protect the cells under heat stress. More importantly, it highlighted the evolutionary molecular chaperone protective roles conserved in both psychrophilic yeast, *G. antarctica*, and mesophilic yeast, *Saccharomyces cerevisiae.*

STRONG AND WIDESPREAD CYCLOHEXIMIDE RESISTANCE IN THE EUKARYOTIC ALGAL GENUS *Stichococcus*

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This research was suggested by the discovery of a unialgal culture of *Stichococcus* (Chlorophyta) that grew in growth medium supplemented with 100 µg/mL Cycloheximide (CHX). Cycloheximide is a widely used antibiotic in purification of cyanobacterial cultures from eukaryotic contaminants. The two resistant strains of Stichococcus were originally isolated from soil on Signy Island, Antarctica. Sensitivity towards CHX was also examined on a Stichococcus strain isolated from the same island about 50 years ago as well as on Stichococcus strains from the Arctic, temperate and tropical regions in order to test how widespread resistance might be within the genus. The generic identity of all six strains was confirmed using the polyphasic approach which includes morphological, ultrastructural and molecular analysis. Based on morphological examination, four strains conformed to the description of *S. bacillaris* whilst two strains ("Antarctica 2" and "Arctic") conformed to *S. mirabilis*. Ultrastructure analysis showed no prominent difference between all studied strains. In 18S rDNA and ITS rDNA phylogenies, one strain was identified as *S. bacillaris* and was located within a strongly supported clade comprised of strains attributed to that species. The identity of the other five strains was not resolved. The sensitivity of each strain towards CHX was compared by determining the minimum inhibitory concentration (MIC), growth rate and lag time in the presence of different CHX concentrations. Five strains were highly resistant to CHX (MIC > 1000 µg/mL). Strain SAG 379-2 was resistant to a lower level (MIC = 62.5 µg/mL). All highly resistant strains had insignificant differences in growth rates between control and treatment (1000 µg/mL CHX). Among the highly resistant strains, the one with strongest resistance could grow in the presence of CHX without an initial adaptation period. Both phylogenetic and CHX sensitivity analyses suggest that CHX resistance is ancestral and widespread within the genus.

FUNCTIONAL FEATURES OF BIOGEOCHEMICAL MIGRATION SYSTEM OF TOXIC CHEMICAL ELEMENTS IN TERRESTRIAL ECOSYSTEMS OF GALINDEZ ISLAND

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The input of toxic chemical elements to Antarctic terrestrial ecosystems is a threat to the stability of their existence related to the slow flow of biogeochemical cycles, the linearity of the food web and the increase in anthropogenic influences in the region. Further intensification of human presence in Antarctica and climate change could have adverse effects on polar ecosystems. The Protocol on Environmental Protection to the Antarctic Treaty (the Madrid Protocol) was ratified by Ukraine in 2001. According to article 3 of this document the Antarctic-Environmental Protocol Parties should conduct continuous and effective monitoring to identify early possible unintended consequences of their activities. It is necessary to evaluate the functioning of the biogeochemical system of migration of toxic chemical elements in Antarctic terrestrial ecosystems in order to assess the characteristics of natural processes, to identify priority pollutants and their sources with a view to establish such monitoring programme.

The study used materials from the 25th Ukrainian Antarctic Expedition (UAE) in 2020. 47 samples of soil, melted water, soil invertebrates, moss, lichens, green alga *Prasiola crispa* and the land plant *Deschampsia antarctica* were collected from 6 model sites. The foliage projective cover, the thickness of soil cover, the quantitative development of the other ecosystem components were estimated. This made possible to estimate their stocks and biomass. The concentration of toxic metals was determined by flame atomic-absorption spectrophotometer C115-M1 with digital analytical complex CAS-101.

According to the results the distribution, accumulation and migration of Ni and Cr as well as Pb are distinct from Cd, Co, Cu, Zn, which share a common tendency. The area of the terrestrial ecosystem of Galindez Island, where the diesel power plant of Ukrainian Antarctic Akademik Vernadsky station is located, is characterized by clear signs of contamination of all components Pb, Cd, Co, Cu, Zn. However, there is no significant increase in Cr and Ni.

The main stocks of Cu, Zn, Pb (42-56%) in the terrestrial ecosystem of Galindez Island are found in the territory of Marina Point. The the major portion of Cd, Cr, Ni, Co (63-72%) is concentrated in the terrestrial ecosystem of the main part of Galindez Island. This indicates that the pathways to terrestrial ecosystems are not directly linked to the research station.

The waterway of migration from the Galindez Island is characteristic of all toxic metals except Pb. Accumulation processes predominate over migration processes for Pb. The annual amount of Pb input to the environment as a result of using the fuel of Akademik Vernadsky station is estimated at 3,427 kg with annual discharge by waterways migration of 0,197 kg. This reflects the intensive anthropogenic pollution of terrestrial ecosystems.

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PHYLOGENETIC RELATIONSHIPS OF THE GENERA PSEUDOALTEROMONAS, PSYCHROMONAS AND OCEANOBACILLUS IN THE POLAR REGIONS

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The aim of the study was the description of the population structure, phylogenetic status of *Nacella concinna* morphotypes and the biodiversity of the mollusc-associated microbiota in the water area of Argentine Islands. Distribution models of *N. concinna* were calculated for different sites. Distribution by depth and population density did not have a strict pattern and significant correlation with morphometric characteristics (shell length, mollusc weight). Barcoding of three *N. concinna* morphotypes was performed using mitochondrial genes 12S, 16S and CO1. The complex genetic structure of the *N. concinna* population and its connections with South American and other Antarctic mollusc populations were revealed. One hundred three pure bacterial cultures associated with molluscs (probably symbiotic microflora) were isolated. The microbiota was represented by halophilic, psychrophilic and mesotolerant gram-negative rod-shaped bacteria and cocci. Isolated pure cultures have oxidase and high agarase activity, as well as proteolytic (caseinolytic, keratinolytic) and glycolytic (α-L-rhamnosidase) activity. According to the barcoding by the 16S gene 29 isolated bacterial strains belong to the genera *Pseudoalteromonas, Psychrobacter, Shewanella, Bizionia, Cobetia, Oceanobacillus* and *Psychromonas*. Bayesian inference phylogenetic analysis revealed that strain 5c/2 belonged to the genus *Cobetia*, clustering with the strain *Cobetia crustatorum* that was isolated from jeotgal (a traditional Korean fermented seafood). Pure culture 16c/2 formed a clade with *Bizionia berychis* that was isolated from marine fish *Beryx splendens* collected from the North Pacific Ocean. Strain 9b/1 combined with halophilic strain *Oceanobacillus picturae*, that was collected from a glacial moraine in Qaanaaq, Greenland. Pure culture 8b/2 formed a clade with *Psychromonas arctica* associated with the sea ice from fjords of Spitsbergen, Arctic Ocean. AA1/1, AA1/7 and AA1/9 strains were combined with *Pseudoalteromonas arctica*, which was isolated from seawater samples collected from Spitsbergen in the Arctic.

Phylogenetic analysis of the *N. concinna*-associated bacteria showed genetic relationships with strains inhabiting the North Pole that may indicate its bipolar distribution and the likely role of currents in bacterial exchange between the polar regions.

ACTINOBACTERIA ASSOCIATED WITH *POLYTRICHUM STRICTUM* FROM THE GALINDEZ ISLAND (MARITIME ANTARCTIC): DIVERSITY, PROPERTIES AND BIOTECHOLOGICAL POTENTIAL

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The extreme environment of the Antarctic can cause unique properties of the microorganisms that inhabit this biotope. In our previous studies, we isolated actinomycetes from rhizosphere of *Deschampsia antarctica* É. Desv. and some of them are representatives of a rare genus *Umezawaea*. According to preliminary data, the genomes of these microorganisms

contain a significant number of the possible clusters of biosynthesis of biologically active compounds. Considering this, to continue studying the diversity of Antarctic microorganisms is important for screening producers of new antibiotics.

The purpose of the work was to study the diversity and properties of actinomycetes associated with dominant moss of Antarctic tall moss turf subformation - *Polytrichum strictum* Brid. from the area of the Karpaty Ridge of the Galindez Island (Argentine Islands, the maritime Antarctic). Samples of *P. strictum* collected in 2017 within the 22nd Ukrainian Antarctic expedition. Using various methods of sample preparation, we found 23 isolates which had an actinomycetes-like morphology.

Phylogenetic analysis of the nucleotide sequences of the 16S rRNA gene made it possible to classify the isolates into 4 genera: *Streptomyces* (7 isolates), *Micromonospora* (14 isolates), *Kribbella* (1 isolate) та *Micrococcus* (1 isolate). The optimal growth conditions of isolated actinomycetes were temperature 28-37 °C and pH 6-8. Some isolates, in particular *Streptomyces* sp. Psp 67-13 and 67-15, showed growth in a wide range of both temperatures (4-45 °C) and pH (4-12). Some strains of *Streptomyces* and *Micromonospora* could grow at up to 7.5% NaCl. *Streptomyces* sp. Psp 67-27 and 67-28 were produced melanoid pigments. The isolates demonstrated the ability to produce a large range of hydrolytic enzymes: amylases, pectinase, lipases, cellulases etc. Most of the isolates showed antagonistic effects against pathogens. Four isolates were antagonists of the gram-positive bacteria *Bacillus subtilis* and *Staphylococcus aureus*; one of them also suppressed the growth of MRSA. Among the isolates were identified antagonists to *Mycobacterium smegmatis*, a typical and multi-resistant strains of *Candida albicans*. Five isolates inhibited the growth of phytopathogenic bacteria. Most actinomycetes (15 strains) inhibited the growth of the phytopathogenic fungi *Aspergillus niger* and *Fusarium oxysporum*. According to the results of PCR screening in genomes more than 80% of isolates detected type I PKS genes, almost 70% contain genes of PKS type II and Polyene-specific CYP450, in 56% of isolates identified genes encoding an aminoglycoside phosphotransferase, which is responsible for resistance to aminoglycoside antibiotics, about 40% of isolates contain genes for isoprenoid synthesis. In 4 isolates there were identified the genes of NRPS and only *Kribbella* sp. Psp 67-2 contains the oxyB specific monooxygenase P450 gene.

The results indicate that the isolated actinomycete strains have a wide range of biological properties. This is clearly required for the synthesis of many bioactive compounds, some of which may not have been previously described. Genomic and metabolic profiling of these isolates will make it possible to assess the spectrum of gene clusters in their genomes and the chemical nature of the metabolites that they synthesize.

GIS AND CARTOGRAPHIC SUPPORT OF THE CHEMICAL COMPOSITION RESEARCH OF THE BOTTOM SEDIMENTS OF THE ARGENTINE ISLANDS` WATER AREA

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This research encompassed the content of heavy and other metals, non-metallic elements that may affect or indicate the presence of biological processes, based on samples of bottom sediments collected in the waters of the Argentine Islands in the straits of Meek, Stella, Skua.

Control samples were additionally collected from the mainland in the Penola Strait, the Barkhan Islands, near King George Island and near Pete Island, to determine the anthropogenic impact on the formation of bottom sediments. All samples were collected directly underwater during underwater research, except samples 4-6 of King George Island. The chemical analysis of the content of the following elements in the selected samples was performed: magnesium (Mg), strontium (Sr), iron (Fe), cesium (Cs), zinc (Zn), copper (Cu), manganese (Mn), lead (Pb), mercury (Hg), phosphorus (P), nitrogen (N), sulfur (S), hydrogen sulfide (H_2S), petroleum products. The nature of the distribution of elements is determined by local biological and geochemical processes. The obtained results show that in the control areas outside the constant anthropogenic impact, the indicators of the content of biogenic compounds are higher and the content of heavy metals is lower. The overall situation is not so straightforward, of course. Maximum allowable concentration was exceeded in some locations for Zn, Cu, Pb, Hg, and for S and H_2S in all sites. The maximum allowable concentration for Mn was not found to be exceeded. We detected a local significant excess of the maximum allowable concentration in the Stella Creek Strait for Pb and Hg. Our other publications will be dedicated to more detailed results.

Here we want to pay attention to GIS and mapping support of the research, which allows to improve geospatial analysis through visualization and application of GIS analysis tools. The mapping of the distribution indicators of the studied elements was performed in ArcGIS. Databases and GIS projects have been created over the last decade for the topography of the Argentine Islands and locally around Galindez Island, for the results of underwater surveys of benthic groups, for the chemical composition of primitive soils. The following was done based on research of the composition of bottom sediments in 2020: 1) geodatabase was supplemented with a new Argentines layer - sampling points of bottom sediments of the region with 14 attributive data of the content of elements; 2) 14 maps with representation of the separate elements content by method of localized (round) diagrams were concluded; 3) data and scales were systematized for the possibility of comparing the results of benthos research, analysis of the chemical composition of bottom sediments and primitive land soils to further identify geochemical trajectories of influence in the places of interaction land-water environment-bottom. Generalized modeling of the indicators for bottom sediments using extrapolation and interpolation methods cannot be performed now. The application of such methods requires a much larger number of sampling points in the study area. It is more expedient to monitor the areas of potential human impact and its activities in the near water area, in our opinion. The monitoring of that type should be implemented through an irregular network of checkpoints, which has yet to be substantiated based on our research in the future. We are planning to publish all summary results of the research soon in the form of a public web map using ArcGIS Online with additional information for each study point of benthos, primitive land soils, and bottom sediments of the Argentine Islands' water area.

ANTIOXIDANT PEPTIDES DERIVED FROM THE ANTARCTIC HYDROBIONTS

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Free radicals are fundamental to living organisms and represent an essential part of metabolism. But an imbalance between the formation of free radicals and their elimination leads to oxidative damage of proteins, nucleic acids, and lipids. A lot of studies reported that excessive generation of reactive oxygen species plays a central role in the pathogenesis of many diseases.

In this case, the timely intake of antioxidant supplements or food containing antioxidants may reduce the risk of oxidative damage and prevent disease progression. In recent years, antioxidant peptides have drawn significant research attention because of their numerous beneficial health effects. Taking into account that marine organisms are rich in bioactive compounds with valuable nutraceutical and pharmaceutical potentials we focused attention on the hydrobionts of the Antarctic region. The present study aimed to investigate the antioxidant potential of the peptides derived from the tissue of Antarctic limpet, Antarctic krill, and Antarctic jellyfish.

At first, the total antioxidant activity was estimated. Most free radicals that are generated in biological systems are quite reactive and exist only for a short period of time. Due to its stability, stable radical 1,1-diphenyl-2-picrylhydrazyl (DPPH) is widely used to predict the antioxidant activity of compounds. According to obtained data peptides from the tissue of Antarctic krill had the most pronounced ability to quench the DPPH radical (36%), which might indicate that the krill peptides are potential antioxidant compounds. The percentage of inhibition of DPPH by peptide derived from Antarctic jellyfish and Antarctic limpet were 10% and 7.5%, respectively.

The estimation of reducing activity of compounds serves as an additional test to check their ability to donate electrons or hydrogen. Antarctic krill peptides showed the highest reducing activity among the tested peptide fractions. The reducing activity of peptides derived from krill was observed to be 64%, whereas these values for Antarctic jellyfish peptides and Antarctic limpet peptides were 2.5% and 6%, respectively.

Considering that superoxide anion radical is one of the strongest reactive oxygen species, the scavenging effect of peptides on superoxide radicals was estimated. Only peptide fraction from Antarctic krill showed the scavenger potential on superoxide anion radicals. The superoxide anion radical scavenging activity of krill peptides reached 20% compared to 55% in the case of ascorbic acid. The capacity of the peptides from Antarctic limpet and jellyfish to scavenge superoxide radicals was about 3%.

Taken together, the findings from this study indicate that peptides derived from Antarctic hydrobionts might be used as natural antioxidant supplements in the management of oxidative stress or/and in the prevention of oxidative damage of food products.

SPECIES DIVERSITY OF THE PARASITE COMMUNITIES OF BONY FISHES FROM THE ARGENTINE ISLAND REGION, WEST ANTARCTICA

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Environmental changes caused by global warming and anthropogenic factors are observed in terrestrial and marine ecosystems around the world; they are particularly pronounced in Polar Regions of Arctic and Antarctic. Parasitic organisms are the most accurate indicators of the state of marine ecosystems since they are ecologically related to various groups of invertebrate and vertebrate animals. Our work aimed to analyze the species diversity of the parasite communities of main species of bony fishes from the Argentine Island region, West Antarctica to monitor the ecological state of Antarctic ecosystems.

In total, 20,392 specimens of helminths were collected from six species of bony fishes in the area of Ukrainian Antarctic Akademik Vernadsky station, Argentine Islands, West

Antarctica, in 2014–2015 and 2019–2020 during the 19th and 24th Ukrainian Antarctic expeditions. All helminths were identified by morphology; changes in the species diversity and structure of the parasite communities were analyzed.

All fishes were found to be infected with helminths of different taxonomic groups. In total, 30 helminth species were found, among them 1 species of Monogenea, 9 – of Trematoda, 4 – of Cestoda, 5 – of Nematoda and 11 species of Acanthocephala. The richest species diversity was observed in Antarctic black rockcod *Notothenia coriiceps* (26 species) and Antarctic dragonfish *Parachaenichthys charcoti* (26 species). Parasite communities of others fish species were less diverse: in *Notothenia rossii* 15 helminth species were found, in *Trematomus bernacchii* – 16, in *Chaenocephalus aceratus* – 23 and in *Harpagifer antarcticus* only 6 helminth species. Analysis of alterations in the species diversity in Antarctic black rockcod *N. coriiceps* revealed a significant decrease in the species diversity between samples collected in 2014–2015 and 2019–2020. Seven helminth species were found to be potential "indicator species" for further monitoring studies of *N. coriiceps* parasite community as a reflection of the ecological changes in Antarctic marine ecosystems.

BIPOLAR DISTRIBUTION OF FISH PARASITES OF ANTARCTICA

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The problem of bipolar distribution is one of the key issues facing taxonomists and biogeographers. What determines the similarity of the faunae of the polar regions – convergence in similar conditions of existence or origin from a common ancestor?

Paleontological evidence of bipolarity among bivalve mollusks of the family Buchiidae from the Late Mesozoic and Early Cretaceous periods is known. Bipolarity has been also shown for representatives of brachiopods and gastropods of those times. For the recent fauna, bipolarity is also known for other invertebrates, including bivalves, gastropods, echiurids, sipunculids, priapulids and pycnogonids, as well as fish families of liparids and zoarcids. Many species are reported to live in both polar regions.

This paper presents the results of a study of the phylogenetic relationships of two morphologically similar species of fish leeches, *Pterobdellina vernadskyi* from the Antarctic and *Pterobdellina jenseni* from the Barents Sea. Both species have common morphological features, in particular the lateral folds characteristic of this genus. There are also common features of the reproductive and digestive systems. Molecular phylogenetic analysis of *cox1*, *nad1* and tRNA Leu gene fragments was used to study 70 taxa of leeches from fresh and marine waters of both hemispheres, as well as 7 species of leeches from other families. Phylogenetic relationships were assessed by the Bayesian method using MrBayes v3.2.6. Both species form a single clade with a posterior probability of 98. In addition, the analysis included an unidentified Antarctic species from the Sea of Cosmonauts, which formed a common clade (with a posteriori probability of 99) encompassing some boreal fish leeches traditionally classified as the subfamily Platybdellinae.

These results indicate the existence of bipolar elements in the piscicolid fauna of polar regions. This suggests that bipolar disjunctions have played a significant role in the evolutionary history of Antarctic fish leeches. Antarctica was most likely the center of origin of this family, whose members colonized the sea and fresh waters of the Northern Hemisphere. On the other hand, the discovery of the undescribed leech in the Sea of Cosmonauts indicates the return of some Boreal species to Antarctic waters.

BACTERIA OF THE GENUS *PSEUDOMONAS* ISOLATED FROM ANTARCTIC BIOTOPES

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Microorganisms of Antarctic habitats have adapted to limited nutrients or their excess, humidity, low ambient temperatures, high concentrations of NaCl. Among the bacteria that were isolated by Romanovskaya V. A. et al. (2009), Tashyrev A. et al. (2010), Wang L. et al. (2016) from various substrates of Antarctica (soil, silt, grass, mosses, lichens, surface intertidal sediments), representatives of *Proteobacteria* (genera *Pseudomonas*, *Methylobacterium*, *Enterobacter*), *Firmicutes* (genera *Bacillus*, *Staphylococcus*), *Actinobacteria* (genera *Brevibacterium*, *Actinomyces*, *Streptomyces*) are predominant. The study of the adaptive capacity of Antarctic microorganisms allows to identify valuable biologically active compounds.

The aim of the work was to conduct phylogenetic analysis and investigate the physiological and biochemical properties of metal-resistant Antarctic isolates from different substrates. Phylogenetic analysis of 16S rRNA gene sequences of isolates was performed using the BLASTN service and the MEGA X program. Phylogenetic reconstruction was performed by the method of maximum likelihood (ML) after 1000 bootstrap replications using the Jukes-Cantor nucleotide substitution model (T. H. Jukes, C. R. Cantor, 1969). Physiological properties were detected using the Remel RapID™ONE reagent kit. Amylase, lipase, proteolytic, activity was detected by the ability to metabolize starch, tween-20, gelatin.

The nucleotide sequences of the isolates are deposited in GenBank (5A_1N_24 (MW362276), 9.9A_102 (MW362268), 79A_102 (MW362274), 89_1T_89 (MW362282)). Isolate 5A_1N_24 was isolated from a sample from Berthelot Island, 9.9A_102 – from Cape Rasmussen, 79A_102 – from Petermann Island, 89_1T_89 – from Galindez Island. According to the phylogenetic analysis of the 16S rRNA gene of isolates, they are classified as *Pseudomonas*. In particular, the 16S rRNA sequences of *Pseudomonas yamanorum* LBUM636 and *Pseudomonas yamanorum* 8H1 were 100% identical to the 16S rRNA gene sequence of isolates 9.9_102 and 79A_102; *Pseudomonas arsenicoxydans* Y24-2 99.93% and *P. arsenicoxydans* IHB B 6474 - 99.78% have the highest identity to the nucleotide sequence of the 16S rRNA gene of isolate 5A_1N_24. The nucleotide sequence of the 16S rRNA gene of isolate 89_1T_89 is 100% identical to the sequence of the 16S rRNA gene of the strain *P. arsenicoxydans* Y24-2 and 99.93% to that of *P. arsenicoxydans* IHB B 6474. Phylogenetic reconstruction confirmed the pairwise similarity of the 16 S rRNA gene of 9.9_102 and 79A_102, 5A_1N_24 and 89_1T_89; these isolates belong to the same clade. According to physiological and biochemical characteristics, isolates are different strains of *P. yamanorum* and *P. arsenicoxydans*. In particular, bacteria of the strain *P. yamanorum* 9.9A_102 are able to withstand up to 7.5% NaCl, form an indole from tryptophan, bacteria of the strain *P. yamanorum* 79A_102 are able to reduce nitrates. Also, the strains differ slightly in the ability to assimilate certain sources of carbon, to cleave ɣ-glutamyl-β-naphthylamide, pyrrolidonyl-β-naphthylamide, lysine decarboxylase activity, which does not correlate with belonging to the species *P. yamanorum* (Arnau V. G. et al., 2015) or *P. arsenicoxydans* (Campos V. L. et al., 2010). All studied strains are characterized by proteolytic and lipolytic activity, *P. yamanorum* 9.9A_102 and 79A_102 also have amylase activity.

This study was performed within project “Metabolic activity, physiological, biochemical and molecular-genetic characteristics of Antarctic metal-resistant strains of microorganisms” under the State Target Scientific and Technical program of research in Antarctica for 2011–2020.

ANALYSIS OF mtDNA HAPLOTYPES IN *BELGICA ANTARCTICA* JACOBS (DIPTERA, CHIRONOMIDAE) POPULATIONS

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Belgica antarctica is endemic to the Antarctic Peninsula. This species can be considered as a model organism for the studies of adaptation mechanisms and successful survival strategies in the harsh conditions of Antarctica. The elucidation of the above mechanisms is provided, inter alia, by monitoring studies at various levels (from molecular to population). Analysis of the structure of *B. antarctica* populations by molecular markers has been done in few studies and concerned *28S* rDNA sequences and the mtDNA *COI* gene. According to the sequence of the *B. antarctica COI* mtDNA gene, collected from 12 populations, belong to 16 haplotypes (according to 48 different sites). Haplotypes are clearly grouped into 4 haplogroups (A–D) (Allegrucci et al., 2012). However, the real situation in populations of this species and its dynamics remain insufficiently studied.

Imagoes of *B. antarctica* collected in March 2012 at Cape Tuxen (S 65.16155, W 64.07443) and on Mount Demaria (S 65.282435, W 64.100000) during the XVI Ukrainian Antarctic Expedition were taken for mtDNA analysis. DNA isolation was performed using QIAamp DNA Micro Kit (Qiagen, USA) according to the manufacturer's instructions. Before DNA isolation, the samples were washed from the ethanol in which the material was fixed. Analysis of mtDNA was performed by sequencing a fragment of the *COI* gene. To do this, the fragments were amplified by PCR using universal primers: LCO1490 and HC02198 (Folmer et al., 1994). After amplifying these fragments, they were purified using a QIAquick PCR Purification Kit (Qiagen, USA) and then sequenced on a sequencer Applied Biosystems 3730 DNA Analyzer (USA) according to Sanger. The sequences of the obtained gene fragments were analyzed in FinchTV Version 1.1.4 (Geospiza Research Team) and the online program for multiple alignment ClustalW.

All four examined sequences were 611 bp in length and were similar to the corresponding sequences of the *COI* gene of *B. antarctica* from GenBank. Three sequences (2 from Cape Tuxen and 1 from Mount Demaria) are identical to the sequence of *B. antarctica* collected on Berthelot Island (JQ672705.1) and belong to haplogroup D. One sequence (Mount Demaria) is characterized by nucleotide A instead of T in position 598 – such substitution was found neither for haplogroup D nor for other haplogroups in previous studies (Allegrucci et al., 2012).

Thus, *B. antarctica* from the vicinity of Akademik Vernadsky station is characterized by haplotype D mtDNA and the presence of one unique variant. Further studies are needed to establish the frequencies of mtDNA variants and their dynamics.

MOLECULAR-GENETIC ANALYSIS OF *COLOBANTHUS QUITENSIS* POPULATIONS FROM ARGENTINE ISLANDS REGION USING RETROTRANSPOSON MARKERS

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Colobanthus quitensis (Kunth) Bartl. (Caryophyllaceae), the Antarctic pearlwort, is one of two vascular plant species found in the maritime Antarctic. The species has the widest range among other genus members, which covers the western coast of Antarctic Peninsula and the southern Andes, and extends north to Mexico, where there are small scattered populations, but population genetic studies of this species are limited to a few studies. Furthermore, due to the fragmented range and limited population size, *C. quitensis* populations in the maritime Antarctic may be a useful model for studying the microevolution, in particular, the effects on genetic diversity of such factors as isolation, migration, and local adaptation. In this study, we assessed genetic variation and analyzed genetic structure of *C. quitensis* populations located in the Argentine Islands region (Graham Coast and neighbouring island groups).

In total, 97 plants from 11 isolated populations were analyzed, including ones from Girard Bay, Petermann Island (northern part), Irizar Island, Eight Island (small island south from Irizar Island), Galindez Island, Skua Island, Cape Tuxen, the greatest of the Berthelot Islands, Cape Pérez, Darboux Island, and Lahille Island. 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.

Totally 217 amplified bands were scored, among which 180 (82.9%) were polymorphic. The percentage of polymorphic bands in individual populations ranged from 18.0% on Cape Tuxen to 46.0% on Galindez Island with an average of 27.2%. The indices of genetic variability calculated from the PCR data for the total sample were as follows: Shannon diversity index (I) – 0.119±0.004; unbiased Nei's gene diversity (expected heterozygosity, He) – 0.081±0.003; and the average Jaccard's pairwise genetic distances – 0.341. According to AMOVA, significant proportions of variation among populations (43%) indicate a limited gene flow among the populations within the studied region. The obtained data indicate the relatively low genetic diversity of the species in the maritime Antarctic that is consistent with the data obtained earlier by other authors for Antarctic populations of *C. quitensis*. The populations under study differ in terms of genetic variation which can be explained by differences in size and origin of population, as well as other factors. The principal coordinates analysis (PCA) based on molecular genetic markers discriminated two main groups of plants, which differed in band patterns of three primers. One of them included plants from Cape Pérez, Darboux Island, and partially from the greatest of the Berthelot Islands. The population of the latter island appeared to consist of plants belonging to one or another of these two groups. The other group included samples from all other studied locations. These results may be explained by the existence of several relatively independent centres of dispersal of the species in the region.

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IN VITRO CLONAL PROPAGATION OF *COLOBANTHUS QUITENSIS* FROM THE MARITIME ANTARCTIC

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The aim of the study is to develop method of clonal propagation of Antarctic pearlwort *Colobanthus quitensis* (Kunth.) Bartl. (Caryophyllaceae) *in vitro*. *C. quitensis* is one of two vascular plants of Antarctica, whose adaptation to unfavorable conditions is maintained, in particular, by specific biologically active compounds. These compounds are able to provide protection of human skin against melanoma, herewith it is of high relevance to have a capacity to obtain the required amount of these plants' biomass in controlled laboratory conditions. **Methods.** Methods of plants' clonal propagation *in vitro* with authors' modifications were applied. The first part of this work was carried out in the laboratory of Ukrainian Antarctic Akademik Vernadsky station, and the second part - in the Department of cell population genetics in Institute of Molecular Biology and Genetics of NAS of Ukraine. **Results.** Samples of Antarctic pearlwort were collected on the Irizar Island (-65.221883°, -64.20357°) during austral summer (January - February 2019). The aboveground part of *C. quitensis* was collected in sterile plastic containers (150 ml) and subsequently surface sterilized in the laboratory of Akademik Vernadsky station. The sterilization procedure included washing under the running water during 5 minutes and vortexing in solutions (300 rpm) according the below scheme: twice in sterile distilled water during 3 min; once in ethanol 70% during 2 min; once in 5,6% NaOCl during 10 min; once in ethanol 70% during 2 min; three times in sterile distilled water during 3 min. Prepared plants were divided to in separate shoots with sterile forceps and planted on solid sterile Gamborg B5 medium (15 mL) with 3% saccharose and 0.1 mg/L naphthylacetic acid in 50 mL sterile Falcon tubes. Plants were left for root formation on the windowsill illuminated by the natural daylight (photoperiod 12/12) at room temperature (about 20°C). If bacterial infection was detected, plants were sterilized repeatedly and planted in fresh nutrient medium. After transportation to Ukraine, *C. quitensis* was planted in 250 mL glass vessels with 40 mL of similar nutrient medium in the Department of cell population genetics in the Institute of Molecular Biology and Genetics, National Academy of Sciences of Ukraine. Plants were adapted to new growth conditions, which included illumination of 2500-3000 lx, 13-14°C and photoperiod of light/darkness 16/8, during the first three months. Each rooted plant formed from two to 12 shoots during two months of cultivation. Plants were aseptically divided in separate shoots and planted in fresh medium. Period of micropropagation was reduced to 30 days. 41 initial seedlings yielded 124 clone plants. Index of propagation is 3. **Conclusions**. Method of *in vitro* clonal propagation of *Colobanthus quitensis* from natural habitat on Irizar Island (Argentine Islands, the maritime Antarctic) was developed.

COMPARATIVE STUDY OF BIOLOGICALLY ACTIVE COMPOUNDS CONTENT IN *DESCHAMPSIA ANTARCTICA* PLANTS OF DIFFERENT ORIGIN

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Secondary plant metabolites are a natural source of biologically active compounds, in particular polyphenols, which are widely used due to their low toxicity as well as pronounced antioxidant, anti-inflammatory, and antimicrobial properties. Synthesis of polyphenols in plants is known to increase under stress conditions. Vascular plants of Antarctica (*Deschampsia antarctica* É. Desv.), growing in extreme environmental conditions, can be considered as a promising source of polyphenolic compounds with a wide range of biological action. Limited plant material of *D. antarctica* makes advisable its culturing under artificial conditions. In the future, this will allow one to obtain in a controlled environment the required amount of high-quality standardized raw materials.

The aim of this work was to compare the biochemical composition of *D. antarctica* plants collected in natural habitats during the 25th and previous Ukrainian Antarctic Expeditions from 10 locations on the Galindez Island, 3 locations at the Lahille Island, one location from the biggest of the Berthelot Islands, Great Yalour Island, Darboux Island and Rasmussen Oasis, as well as artificially grown (*in vitro*) plants originating from seeds of same localities. Extracts were prepared from the leaves of *D. antarctica*, their composition was studied by means of HPLC and MALDI MS, and their antioxidant properties were estimated using the Folin-Chocalteu method and DPPH-test.

It was revealed that all extracts of *D. antarctica* had a high content of polyphenols, terpenoids, and carotenoids; the composition and amount of phenolic compounds were defined by the plant growth conditions. The highest content of flavonoids (about 8 mg/g) was found in the plants from two locations at the Galindez Island. In plants from the natural habitats, luteolin glycosides predominate among flavonoids, while *in vitro* cultures are characterized by significantly increased content of apigenin. Plants grown *in vitro* also have high content of carotenoids, simple phenols, and carboxylic acids. The highest content of phenolic antioxidants and the highest activity in the reaction with DPPH (inhibition of about 90% of radicals per hour) were registered for plant extracts from four locations of Galindez Island and plants from the biggest of Berthelot Islands and Great Yalour Island, as well as for extracts of two plants grown *in vitro*.

The study was performed in the framework of the State Targeted Scientific and Technical Program for Research in Antarctica for 2011-2020 with the financial support of the SI NASC MES of Ukraine (R&D No H/17-2020 "Study on the unique properties of biologically active compounds of *in situ* and *in vitro* Antarctic vascular plants").

CALLUS FORMATION, ORGANOGENESIS AND PLANT REGENERATION *IN VITRO* OF *DESCHAMPSIA ANTARCTICA*

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The objective of the work was to determine the optimal conditions for induction and proliferation of *D. antarctica* E. Desv. tissue culture obtained from plants from various localities of the Martime Antarctica. Previous cytogenetic analysis showed that the original plants used for callus induction included diploids (2n=26) R30 and R35 from Cape Rasmussen; G/D12-2a and G/D1-1 from Galindes Island; S16 and S22 from Skua Island; L57 from Lahille; W1 from Winter Island; Y62 from Great Yalour Island; DAR13 from Darboux Island; DAR12 diploid plant with B-chromosomes (2n=26+0-3B) from Darboux Island; Y66 mixoploid with a triploid modal chromosome number and chromosome rearrangements; Y67 mixoploid with a diploid modal chromosome number from Great Yalour Island (Amosova et al., 2015; Navrotska et al., 2017). Root, leaf, and shoot growth point (s.g.p.) segments were used as explants to induce callus formation. For callus induction, the following media were used: MS (Murashige, Skoog, 1962), B_5 (Gamborg, Eveleigh, 1968), 5S (Kunakh, Mozhylevska, 1997), 3S (modified 5S with sucrose content reduced to 30 g/L), which were supplemented with various concentrations of phytohormones such as 2,4-D, BAP, NAA, and Kin.

It was found that callus formation frequency depended on the mineral composition of culture medium, ratio and concentrations of growth regulators, type of explant, and genotype of a donor-plant. The highest rate of callus induction from different explants was observed on the following media: B_5 + 2 mg/L 2,4-D + 0,1 mg/L BAP; B_5 + 10 2,4-D + 0,2 mg/L BAP; MS + 5 mg/L 2,4-D + 0,1 mg/L Kin; and 3S + 2 mg/L 2,4-D +2 mg/L NAA + 1 mg/L Kin. On both variants of modified B_5 medium, callus formation rate from different explants ranged from 7.1% to 100%. These media were effective for callus induction from R35, G/D12-2a, S16, S22, W1, DAR13, Y62, and Y66 genotypes. The modified MS medium was the most effective for callus induction from R30 and DAR12 genotypes (4.5-100%) and the modified 3S medium was the best for L57, G/D1-1, and Y67 (2.9-100%). Callus induction rate was the highest for s.g.p. explants (33.3-100%), medium for root explants (3.4-56.3%), and the lowest for leaf explants (2.8-25.0%). The best growth rate of callus tissues of different genotypes in subculture was achieved on B_5 + 2 mg/L 2,4-D+0.1 mg/L BAP; MS +1 mg/L 2,4-D+0.1 mg/L Kin; and 3S + 1 mg/L 2,4-D + 0.1 mg/L Kin.

In addition to non-morphogenic, morphogenic tissue cultures were obtained from leaf and s.g.p. explants. When signs of regeneration appeared, the formed organogenic structures were transferred to light (6,500 Lux) and placed on medium B_5 + 0.1 mg/L NAA or 3S without phytohormones. Regenerated plants were transferred to pots with a mixture of soil : vermiculite : peat and then cultivated in a growth chamber under 16-hour light period at 16-18° C and humidity of 55-65%.

Thus, the optimal culture conditions were identified for the induction and proliferation of tissue culture from leaf, root and s.g.p. explants of *D. antarctica* from different localities of the Martime Antarctica. Non-morphogenic and morphogenic cultures were produced. The optimal conditions for obtaining and rooting of regenerated plants of *D. antarctica*, as well as for their cultivation in a growth chamber were determined.

The study was funded within the Targeted program of the NAS of Ukraine “Genomic, molecular and cellular bases for the development of innovative biotechnologies”, research project No. 0120U103216 “Development of cell culture technologies for production of plant-derived biologically active compounds for pharmaceutical and food industries” (2020-2024).

CORRELATION MODELS OF ADAPTABILITY *DESCHAMPSIA ANTARCTICA* GENOTYPES OF DIFFERENT ORIGIN GROWN UNDER *IN VITRO* CONDITION

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Main objective of the research was to construct adaptability correlation models of *Deschampsia antarctica* É. Desv. plants from the collection of genotypes obtained from seeds collected at different sites in the Argentine Islands region, the maritime Antarctic and grown *in vitro* in Institute of Molecular Biology and Genetics, National Academy of Sciences of Ukraine. **Methods.** Genetic distances by ISSR and IRAP markers according to the article (Navrotska et al., 2017) and genome size for genotypes set were used as basic indices of initial genetic heterogeneity for analyzed plant genotypes. To assess individual adaptability indices for *D. antarctica* genotypes measurement of the leaf length morphometric index and determination the flavonoids content by rutin were used. To estimate probabilistic relations, the method of extreme grouping was used for pairwise comparisons of series of differences of indices for each pair of genotypes. Within this method, when the increase/decrease of genotype differences in one index is accompanied by their increase/decrease in another corresponds to a positive probability connection value, while the increase/decrease of genotype differences in this index is accompanied by a decrease/increase in another one corresponds to its negative value. **Results**. Correlation models of adaptability were constructed in the form of a bipartite oriented graph based on probabilistic relationships between the pairwise differences of the four measured parameters: genome size, genetic distances, leaf length and flavonoid content in the leaves for *D. antarctica* genotypes set. **Conclusions**. The individuality of the adaptive portrait of all studied genotypes *in vitro* cultivation is shown. The influence of the main genetic characteristics: genome size and genetic distances on the adaptability indices leaf length and flavonoid content probably depended on auxin-related metabolism is shown. Among the studied genotypes we distinguished four different variants by correlation models. The first group contains diploid genotypes of the same origin Y62 and Y67, which have mostly positive connections, except for one negative in the graph 'genetic distances'. The second group contains genotypes Y66 and DAR12 with chromosomal polymorphisms that have negative relationships in the 'genome size' graph and between the graphs. The third group contains S22 and R35, characterized by the presence of only positive and neutral connections in both graphs. The fourth group contains diploid genotypes W1 and L59 characterized by two positive and one negative relationship in the 'genome size' graph and negative relationships in the 'genetic distances' graph and between the graphs. The genotypes individuality and their grouping according to the peculiarities of adaptability correlation models should be taken into account during experimental studies when these genotypes are used as model plants, especially in experiments to study the productivity regulation, study the influence of various exogenous factors and so on.

COMPARATIVE ANALYSIS OF THE CONTENT OF BIOLOGICALLY ACTIVE COMPOUNDS IN INTACT PLANTS AND TISSUE CULTURE OF *DESCHAMPSIA ANTARCTICA* E. DESV.

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The basis of plant resistance to adverse conditions is the restructuring of metabolic and physiological processes, as well as the synthesis of a number of biologically active compounds (BACs), which help to overcome the effects of stressors. In particular, the processes of adaptation of plants to low temperature stress are accompanied by the activation of the synthesis of flavonoids, which increase the resistance of plants to adverse environmental conditions. One of the model objects that can be used to study these processes is *Deschampsia antarctica* E. Desv. as extremophile plant that has adapted to the harsh conditions of Antarctica. In this work, we analyzed the quantitative and qualitative content of phenolic compounds and flavonoids in plants with different numbers of chromosomes under different growing conditions (growing in nature, cultured *in vitro*, regenerated plants and plants grown in a growth chamber), as well as in tissue culture *D. antarctica*.

The biochemical analysis showed that aerial part of *D. antarctica* plants has a higher content of phenolic compounds and flavonoids compared to the roots. It was found that the content of flavonoids in nature plants was in the range of 16.6–25.3 mg/g; in plants cultured *in vitro* slightly lower – 2.3–21.3 mg/g. In tissue culture of *D. antarctica* the amount of phenolic compounds and flavonoids was significantly lower than in donor plants of the original explants (1.65–4.46 mg/g – phenolic compounds and 0.15–7.17 mg/g – flavonoids). The largest amount of these compounds was found in wild plants from Yalour island, as well as hypotriploid plant Y66 grown in a growth chamber, which originates from the same island. Among plants cultured *in vitro*, the highest content of phenolic substances was found in plants of the DAR12 genotype. Regenerated plants did not differ significantly in the content of BACs from the original plants *in vitro*. The amount of phenolic compounds was similar in *D. antarctica* plants under different growing conditions. However, when transferring plants from aseptic conditions to a growth chamber, a significant decrease in flavonoid content was observed. No significant differences in the number of phenolic compounds and flavonoids for different chromosomal forms of *D. antarctica* were found.

The qualitative analysis of extracts by HPLC revealed 5 substances present in similar ratios in the samples of wild and *in vitro* grown plants. One of the abundant substances was identified as orientin or luteolin-8C-glycoside. These 5 basic substances (including orientin) could not be detected in the analyzed tissue cultures. Instead, they found three other more polar compounds, one of which is present in smaller amounts in *D. antarctica* plants. Thus, in tissue cultures there is a shift in the biosynthesis of BACs towards the formation of more polar metabolites. Calli of different origins contained mostly the same set of substances, but in different quantitative ratios, which did not depend on the type of source explant used for callus formation.

Thus, *D. antarctica* plants contain significantly more BACs than tissue culture. The content of phenolic compounds and flavonoids in plants cultured *in vitro* is generally comparable to that in wild plants. It is shown that the transition of cells to undifferentiated growth is accompanied by a decrease in the content of BACs and significant changes in their qualitative composition. Cultivation of plants *in vitro* may lead to some reduction in the content of phenolic compounds and flavonoids compared to plants *in situ*. However, in general, the levels of their accumulation are comparable, which gives reason to consider the culture of *in vitro D. antarctica* as a promising system for obtaining appropriate BACs.

GENTOO BREEDING CHRONOLOGY BY CEMP CAMERAS - VALIDATION EXPERIMENT

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The results of validation experiment for time-lapse cameras pictures of the CEMP camera monitoring project of CCAMLR at Galindez Island gentoo colonies are discussed. Gentoo (*Pygoscelis papua*) penguin colony population behavior/dynamics were studied during 2018/19, 2019/20 and 2020/21 seasons. The aim of this work is to investigate qualitative changes in the habitats of P. papua penguin populations in the CCAMLR Subarea 48.1 under the influence of climate change and krill fishery: nesting behavior, feeding and breeding of penguins as key species of the Antarctic ecosystem; the results will be used for monitoring and forecast of the krill population state within CAMLR Ecosystem Monitoring Program CEMP of the CCAMLR. The detailed observation of bird arrival, nesting, hatch and crèche has been provided in two colonies at GAI CEMP site at Galindez Island nearby the Akademik Vernadsky station. We inform on the results of visual survey of penguin population and penguin count. During three seasons the winterers-biologists at Akademik Vernadsky station, provided continuous observations every day/each five days of Gentoo's GBV and GPP sites. The results of visual observations of penguin population changes are discussed. The three seasons of the data validation experiment have been provided for pictures from time-lapse cameras of the CEMP camera monitoring project of CCAMLR are discussed. During 2017/18–2019/21 seasons, biologists-winterers at GAI CEMP site, provided daily observations of 15 gentoo nests chosen at the three monitoring sites GBW, GPP1 and GPP2, simultaneously with automatic time-lapse cameras taking pictures. The results of visual observations have been compared with data from camera pictures, which registered the same nests that were observed. The comparison of lay, hatch, and crèche dates was undertaken. The comparison of the first and second lay, first and second hatch, and crèche dates demonstrates the reasonable correspondence within 0-3 days between visual observations and data, obtained by pictures processed. The preliminary results exhibit the reasonable correspondence within 0-3 days between visual observations and time-lapse camera data for three seasons. The standard deviation for each event varies from ±1 to ±3 days for 15 control nests at the three test sites. The time delay in 1 to 3 days between the registered dates by camera and visual observations was recorded. This delay should be taken into account when the event dates from camera data analyzed without correspondent visual observations.

PHOTO-IDENTIFICATION STUDY OF HUMPBACK WHALES (*MEGAPTERA NOVAEANGLIAE*) NEAR THE SOUTHERN ORKNEY ISLANDS DURING AUSTRALIAN SUMMER 2020-2021

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The unique pattern of pigmentation, shape and natural markings on the ventral side of the fluke of humpback whale allows individual identification. Photo-identification of humpback whales is a widespread methodology to study biology, behaviour and ecology of both individuals and populations of that species.

Photo-identification study of humpback whales (*Megaptera novaeangliae* Borowski, 1781) was conducted during the Australian summer 2020-2021 from December 2020 till March 2021 in waters around Southern Orkney islands. Opportunistic-based photo-identification study extends the long-term cetacean monitoring program based at the Akademik Vernadsky station. The Ukrainian krill fishing trawler "MORE SODRUZHESTVA" was used as the opportunistic platform. Photos were taken from the main deck of the vessel (7 m height) and starboard sides of the captain's bridge (17 m height) by two photographers. Photos were taken with two cameras: Canon EOS 70D with 70-300 mm lens 1:4-5,6 IS and Canon EOS 7D Mark II with Canon EF 100-400mm f/4.5-5.6L IS II USM lens.

293 individuals were identified and cataloged from 352 good and high-quality photographs of humpback flukes, and 27 (9,2%) of them were re-sighted during the cruise. 21 re-sighted animals were met twice in the same day and only 6 from that 27 re-sightings (22,22%) occurred on other days. Maximum gap between re-sightings was 6 days. The high number of re-sightings is due to trawling routes around the South Orkney islands: krill fishing implies moving around krill spots from a day to a week. Some of the groups of humpbacks were met 4 times during the cruise. Groups of whales from 1 to 18 individuals were recorded, and more than 2000 sightings were registered during the survey. Median group size was 2.

All the individuals were primarily divided into 5 groups based on individually unique and stable patterns of black and white pigmentation on the ventral side of the tail flukes and specific individual marks (e.g., scars): Trailing edge (TR), Notch (N), Black border (B), Black center (BC), Black (B). As a result, we have 8,87% of humpbacks belonging to the Trailing edge group; 19,45% from the Notched ones; 21,5 Black centered whales; Black border flukes have 27,3% of animals and 22,86 were the all Blacks. Also, secondary characteristics were used for identification (black stem, damage, rare mark, white in other regions). We observe similarity of fluke patterns in groups – particularly in mother-and-calf groups. Mark-recapture techniques and matching with other catalogues would allow to investigate migrations, abundance and population dynamics of humpback whales near South Orkney islands.

CETACEAN SPATIAL DISTRIBUTION NEAR THE SOUTHERN ORKNEY ISLANDS DURING ANTARCTIC KRILL FISHERY, AUSTRALIAN SUMMER 2020-2021

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Cetacean observations were conducted onboard the Ukrainian trawler "MORE SODRUZHESTVA", which fished Antarctic krill and was used as a platform of opportunistic research during the cruise from December 2020 till March 2021. During the Australian summer the fishing grounds were in the CCAMLR Statistical Area 48.2 (South Orkney Islands). Visual observations of marine mammals were conducted from the port (P) and starboard (S) sides of the captain's bridge (height 17 m) by two observers. Two data sets were recorded: Effort parameters (observation details, time, date, weather conditions, vessel speed and course, etc.) and Sightings parameters (geographical coordinates, species and number of animals in a group, distance from the vessel, behavioral specific details, etc.).

As a result, over the observation period 1232 sightings from the starboard (corresponding to at least 3027 individuals) and 1404 sightings from the port side (corresponding to at least 3530 individuals) were recorded. Baleen whales belonging to four species, humpback whale (*Megaptera novaeangliae*), fin whale (*Balaenoptera physalus*), southern Minke whale (*Balaenoptera bonaerensis*) and southern right whale (*Eubalaena australis*), were observed. Also, there were a few sightings of killer whales (*Orcinus orca*). There were no significant differences in species composition between observations registered from different boards. Approximately 70% of sightings were humpback whales, 25% were fin whales and other cetacean species accounted for about 5%. Observed humpback whale group size varied from 1 to 18 individuals, on average 2.18(S) and 2.25(P) (median 2) individuals in the group and fin whales were in groups of 1-30 individuals, on average 4.2(P) and 4.4(S) (median 3) individuals in the group. Besides that, there were several records of mixed groups of humpback whales and fin whales or minke whales.

The observation period was divided into three equal intervals 23 days long to describe dynamics in local occurrences (registered groups per hour) of humpback/fin whales. In the first cycle (25.12-16.01), the occurrence of baleen whales was the lowest, 4.36 group/hour and 0.23 group/hour for the hump and fin whales respectively. The maximum occurrence falls on the second period (17.01-09.02) and was 9.46 group/hour for the hump and 3.64 group/hour for the fin whales. Further, for the last period corresponding to the end of Australian summer (10.02-04.03) occurrence of the fin whales remained at about the same level as in the previous period - 3.4 groups/hour, and for humpbacks it decreased to 4.79 groups/hour.

TEMPERATURE CONDITIONS OF DWELLING OF ANTARCTIC TOOTHFISH (*DISSOSTICHUS MAWSONI*) IN ANTARCTICA (WEDDELL, ROSS AND AMUNDSEN SEAS)

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In order to study the ecological links between the fishery and the environment and in accordance with the commitments made by Ukraine at the XXXVI session of the CCAMLR, observers on Ukrainian vessels, in addition to their main responsibilities, also performed some oceanographic work that was possible at the fishing ships. These procedures on Ukrainian ships were performed using a DST CTD recorder manufactured by the Icelandic company STAR OGGI. For three fishery seasons in 2017-2020, 127 stations were made in the Weddell, Ross and Amundsen Seas. Vertical temperature variability, temporal and spatial variability of bottom temperature was analyzed. Interannual variability of temperature in some seas was discovered (in almost all regions there was a slight decrease in water temperature along the entire vertical). Particular attention was paid to the effect of bottom temperature on toothfish catches. A clear dependence of catches on effort on the bottom temperature was observed only in some areas and in certain periods. There was a slightly better dependence of catches on effort from the temperature on the horizons of 500 and especially 1000 meters. Summarizing the data for the three Seas (taking into account both the optimal temperature and trends), it was concluded that the optimal temperature range for the Antarctic toothfish is -0.11 to +0.01 °C. For the Weddell Sea, this is depth about 1600-1800 m, for the Ross Sea - 600-900 m, and in the Amundsen Sea such a temperature in the bottom layers is not observed at all, as in this sea does not form a cold local deep-water mass (modified shelf water). This may explain the lower catches per effort in this sea compared to, for example, the Ross Sea. Only subdivision 48.1 falls out of the overall picture. There is an optimal temperature for fishing -0.33 to -0.44 °C here and there is a tendency to increased catches with its further decrease. In the Weddell Sea, maximum catches were obtained with minimum bottom temperature gradients. This seems strange, because of course, fish concentrations are caught with trawl gear near gradient zones. This may not be the case for more scattered objects of longline fisheries.

STUDY OF THE STATE OF THE IMMUNE SYSTEM OF ANTARCTIC EXPEDITIONS MEMBERS

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NK frequency and NK cytotoxicity are significant parameters for clinical outcome and predicting complications of health. In our previous study we showed prognostic clinical significance of immune parameters when they are out of favorable corridor (accentuated). We showed associations between immune accentuations and negative IVF and pregnancy outcome. We also found that combination of immune accentuations increased negative clinical significance in children with viral infections. Demonstrating phenomena support our idea about clinical significance of Immune Accentuation as possible prediction marker. Our data approve immuno-accentuation theory. This approach is also significant for specific clinical favorable prognostic values formation.

Participants of Antarctic expedition form a unique group for investigations of Immune accentuations' significance for estimation of health condition and prediction of complications.

We study lymphocyte subsets (CD3+, CD3+CD4+, CD3+CD8+, CD3-CD56+, CD3CD56) and levels of KIR receptors and activation marker (CD158a, CD335 and HLA-DR) on lymphocyte subsets. We also investigated NK cytotoxicity levels against cell lines K562 and MOLT-4. We analyzed IgG, IgM, IgA levels and levels of anti-Cov19 and anti-phospholipids antibody levels. We froze serum sampled for comparison with samples that was taken in of Antarctic expedition time and with serum samples that will obtain after "coming back home".

We plan to find immune predictors of unfavorable health complications. We also plan to find the answer - how the Antarctic expedition affects the immune system and immune phenotype.

ASSESSMENT OF *COLOBANTHUS QUITENSIS* GENETIC DIVERSITY IN THE ANTARCTIC BY ANALYSIS OF INTRON POLYMORPHISM OF CYTOSKELETON PROTEIN GENES

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Colobanthus quitensis (Kunth) Bartl. (Caryophyllaceae) is one of the two angiosperm species in the Antarctic and has a very long latitudinal range, which in this region is represented by isolated island populations in a wide diversity of conditions, so much attention is paid to the study of its morphophysiology. At the same time, insufficient attention has been paid to the study of genetic differences between *C. quitensis* populations. Information about the genetic diversity of vascular plants in the Antarctic has been obtained mainly from the results of a small number of studies on *Deschampsia antarctica* É. Desv. (Poacea). Currently, our knowledge regarding the genetic characteristics of Antarctic pearlwort is drawn from isoenzyme analysis or based on a small sample of plants. One of the most informative population genetic studies of *C. quitensis* is its analysis using sequences of mobile elements.

Today, marker systems based on the assessment of intron length polymorphism (ILP) are gaining more and more practical application. For vascular plants of the Antarctic region, one such method - assessment of tubulin gene intron polymorphism (TBP) - was used to evaluate genetic polymorphism levels of island populations of *D. antarctica*. Molecular genetic analysis of *C. quitensis* using ILP-marker systems, in particular those based on the studied intron polymorphism of highly conserved cytoskeleton protein genes, has not been done before. Therefore, the aim of the study was to identify molecular genetic differences between different populations of *C. quitensis* in the Antarctic by estimating the intron length polymorphism of α-, β- and γ-tubulin genes, as well as actin.

The analysis of the intron length polymorphism of the α- and γ-tubulin genes failed to reveal genetic differentiation between individual *C. quitensis* populations from the Antarctic. At the same time, by estimating the intron length polymorphism of actin genes, it was found that populations of *C. quitensis* from Skua Island (Argentine Islands) had amplicons, unique to this location. Molecular genetic differences between *C. quitensis* populations from the western coast of Graham Land were also revealed by assessing the 1st and 2nd intron polymorphism of the β-tubulin genes. The 1st intron length polymorphism of the β-tubulin genes indicates that among

the studied populations of the Antarctic pearlwort, populations from Cape Pérez, Darboux Island and some of the samples from Berthelot Islands stand out. In general, the low level of genetic polymorphism of *C. quitensis* in Antarctic was shown by the intron length variability of the cytoskeleton protein genes.

GEOLOGICAL SURVEY ON THE UKRAINIAN ANTARCTIC STATION AREA (THE HISTORY, CURRENT STATE AND THE FUTURE)

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Geological exploration of the Graham Coast and adjacent islands of Wilhelm Archipelago where Ukrainian Antarctic station (UAS) is located were started in 1904 by the French expedition under the command of J.B. Charcot. The regional geological studies were continued by British researchers in the 1930s and 1950s. The main volumes of geological survey were carried out under adverse conditions. Therefore, the created medium-scale geological maps turned out to be fragmentary and insufficiently provided with factual material. Due to the poor ice conditions and the local peculiarities of the organization of geological routes, the numerous bays that sink into the Graham Coast, as well as its inaccessible inland areas remained unexplored. Similarly, part of the islands of the Wilhelm Archipelago remote from the navigable Lemaire Channel, Penola Strait and Grandidier Channel, were not explored at all. The Argentine Islands were the only area where large-scale geological surveys were conducted. However, the geological map created in the course of this survey has a number of significant shortcomings. In particular, only purely petrographic data without beddings of rocks, tectonic deformations, zones of postmagmatic changes and manifestations of ore mineralization were plotted on this map. The spatial distribution of some geological formations was not always true. The age of individual geological bodies was insufficiently substantiated or erroneously determined. All of the above explains why the level of geological study of the area at the time of the establishment of the UAS remained much worse compared to adjacent territories.

Since 1996, the Graham Coast and Wilhelm Archipelago have been studied by Ukrainian scientists. Specialized studies in geophysics, geomorphology, sedimentology, geochronology, petrology, geochemistry and ore formation are carried out in the UAS area. In the course of research, specialists in all these branches have repeatedly encountered inaccuracy or complete absence of geological data on certain objects. Therefore, in 2017, the authors began work on geological surveying and geological mapping of the UAS area, which continues to this day. In addition to the Argentine Islands, large-scale geological surveys now cover large areas on the Berthelot Islands, Roca Islands, Anagram Islands, Vedel Islands and Petermann Island. On the mainland of the Graham Coast, the coastline of the Kyiv Peninsula from Cape Renard to Cape Tuxen has been surveyed, including the unexplored inland area of Girard Bay and Waddington Bay. Several reconnaissance routes have been made deep into the Kyiv Peninsula along the line of Rasmussen Hut – Mount Mill – Guys Cliff – Bussey Glacier – Rusty Rocks. As a result, new data were obtained on the general state of the exposed areas, the available rock outcrops, their geological occurrence and petrographic composition, associated mineral formations and ore-bearing capacity. A number of previously unknown geological objects have been identified, in particular: Mesozoic sedimentary strata including fossiliferous ones; the conduit volcanic facies and ignimbrites; layered gabbroic intrusions, gabbroids with orbicular and comb-layered structures; hybrid igneous formations with the mafic magmatic enclaves, the mafic dykes swarms; the subvolcanic rocks of Neogene-Quaternary age; new manifestations of Cu, Ti, V, Cr, TR and Th mineralization. Further perspective for geological study and estimation of the mineral

resource potential of the UAS region should be determined by the State Targeted Scientific and Technical Research Program in Antarctica, which was recently extended by Government decision until 2023.

APPLICATION OF GEOPHYSICAL AND BIOLOGICAL APPROACHES FOR INVESTIGATIONS OF ICE-CAPS ON THE ARGENTINE ISLANDS (WEST ANTARCTICA) (TIME PERIOD: 2017-2020)

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Ground penetrating radar (GPR) investigations of the ice-caps on Wilhelm Archipelago islands were started in April 2017. Investigations include measurement of the ice thickness, identification of interior structure of the ice-caps, investigation of water saturated areas and monitoring of interior changes.

Monitoring of the Argentine Islands ice-caps interior changes was started in April 2017. The surveying is done once a month on the Woozle Hill (Galindez Island). Other sites are more remote from the Ukrainian station and surveyed more seldom: Winter and Skua islands – 2-3 times per year, Corner, Irizar, Barchans, Uruguay islands – once per year.

Measurement of the ice thickness and subglacial topography of the major ice-caps on Argentine Islands was done during seasonal GPR investigations by Ukraine-Latvia expedition in 2018. The ice thickness and presence of the crevasses which provoke GPR anomalies under the ice were confirmed by drilling results.

The subglacial lake was identified on the island Uruguay by GPR surveying results. The presence of water under ice was confirmed by drilling. However, it is probably not an isolated system, as biological samples show the presence of the same crustaceans *Brachinecta gaini* (redefined; previously identified as *Brachinecta granulosa*) in the water of the lake on the open-air Earth surface and in the subglacial lake.

Ground penetrating radar surveying is one of the most productive and informative methods for the investigation of under surface area in polar regions. This method helps to investigate objects of high scientific interest in Antarctica: glaciers, ways of under ice water migration and accumulation, helps to investigate Antarctic soils thickness. Research of the subglacial topography would help to understand glacial, geological history of the region. Mentioned topics are among major research directions of the Scientific Committee on Antarctic Research (SCAR).

THE RESULTS OF LONG-TERM TECTONOMAGNETIC RESEARCH ON ANTARCTIC GEOPHYSICAL POLIGON

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Tectonomagnetic studies in the area of Akademik Vernadsky station are performed in order to study the current dynamics of the Antarctic Peninsula, its tectonic zoning and to identify tectonic faults and geological structures. Tectonomagnetic investigations are based on the study of temporal changes in the local magnetic field of the Earth - tectonomagnetic anomalies, and their tectonophysical interpretation. The Akademik Vernadsky station area is located in the zone of influence of subduction processes on the borders of the Antarctic plate and the Skotia plate, Bransfield rift. Deep faults of sublatitudinal and submeridial direction near UAS, within which active seismotectonic processes take place, the study of which is of great importance for building models of deep structure of the Earth's crust and forecasting of mineral deposits. Given the specifics of the area of work, tectonomagnetic points were established mainly on the islands of the Argentine archipelago. Two tectonomagnetic profiles were laid down: sublatitudinal profile I (Barchans - Rasmussen) - total length 11 km, 7 (17) points, on which 13 cycles of observations were carried out (1998-2020); submeridional profile II Darbo - Pleneau - total length 34 km, 14 observation points.

According to the results of tectonomagnetic observations for each point of the poligon, the temporal changes of the local geomagnetic field were determined, and the regularities of their spatiotemporal structure were investigated. According to the nature and amplitude of tectonomagnetic variations, the zoning of the poligon territory was performed. In the area of works three characteristic tectonomagnetic zones under the conditional name western, central and east are allocated. The western zone - Barchans Island, Three Little Pigs Island, Forge Island, Skua Island, Grotto Island is characterized by a pronounced negative linear trend. The most intense changes in ΔF are characteristic of Three Little Pigs, where in point 3 they reached -44 nT for the period 1998-2020. The central zone - Galindez Island, Skua Island, Yalour Island, Uruguay Island, Petermann Island, Irizar Island, is characterized by insignificant, minimal changes in the ΔF field, which fluctuate relative to the zero horizontal trend almost within close to the error (± 1.5 - 2 nT). The eastern zone - Tuxen Cape, Rasmussen Cape, Rasmussen Island, has a peculiar morphology: an almost nonanomalous ΔF field in 1998-2003, and a sharp negative trend after 2004. This zone captures the mainland of the poligon.

The nature of tectonomagnetic anomalies is probably due to the piezomagnetic effect, which is due to the occurrence of magnetization in the ferromagnetic substance under the influence of tectonic stresses in the presence of an external magnetic field. Based on the piezomagnetic mechanism of tectonomagnetic anomalies, the magnitude and direction of tectonomagnetic breach in the upper part of the Earth's crust were estimated. It is concluded that in the area of the archipelago rocks are subjected to tensile horizontal stresses in the eastern part of the profile and compressive - in the western (several bar / year).

In general, the block distribution of the region by tectonomagnetic monitoring coincides with geological and tectonic data, according to which along the Penola Strait in the north-eastern direction extends the tectonic fault of the same name, which is one of the important elements of the region's tectonics. Calculated according to tectonomagnetic observations, small stress changes for the interval 2019-2020 give grounds to draw a general conclusion about the relative stabilization of tectonic processes in the lithosphere of the UAS region.

VARIATIONS OF INDUCTION VECTORS AT THE AIA MAGNETIC OBSERVATORY (AKADEMIK VERNADSKY STATION)

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Magnetotelluric and magnetovariational methods of studying the structure of rock massifs are based on the application of variations of the Earth's natural alternating

electromagnetic field. A feature of these methods is the use of sources of natural origin. Sources are associated with magnetospheric-ionospheric processes in near-Earth space.

This method is based on the study of linear relationships between different components of the field. Such connections are frequency dependent, and therefore can be considered as transfer functions of the environment. The environment is only horizontally inhomogeneous. The presence of existing vertical components of the magnetic field Hz and horizontal derivatives of any field components is possible only in the conditions of horizontal changes in the resistance of the medium, if the field source is homogeneous. That is, the source is far from the point of observation compared to the length electromagnetic wave in Earth.

The minute data of magnetovariation observations at the AIA magnetic observatory (Akademik Vernadsky station) for 2005-2020 were used for processing. The time series of the components Cu (real part) and Sv (imaginary part) of the Wiese vectors for the periods were obtained 1^m - $2{,}5^m$, $2{,}5^m$ - 5^m, 5^m - 10^m, 10^m - 20^m, 20^m - 40^m, 40^m - 60^m.

For the period of 40-60^m in the time series of the modules of induction vectors, annual fluctuations with maxima in winter are observed. The amplitude of fluctuations ranged from 0.087 in 2017 to 0.185 in 2006. The average value of the amplitude of seasonal fluctuations for 2001-2020 is 0.124. For the periods 20-40^m and 10-20^m seasonal fluctuations are absent. At smaller periods (5-10^m and 2.5-5^m) the oscillations of the modules of induction vectors appeared only in 2011-2014, with highs in winter and lows in summer. The average value of the amplitude of seasonal fluctuations for 2011-2020 is 0.08 for the period 5-10m and 0.11 for the period 2.5-5m.

A slightly different oscillatory process is observed for the arguments of the real parts of the induction vectors. Here oscillatory processes are observed for all ranges of periods, except the shortest. For a range of periods of 40-60 minutes annual fluctuations with maxima in the winter period are observed. The most clearly seasonal fluctuations are shown for ranges of the periods of 20-40 minutes. and 10-20 minutes. For these ranges of periods, the annual fluctuations are similar in shape and close in amplitude. Highs are observed in winter and lows in summer. For a range of periods of 5-10 minutes seasonal fluctuations are still observed with a maximum in the winter months, but their amplitude decreases. For ranges of periods of 2.5-5 minutes annual fluctuations are not manifested. In addition, on short ranges of periods (5-10 minutes and 2.5-5 minutes) in 2018, anomalous values of the argument of the real part of the induction vector are observed.

In 2016-2020, there was a decrease in the modulus of the real parts of the induction vectors. In 2009, for medium and short ranges of periods, there was an episodic increase in the average annual value of the modulus of the induction vector. For a range of periods of 10-20 minutes change of the induction vector is insignificant. For a range of periods of 5-10 minutes the amplitude of changes is twice the age changes for this range of periods. For the range of 2.5-5 minutes module changes abruptly become anormal.

Thus, as in previous years, in the time series Cu and Sv there are changes that have an oscillatory nature with different periods and amplitudes and episodic changes of different duration and intensity.

SEISMO-ACOUSTIC MONITORING OF THE CRYOSPHERE IN THE AKADEMIK VERNADSKY STATION REGION

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The cryosphere collectively describes all forms of frozen water at the Earth's surface - sea ice, ice sheets, ice caps, glaciers, snow cover, permafrost, seasonally frozen ground and solid precipitation. In terms of the ice mass and its heat capacity, the cryosphere is the second largest component of the climate system (after the ocean). It is an important component in the context of climate change as it affects and is affected by changes in temperature. Antarctica represents one of the most serious potential threats from rapid cryosphere warming at the global level.

In the Antarctic Peninsula region, Ukrainian researchers focused their observations of the cryosphere, mainly on the ice caps of the archipelago and the glaciers of the Kyiv Peninsula. Continuous long-term monitoring of the glacier is not an easy task. For the Woozle Hill ice cap near the Akademik Vernadsky station, which is located on Galindez Island (Argentine Islands Archipelago), the task was solved by periodic ice sampling, GNSS measurements, photometry, and the use of GPR in the summer season. Some meteorological parameters were also periodically measured inside the ice cave in the glacier when conditions were favorable. In the past few years, GPR measurements have become more constant, and now they are carried out monthly.

Seismic measurements are one of the most effective methods for studying the cryosphere. Cryoseismic research involves quantitative studies of ice processes that in many cases are known or suspected to show sensitivity to climate change. For example, high-quality seismographic networks can be deployed to study ice shelf stability/disintegration, which has been discovered to sometimes occur catastrophically. For continuous monitoring of the internal stresses of the glacier, we proposed using a network of seismo-acoustic mini-arrays located along the perimeter of the glacier. Each array consists of four seismo-acoustic sensors arranged in a cross. The length of the line between the extreme sensors reaches 100 meters. Proprietary sensors use an optical system for recording the seismic and infrasonic vibrations. The built-in microcontroller of each sensor transmits the digitized data (16 bit, 100 or 300 Hz) to the main unit based on the LattePanda, where preprocessing is performed. GPS receiver is also connected here for data synchronization. There is a Wi-Fi module for transmitting data to the collection station. Also, data can be transmitted to the collection station by wires installed on the cable-growth. Power is supplied 220 V through an adapter and a 12V battery. The sensors are waterproof, the rest of the equipment is assembled in a sealed waterproof box. There are three such arrays, in their turn, they form a regular triangle with a side of 700 meters, inside which there is a glacier. The processing consists of detecting signals in each array by the STA/LTA method, followed by correlation processing of the selected data fragment and calculating the azimuth to the signal, wave velocity, period, and amplitude. Also, the isolation of the coherent part of the low-intensity signal at the noise level can be carried out without preliminary STA/LTA detection, using algorithm F-statistics. Correlated interference is clipped in azimuth. The intersection of two or three azimuths allows one to locate the signal source. All parameters of detections with time stamps are recorded in the database and can be further processed using station meteorological data. The system began to be deployed around the glacier in January 2021.

INFRASOUND ARRAY OBSERVATION IN THE ANTARCTIC PENINSULA REGION, FIRST RESULTS

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Atmospheric pressure fluctuations at the location of Akademik Vernadsky station are caused by the physical interaction between the atmosphere, oceans, cryosphere, and solid earth in the Antarctic Peninsula region. These oscillations associated with changes in the environment and sources of generation near the Earth's surface can be observed and measured using infrasound waves (pressure waves with frequencies in the range from the hundredths to the first tens of Hertz), propagating with small attenuation over long distances. Among the main sources of natural infrasound - ocean waves, storms, hurricanes, thunderstorms, sprites, meteorites, earthquakes and tsunamis, volcanic eruptions, auroras, avalanches, icebergs calvings. Infrasound from powerful energy sources can travel thousands of kilometers across the globe through the stratosphere and ionosphere, allowing it to be used effectively for remote sensing of the atmosphere.

In 2020, four Chaparral Physics Model64Vx microbarographs (USA, Alaska) were purchased for infrasound monitoring in the region of the Akademik Vernadsky station. The frequency range of the sensor is 0.03 - 245 Hz, the sensitivity is 0.03 V/Pa, the full range is 720 Pa. Noise cancellation systems were not used. The logger was an HP Compaq T510 thin client with a 4-channel 24-bit ADC and external GPS. The sampling rate was 40 Hz. Control system was based on Linux SUSE. To test the system, microbarographs were located at a distance of about 100 meters from each other to form a triangle in space with one element in the center. In fact, an infrasound array (phased antenna array) is formed, which makes it possible to isolate the coherent component in atmospheric pressure fluctuations, to determine the parameters of the direction, velocity, and dominant frequency of the recorded signal. The Progressive Multichannel Correlation (PMCC) algorithm is used for signal detection.

Test registration infrasound array started on February 17, 2021. Microbars are the main type of signals. Dozens of signals from the peninsula related to iceberg formation have been registered, with both acoustic and seismic components being recorded. Signals can be decomposed in time and space by directions. Unique signals from lightning discharges are recorded. The task in the near future to track the dynamics of the amplitude and phase changes of infrasound during the year (during the winter 26 UAE). It is also assumed that data from the CTBTO infrasound arrays in Ushuaia (Argentina) and Neumayer (Antarctica) will be used for event registration. It is planned to further increase the aperture of the antenna array to 500-700 meters, install noise protection devices, improve the data logging system and automatically detect useful signals.

CHANGES IN THE GEOMAGNETIC FIELD AND SURFACE AIR TEMPERATURE IN ANTARCTICA

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Since the beginning of Ukraine's scientific activity in Antarctica, the Institute of Geophysics of the National Academy of Sciences of Ukraine has been studying the geomagnetic field variations of various time scales, from secular variations to geomagnetic disturbances. In order to fulfill the tasks of the State Targeted Scientific and Technical Research Program in

Antarctica, studies of the relationship between the geomagnetic field and climate for the Antarctic region were conducted. This issue is highly controversial, primarily due to the lack of obvious mechanisms for such connection. The current hypotheses about the mechanisms of the connection between the geomagnetic field and the climate suggest that the mediator is probably cosmic rays of different origins. However, as a result, none of the mechanisms proposed so far is able to explain the effect of geomagnetic "signal" on climate variability. We propose a mechanism for linking the geomagnetic field and surface air temperature, which is a chain of causal relationships, where the main factors are the modulation of cosmic rays fluxes by the geomagnetic field, their effect on ozone concentration in the lower stratosphere, the effect of ozone on temperature and humidity in the tropopause region (upper troposphere - lower stratosphere), the influence of conditions in the tropopause region on the radiation balance in the troposphere ("greenhouse effect") and on the surface air temperature.

The determined space-temporal features of the distribution of the geomagnetic field and climatic parameters indicate the existence of their connection from the beginning of the last century to the present day, both according to observations and models. West Antarctica has the fastest decrease in geomagnetic field intensity and the largest increase in surface air temperature. West and East Antarctica have different dynamics of changes in both temperature and geomagnetic field. According to the ERA20CM re-analysis, there is a period of cooling in western Antarctica in the 1940s and 1970s. At the same time, the rate of change of the geomagnetic field was increased here. According to observations of the Antarctic Peninsula stations, there is also a slight decrease in temperature at the beginning of the XXI century. At the same time, according to the AIA geomagnetic observatory data, the amplitude of the geomagnetic secular variation is increasing. Analysis of the space-temporal distribution of ozone in Antarctica has shown that its concentration is generally lower in West Antarctica than in East Antarctica. There is a close relationship between the ozone concentration at 70hPa and surface air temperature – the cooling period is accompanied by a high ozone concentration. With the help of our proposed mechanism, the peculiarities of these space-temporal changes of these factors in Antarctica are explained.

SIGNS OF ORE MINERALIZATION IN THE AREA OF THE ARGENTINE ISLANDS

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First studies of the ore bearing of the Argentine Islands region were carried out in the 1980s (Hawkes, 1982). The ore mineralization in this area has been determined to be similar to the root area of the porphyry copper system.

During the geological studies of the Argentine Islands area, Ukrainian researchers significantly improve the ideas about the prospecting for minerals in this region. They found some places with mineralization for gold, tungsten, copper, lead and cobalt, which had not previously been noted.

In the eastern part of the Cruls Islands a steeply dipping (dip direction NW 345°, dip 82°) tectonic zone up to 10 m wide in granodiorites was found. It includes three bands of metasomatites with maximum thickness of up to 0.5 m. These metasomatites were formed by the sheared of tectonic breccia of granodiorites, which consists of granodiorite fragments cemented by magnetite. Metasomatites are represented by pyrite-plagioclase and pyrite-epidote rocks

formed as a result of hydrothermal-metasomatic processing of tectonic breccia along granodiorites. Cobalt (800 gram/ton), copper (200 g/t), and gold (0.3 g/t) were found in these metasomatites by ICP-MS and quantitative spectral analysis. The sign of an iron oxide-gold-copper formation is also presented in this rock.

According to the results of petrological-mineralogical and microprobe research the sulfide mineralization in andesites and dacites of the Upper Jurassic volcanic group in the Argentine Islands is discovered. In breccias of dacites of Irizar Island sulfide content reaches 20-25%. In pyrite there are impurities of Au (0.08%), Ag (0.04%), Co (0.17%) and Cu (0.12%). In pyrite from dacites of Skua Island there are Au (0.06%) and Co (0.11%), while pyrites from the andesites of Winter Island contain Au (0.18%), Ag (0.05%), and Co (0.10%).

On the Roca Islands a lamprophyre dike with a thickness of up to 0.5 m was found in the granodiorites of the Andean complex with mineralization of tungsten (28.7 g/t), copper (445 g/t), zinc (207 g/t) and lead (123 g/t). These lamprophyres were formed from the residual magma of the granodiorite intrusion.

In the dikes of Fe-Ti cumulates in the intrusions of gabbroids of the Andean complex high content of V (up to 1674 ppm), Cr (up to 421 ppm), Cu (up to 360 ppm), Zn (up to 216 ppm) and Co (up to 85.0 ppm) was found. Ore mineralization of this type was formed as a result of differentiation of basic magma chemically corresponding to tholeites.

Conclusions and further perspectives. New genetic types of ore mineralization associated with metasomatites in the areas of the latest steep faults of the northeastern (~ 50 °) strike were found near the Argentine Islands area. They have signs of iron oxide-gold-copper formation and lamprophyres of the late intrusive phase associated with granodiorite intrusions of the Andean complex. The perspective of andesites and dacites of the Upper Jurassic volcanic group for precious metals mineralization associated with syngenetic sulfide mineralization were determined. To assess the outlook for these types of ore mineralization we have to expand the geological survey to Antarctic Peninsula as well as to stress attention on tectonic zones in the west of region.

MAGNETIC TEXTURE OF GABBROIDS OF THE WILHELM ARCHIPELAGO AS AN INDICATOR OF REGIONAL TECTONIC PROCESSES

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The rock magnetism methods can provide significant improvement of our knowledge of geology and geophysics, including stratigraphy, petrology, geotectonics, geodynamics etc. Different magnetic parameters represent the genesis of the rocks. Magnetic texture and anysotropy of magnetic susceptibility (AMS) of igneous rocks can provide fundamentally important information for directions of magma flow, detecting hidden stratification and strain-stress fields in geological bodies, as well as for identifying the tectonic deformations. The latter is especially important for visually "massive" intrusive rocks when the measuring of bedding elements is impossible.

In 2017 the authors began the geological survey and geological mapping of the Akademik Vernadsky station region which continued in 2019-2020. As a result, numerous new outcrops of gabbroids were identified which are partially described in [Mytrokhyn et al., 2017; Mytrokhyn et

al., 2018; 2020; Alekseenko, 2020] and are only small exposed parts of much larger intrusion, which is bedding under Bellingshausen sea or buried under a glacial shield. It was proposed to combine the gabbroids into the unit petrographic association - the gabbroid complex of the Wilhelm archipelago. The gabbroid intrusions were formed between the eruption of Jurassic volcanics and the rooting of granitoid plutons of the Late Cretaceous ages [Mytrokhyn and Bakhmutov, 2019]. A large period of time elapsed between the formation of gabbroids and granitoids. In particular, before the intrusion of granitoid plutons there was a complete crystallization and cooling of gabbroids, their tectonic deformations, local low-temperature metamorphism and exhumation to the hypabissal level.

In some places the gabbroid intrusions are characterized by subvertical bedding. The rhythmic-gradational layering of the gabbroid of Anagram Islands gave direct evidence of magmatic origin and primarily horizontal occurrence of this stratification. The relative position of its bottom and top with the general build up of the section from the north-west to the south-east was determined. AMS data obtained on 7 gabbroid outcrops (and their comparison with data on the Ukrainian Shield, where gabbroid intrusions are not affected by tectonic deformations) and coherently changing in the composition of rock minerals with a trend of increasing plagioclase calcium and pyroxene magnesia from the northwest to the southeast were confirmed by field observations. All available data testify to regional tectonic deformations suffered by consolidated gabbroid intrusions during exhumation (or later) together with older Jurassic volcanogenic rocks, which led to their current steep bedding.

These results allow us to conclude that the bottom part of the big gabbroid intrusions is exposed near the north-western coast of the Anagram Islands or even further to the northwest. In this part of the intrusion, we can expect ore mineralization of Ti, V, Cr, Cu, Ni, Co and elements of the platinum group which formed on the magmatic stage in appropriate conditions of bottom deposits with further crystallization.

GEOPHYSICAL RESEARCH OF ANTARCTIC AND ARCTIC GLACIERS AT THE UNIVERSITY OF LATVIA

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Since 2014 scientists from the University of Latvia, Faculty of Geography and Earth Sciences, have conducted seven scientific expeditions to the Arctic and Antarctic Regions with the main aim to study the characteristics and changes of glacier thickness, thermal structure, drainage and subglacial topography. The research has been conducted on cold, warm and polythermal glaciers, thus allowing to obtain novel and high-resolution data from glaciers with variable thermal regimes. The expeditions to Antarctica and Svalbard were conducted in cooperation with scientists from the National Antarctic Scientific Center of Ukraine and Nicolaus Copernicus University in Toruń, Poland. The international cooperation has provided valuable logistical and scientific support during the expeditions and has resulted in joint publications.

The main scientific activities have included the measurements by ground-penetrating radar (GPR) combined with the surveys by unmanned-aerial vehicles (UAV) (e.g. Lamsters et

al., 2020a, b, c; Karušs et al., 2019; Chernov et al., 2018). Additional scientific institutions have been taking part in polar studies analysing persistent pollutants, microbial diversity and grain microstructures from different glacial and pro-glacial environments. Thus, during the recent years the field of polar studies has been developed at the University of Latvia. As the result, the Polar Research Center, Faculty of Geography and Earth Sciences, University of Latvia has been established in 2021 and aims to facilitate the scientific cooperation and research in the field of polar science.

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EVOLUTION OF CENOZOIC MAGMATISM OF THE ANTARCTIC PENINSULA ON THE EXAMPLE OF THE BARCHANS-FORGE ISLANDS ACCORDING TO GEOLOGICAL AND GEOPHYSICAL DATA

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According to the results of field observations on the Barchans-Forge Islands and comprehensive analytical studies of the samples, new data were obtained on the rocks formation during the Cenozoic stage of the evolution of the Antarctic Peninsula (AP) batholith in the region of Akademik Vernadsky station. On the Barchans-Forge islands are exposed mainly granitoids of Early Paleogene age, which are crossed by numerous mafic dykes. Their study shows that magmatic activity in the UAS area did not stop at least until the end of the Miocene [Mytrokhyn et al., 2020]. The youngest manifestations of Neogene-Quaternary magmatism are represented by subvolcanic dykes of basalts, diabases, diorite porphyrites, andesites and dacites, which cross the Barchans-Forge granitoid complex of Paleogene age.

During our study the petromagnetic properties of the rocks were determined, a map of the anomalous magnetic field was constructed, and tectonophysical study was carried out. As a result, an interpretation model for the basement and upper crust structure of the onshore and

offshore the Barchans-Forge Islands was created. This allowed to identify the areas and anomalous zones corresponding to distribution of different rock types and to set up a scheme of geological structure of the area. Based on these results, we propose a scenario of evolution of magmatic activity that started by intrusions of gabbro. Then, after a certain time span, the granite-diorites intruded, recent thereafter granites were formed. Among the latter, according to the magnetic properties, there are distinguished the granites localized along the Barchans fault zone. The youngest rocks should be considered aplitoid granites and aplites - products of residual magmas melting, depleted (up to the absence) in dark and ore minerals [Mytrokhyn et al., 2020]. Based on the interpretation of geological and geophysical data, we proposed a model that reflects the history of formation of gabbro-diorite-granitoid complex of the AP, starting from the subduction of the Proto-Pacific (Phoenix Plate) oceanic plate under the western edge of the AP, which caused intense processes of calcareous-alkaline granitoid plutonism in the Cretaceous and Paleogene times, the formation of the AP magmatic arc and the corresponding magnetic anomaly of the AP batholith.

PROSPECTS OF STUDY OF ELECTRIC PHENOMENA IN SNOW-AIR INTERACTIONS

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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. In our previous works we supposed that combined effect of various environmental conditions can give electric field gradients that may be sufficient for the onset of point or corona discharges followed by generation of high local concentrations of the reactive species and initiation of free-radical and redox reactions.

Analyses of various ways of snow/ice crystals electrification in clouds can help us to understand what electrification processes can also ‘work’ near the Earth’s surface, for instance in blizzards. Such mechanisms as sublimation, growth, fracturing have to be considered.

The report discusses possible steps in the study of this issue - field experiments in the Arctic and Antarctic, laboratory research, as well as the possibility of practical use of these phenomena for capturing ultrafine aerosols and in "green chemistry" methods for the decomposition of explosive toxic substances.

THE COMPLEX STUDY FOR DETERMINATION OF THE VOLUME CHANGES OF GLACIERS ON GALINDEZ AND WINTER ISLANDS

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The Antarctic ice cover is a complex natural system whose internal dynamics is sensitive to both atmospheric and oceanic influences. A deeper understanding of the underlying processes may have a profound impact on the development of prognostic models.

Studying glaciers from a wide range of remote sensing platforms and techniques has become an expanding field over the past decade. Key reasons for this are the wide recognition of glaciers as indicators of climate change and the strong impact of their changes on society at global, to regional and local scales. Small glaciers are an important part of the cryosphere and tend to respond rapidly to climate warming. Historically, mapping small glaciers using satellite imagery has often been subjective due to the difficulty in differentiating them from perennial snow patches. For this reason, according to the analysis of literature sources, advantages and disadvantages of glaciers research methods it is established that the use of terrestrial laser scanning and terrestrial digital surveying is a priority for monitoring changes in small, island glaciers and their frontal parts. This will avoid "blind" areas of laser scanning and increase the accuracy of determining volume changes of glaciers.

A technique based on the use of digital stereophotogrammetric photography and terrestrial laser scanning is proposed. According to the required accuracy of determining changes of glaciers volume, the parameters of terrestrial laser scanning and construction of a digital model of the glaciers surface based on terrestrial digital surveying data were calculated. The workflow of the proposed technique of complex research of volumes changes of island glaciers which takes into account the details of the choice of parameters and data processing is presented. Recommendations are given for the implementation of the stages of technical design, field work of terrestrial laser scanning and terrestrial surveying, processing of materials and determination of volume changes. The main attention is paid to the peculiarities of performing measurements of glacial surfaces and the means of their processing. Algorithms for detecting "blind" areas of terrestrial laser scanning and optimizing the interval choice for the construction of digital models of glacier surfaces based on terrestrial surveying data are presented. According to the proposed optimization algorithm, the grid interval for the construction of a digital model of glacier surfaces is calculated, which will provide the determination of volume changes with an accuracy of 1%.

Another approach to observation of melting glaciers is to apply current means of remote surveys, such as images taken by unmanned aerial vehicles (UAV). In view of this, the complex method has been modified for the use of terrestrial digital stereophotogrammetric and UAV survey.

Data of field works were processed and point models obtained according to terrestrial laser scanning data and digital models of glacier surfaces obtained according to terrestrial surveying covering "blind" area were built. Volume changes of island glaciers are calculated as the volume differences between observation cycles. The proposed technique was tested for monitoring glaciers on the Winter and Galindez islands during 2013-2014, 2014-2018 and 2018-2019 years.

CRYSTAL STRAIN ANALYSIS IN THE PENOLA STRAIT - LEMAIRE CHANNEL FAULT AREA

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The purpose of the study is to identify recent local geodynamic processes in the Penola Strait - Lemaire Channel fault area (West Antarctica) GNSS observations. Structurally, the work covers and reveals three main research directions:

- geodynamic monitoring polygon in the Penola Strait - Lemaire Channel fault area;
- recent local geodynamic processes in the Penola Strait - Lemaire Channel fault area;
- kinematic model of the Penola Strait - Lemaire Channel fault area.

The study was based on the results of 5 cycles of periodic static GNSS campaigns conducted during 2003-2019. The vectors of horizontal and vertical movements of the geodynamic polygon are determined in the work and their scheme is constructed. Based on the determined average linear velocities of vertical movements, the field of their spatial distribution in the Penola Strait - Lemaire Channel fault area was constructed. As a result of the analysis of velocity distribution of the vertical movements in the Irizar Island area, the area of subsidence was identified. On the basis of the determined average linear velocities of the horizontal movements, the values of the dilatation velocity – the parameter of deformation of the Earth's surface, which characterizes the relative expansion or compression of the territory, as well as the value of total shear, which characterizes the horizontal heterogeneity of the deformed area, were calculated, and the field of their spatial distribution in the area of Penola Strait - Lemaire Channel fault area was constructed. As a result of the distribution analysis of the territory's dilatation velocities, the zones of extreme compression and expansion values were revealed, indicating increased geodynamic activity of the region. As a result of the analysis of the distribution of values of the total shear, it is confirmed that the studied region is horizontally heterogeneous. Based on the analysis, a new kinematic Penola Strait – Lemaire Channel fault area model was developed. The assumption was made that the specified fault transgressive is characterized by a combination of strike-slip and thrust.

MODELING ULF AND VLF ACTIVITY IN THE NEAR-EARTH SPACE ENVIRONMENT: BOUNDARY CONDITIONS AND PROPAGATION EFFECTS

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The NEELS method (Nonlinear evolution equations for wave processes in layered structures) is developing for very low frequency (VLF) disturbances in the waveguide Earth-Ionosphere (WGEI).

For the propagation of VLF waves in WGEI, the boundary conditions at the entrance to the region of the waveguide, where the external current source is located, are important, as well as complex impedance conditions at the boundaries of the WGEI; the system of evolutionary equations for coupled wave beams in WGEI is solved with the above mentioned boundary conditions. Based on measurements of VLF and LF signals in Japan (data provided by Professor M. Hayakawa), fluctuations in the VLF amplitude in WGEI with periods of about 5-10 minutes, of the order of several hours and of the order of 7 days have been revealed. Using the developed tensor-impedance method for modeling the propagation of electromagnetic beams (TIMEB) and an electrostatic-photochemical model of seismic-ionospheric communication, a qualitative explanation of the increase in VLF wave losses in WGEI before strong earthquakes is proposed. A model of VLF activity in the plasmasphere is constructed using the data on whistlers excited by lightning and VLF transmitters. For the first time, adequate boundary conditions are established for modeling the penetration of ultra low frequency (ULF) and a quasi-static electric field through the Lithosphere (Earth)-Atmosphere-Ionosphere-Magnetosphere (LEAIM) system in the presence of an external current source. Boundary conditions depend on structure of the geomagnetic field (open or closed lines); the results obtained using the quasi-static and dynamic models are compared; the range of applicability of qiasi-static approximation is determined.

Currently, models are being developed: (1) to test the hypothesis that the observed fluctuations of the VLF signal amplitudes in WGEI with a period of 5-10 min are the main Vaisal-Brunt AGW mode and excitations adjacent in the spectrum; 2) combining TIMEB and the model of ELF excitation in WGEI by external currents, including those caused by powerful lightning discharges and the impact of HF radiation on the ionosphere during active experiments, as well as the propagation of ELF disturbances in the LEAIM system; (3) using a combination of TIMEB and complex geometric optics (CGO) to investigate the penetration and propagation of WGEI whistlers in the upper ionosphere and magnetosphere; Corresponding VLF excitations from a single current source can be detected by both ground-based and satellite observatories. The proposed models will be useful for ionospheric monitoring of the most powerful physical

processes in the LEAIM system, including the Antarctic region, as well as for the interpretation of active experiments.

TESTING THE ARTIFICIAL NEURAL NETWORK FOR SCALING IONOGRAMS OBTAINED AT UKRAINIAN ANTARCTIC AKADEMIK VERNADSKY STATION

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Last year, an artificial neural network (ANN) was developed for identifying ordinary radio wave traces of the F2 layer (F2o) on ionograms obtained by the IPS-42 ionosonde installed at the Ukrainian Antarctic Akademik Vernadsky station (UAS). The ANN is based on the U-Net architecture and developed in Python programming language with use of the Keras library. Initially the ANN was trained using just 31 manually scaled ionograms obtained on March 17, 2017. Therefore it has such minor flaws as occasional mistakenly marking multiple reflections from the ionosphere and traces of the x-component of the radio wave (F2x) and as well as not reliably processing F2o traces when critical frequency foF2 is more than 4 MHz. These flaws can be easily eliminated by retraining the network on a more representative dataset (obtained in various years and seasons). We manually prepared 139 additional images for training ANN to recognize F2o trace more accurately. These 139 masks with F2o traces were produced from ionograms obtained in June 1–8, 2017, June 11–18, 2017, September 21–22, 2017, December 1–12, 2018, January 1–7, 2019, and June 4–5, 2019. Time for training ANN increased from 5 to 20 hours (due to using ImageDataGenerator class from the Keras library that generates images by means of rotation, scaling and shifting original ones, 31 ionograms yielded 2909 images and 170 ionograms yielded 6802 images).

The purpose of this work is to show the results of testing the ANN for scaling ionograms. The testing was provided on the ionograms obtained at UAS in June 9–10, 2017, September 22–24, 2017, December 19–20, 2018, June 6–10, 2019, June 28–29, 2019, and September 14–24, 2020. The results of automatic scaling using the initial and retrained ANN were compared with the results of manual scaled F2o traces. The retrained ANN works more correctly than the initial version. And it's shown that there is possibility to update a training dataset with some specific ionograms. This can be used for adding data obtained during different phases of solar cycle and under various geomagnetic conditions (e.g. magnetic storms).

Considering the good results obtained in this work, the next step in developing the procedures of automatic scaling of ionograms obtained by IPS-42 installed at the UAS will be training another ANNs the identical architecture for identifying F2x, F1o, F1x, Eo, Ex, Es layers' traces.

PLANETARY WAVE INFLUENCE ON THE OZONE HOLE IN 2010–2020

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The ozone hole over Antarctica is located within the southern stratospheric polar vortex existing during winter and spring. Ozone depletion occurs predominantly in the lower and middle stratosphere impacting total ozone column. The ozone hole is limited by the 220 Dobson Units (DU) value according to the traditional definition. The ozone hole development starts in August due to ozone-destroying reactions occurring with appearance of solar radiation after the polar night. Typically, the polar vortex disrupts in late November and ozone values return to usual levels close to 300 DU.

Ozone hole area was increasing in the 1980s and in the early 1990s with the parallel diminution in the ozone column. From the mid-1990s, a tendency to the ozone hole stabilization has been observed with significant interannual variations when the sudden stratospheric warmings (as in 2002 and 2019) and large ozone holes (as in 2000, 2006 and 2020) can appear even in the neighboring years. Respectively, analysis of the ozone distribution parameters is necessary to estimate modern trends and to study the ozone layer recovery expected in the twenty first century.

Along with the chemical factors, dynamical ones are decisive for the polar vortex and ozone hole evolution. Large-scale planetary waves penetrate from the troposphere into the stratosphere, dissipating there with sudden warming, polar vortex weakening and increasing in the ozone levels. Planetary wave activity is responsible for the strong interannual variations in the polar stratosphere on the background of long-term changes in chemical processes. The planetary wave with zonal number 1 (PW1) causes displacement of the polar vortex (with ozone hole inside the vortex) relatively the pole, and PW2 leads to the polar vortex elongation. Correspondingly, the shape and location of the ozone hole are changing on the interannual and long-term scales.

Almost continuous total ozone satellite measurements have been done since the late 1970s. In particular, global Total Ozone Mapping Spectrometer and Ozone Monitoring Instrument data are useful to study the ozone distribution and planetary wave influence on the ozone hole. In this paper, the satellite data are processed to analyze the ozone layer behavior over the Antarctica in the last decade. Our attention is paid to the total ozone variations and planetary wave parameters in the austral spring (September–November). Longitudinal shift of the quasi-stationary ozone minimum and signs of total ozone stabilization were investigated. Besides, changes in the PW1 and PW2 parameters are also discussed.

WIND CONTROL OF DIRECTIONS PROPAGATION AND AMPLITUDES OF WAVE PERTURBATIONS IN THE UPPER ATMOSPHERE OVER ANTARCTICA

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Based on the measurements onboard the Dynamics Explorer 2 satellite, the relationship of acoustic-gravity waves (AGWs) with disturbed wind circulation in the upper atmosphere over Antarctica was investigated. The analysis of the satellite measurements show that AGWs are systematically observed in the F2-region of the ionosphere over Antarctica. Their amplitudes are several times higher than the characteristic amplitudes of these waves at the middle and the low latitudes. In this case, the waves of the large amplitudes are localized within the auroral oval and correlate with the geomagnetic activity. It has been also found that these waves have a spatial scales of 500-650 km and time scales of 10-14 minutes.

On the basis of the methodology developed by the authors, the directions of the wave motions are determined. It was found that acoustic-gravity waves over Antarctica systematically propagate upwind. The azimuths of their movements can be grouped in two main directions: towards the magnetic noon and towards 15-16 hours of the local magnetic time. A clear trend in the azimuths of the wave propagation is a clockwise direction appearing above the south polar cap. An empirical dependence of the observed wave amplitudes on the wind speed is obtained. The maximums of the wave amplitudes are achieved in the spatial region of a strong non-uniform flow of the thermosphere.

The observed properties of AGWs in the thermosphere over Antarctica are: 1) the large wave amplitudes in comparison with middle latitudes; 2) the dependence of the amplitudes on the wind speed; 3) the presence of the selected spectral properties. The connection between the azimuths of the wave propagation and the circulation of the polar thermosphere makes it possible to draw a conclusion about the close interaction of AGWs with atmospheric flows.

A theoretical mechanism is proposed that makes it possible to explain the experimentally observed features of AGWs in the thermosphere over Antarctica. It is shown that the region of spatially inhomogeneous flows is a filter and an amplifier of the wave amplitudes due to the exchange of wave energy with the medium. AGWs with a positive projection of the wave vector are rapidly damped or absorbed by the medium. On the contrary, counter propagating waves are increasing in the amplitudes. Since the counter propagating waves are significantly enhanced with the flow, they also prevail in the observations. As a result, the wave field observed over Antarctica does not show the distribution of AGW polar sources. The properties of the waves in this region are determined by the wind polar circulation of the thermosphere.

VIEW ON TROPOPAUSE BEHAVIOR OVER ANTARCTICA

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Tropopause behavior over Antarctica has been considered from the perspective of chemical composition. In this analysis, ozonesondes measurements of temperature, ozone, and water vapor from Neumayer station ($70^{\circ}39^{''}$S $8^{\circ}16^{''}$W) were used. Using the relationship of the stratospheric tracer O_3 and the tropospheric tracer H_2O, the tropopause sharpness in terms of the chemical composition was studied. The tracer ratio near the tropopause indicates the characteristics of the tropopause transition layer where mixing of stratospheric and tropospheric air masses occurs. Using both stratospheric and tropospheric chemical tracers together with temperature laps rate for the tropopause definition allow assessing tropopause thickness and characteristic of the stratosphere-troposphere and the troposphere-stratosphere exchange. Latest study shows that the dynamics of the lowermost stratosphere above the tropopause and tropopause inversion layer possibly can serve as the tropopause wave source which could excite the stratospheric events like stratospheric warnings. Studying the tropopause parameters and its behavior using definitions thermal, chemical and ozone tropopauses, we are trying to receive new data on this possible wave source.

HF RADIO SOUNDING OF THE IONOSPHERE ON LONG-DISTANCE RADIO PATHS WITH A RECEIVING SITE AT THE AKADEMIK VERNADSKY STATION: THE RESULTS OF THE FIRST 11 YEARS OF OBSERVATIONS

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Doppler monitoring of the propagation of HF signals from Europe and North America to the Antarctic Peninsula region has been performed continuously at the Ukrainian Antarctic Akademik Vernadsky station (UAS) since May 2010. Data analysis of long-term measurements shows that long-distance propagation in these directions is provided by four different mechanisms that are realized at different times or simultaneously. These are multi-hops or waveguide propagation along either the straight great-circle arc or the reverse great-circle arc, propagation due to focusing along the solar terminator, and due to scattering on plasma irregularities in the auroral oval into the interlayer waveguide toward the UAS. This paper describes the mechanisms supported by measurements of the propagation time of radio signals from the RWM time service station (near Moscow, Russia) during radio pulse transmissions at a 10 Hz repetition rate. Signals scattered in the northern polar oval arrive at the UAS for all RWM carrier frequencies, 4996, 9996, and 14996 kHz. Signals scattered in the southern polar oval are detected less frequently (most probably due to the geometry of experiment and the configuration of geomagnetic field). Propagation of the signals transmitted by CHU time service station (near Ottawa, Canada) propagates toward UAS by scattering on plasma irregularities of polar ovals as well. Spectral and time selection of HF signals on long-distance radio paths allows determining the location of the equatorial boundaries of the auroral ovals and estimating the drift velocities of the ionospheric irregularities in the scattering region. The measured values of the speed of auroral plasma irregularities and its diurnal, seasonal and interannual variations will be discussed in the presentation.

The results were obtained with the partial support of the EOARD-STCU-IRA NASU Partner Project P735, as well as the series of scientific projects "Heliomax" funded by the NASC in the frames of the State target scientific and technical program for conducting the research in Antarctica for 2011-2020 (state registration numbers are 0119U103575, 0120U104223).

HF RESPONSE IN ANTARCTICA DURING EISCAT-UKRAINE HEATING CAMPAIGN (JUNE, 2020)

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A dedicated HF ionosphere modification campaign was carried out during 23 - 26 June 2020 at the EISCAT heating facility, Tromsø, Norway within the framework of the Program of Scientific collaboration between Ukraine and the EISCAT scientific association. In the course of the experiment, O- and X-mode waves at frequencies stepping by 10 kHz around the 3rd electron gyroharmonic were injected toward the magnetic zenith and excited artificial ionospheric turbulence (AIT). The EISCAT UHF incoherent scatter radar and ionosondes at the site were monitoring the F2-region response. In addition, stimulated electromagnetic emissions (SEE) and the propagation characteristics of transmitted waves along radio paths of different lengths were explored by a network of HF receivers comprising the special broadband SEE receiver and Ukrainian receivers at spatially separated positions. Two-channel receivers were located at a 15 and ~1000 km distance from the heater, a three-position system near Kharkiv, Ukraine at a ~2400 km distance, and a two-channel receiver at the Ukrainian Antarctic Akademik Vernadsky station at the distance of ~16 600 km.

As a part of the experiment, we investigated the possibility of feeding the ionospheric waveguide formed between the E- and F- region density peaks. Trapped by scattering off artificial plasma irregularities into this waveguide, the transmitted radio wave will propagate along very long distances almost without attenuation. To detect this effect, we transmitted the O- and X-mode waves in succession at frequencies close to the critical frequency of the F2 layer to reach the maximum heating effect. To compare the behavior of the signals of "O" and "X" polarizations as they propagate along a quasi-vertical radio path (heater-Tromsø) and long-distance radio path (heater-Antarctica) we analyzed the HF data recorded in Tromsø and at UAS. It was determined that near the heater the level of X-mode signal exceeded the O-mode level, probably because some part of the O-mode power supported heating. The O-mode intensity in Antarctica exceeded the X-mode level. The inverse difference between the levels of O-mode and X-mode signals with the long-distance radio link in comparison with the quasi-vertical path can be explained by feeding the ionospheric waveguide with the pump wave scattered on the AIT, effectively excited only by the O-mode signal.

ADVANCED TECHNIQUE FOR ESTIMATING THE MONTHLY MEDIAN IONOSPHERIC PARAMETERS AT THE AURORAL REGIONS

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Ionosphere is a partially ionized part of the Earth's atmosphere, where the level of ionization is enough to substantially affect the propagation of radio waves. A remarkable property of the ionosphere is its ability to reflect the high-frequency waves (3...30 MHz). This made it possible for mankind to organize sustainable over-the-horizon radio communication for the distances up to 5,000 km and sometimes even in global scale (up to 20,000 km). On the other hand, the ionosphere affects the quality of satellite communications, navigation, remote sensing of the Earth from space, etc., because signals from satellites are passing through the ionosphere. In general, the ionosphere is an inhomogeneous and non-stationary medium. The large-scale irregularities such as solar terminator and its related processes, differences of the value of electron density on the illuminated and dark sides of the planet, the main ionospheric trough, etc., are studied relatively well and can be adequately described by modern models. Irregular plasma disturbances of smaller scales are studied much worse. Plasma inhomogeneities at the auroral regions are most unpredictable and intensive in comparison with ones at other areas of

the Earth, thus their study seems as important task of the geophysical and geospace research. For analyzing the climate characteristics of the ionosphere the median values of ionospheric parameters such as foF2, M(3000), foEs, are calculated traditionally. At the first step of data processing those parameters are estimated using auto- or manual scaling of ionograms. Unfortunately, such technique usually becomes inapplicable for the polar ionosphere even for the time of weak geomagnetic disturbances.

This paper aims to describe the technique for estimating the averaged (median) height-time diagrams of ionospheric parameters that characterize more completely the ionospheric conditions during the month in comparison with traditionally derived medians. Moreover, the proposed technique could become a more reliable approach for analyzing the monthly averaged ionospheric conditions in the polar ionosphere due to inapplicability of traditional ones. This technique is tested on the data obtained using ionosonde developed and manufactured at Space Research Centre of Polish Academy of Sciences that was operating at the Hornsund Polish Polar station (Svalbard, 77.00 N, 15.55 E) for many years. The features of diurnal and seasonal variations of the polar ionosphere above the Svalbard Archipelago are discussed.

SEASONAL EFFECTS IN VARIATIONS OF ELECTRON DENSITY OVER THE UKRAINIAN ANTARCTIC STATION: RESULTS OF OBSERVATIONS AND MODELLING

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Several decades ago, the main seasonal features of ionospheric manifestations of geomagnetic storms were identified, which are related to seasonal features of the global thermospheric circulation and the neutral density. However, there is a relatively small number of works devoted to investigation of manifestations of geomagnetic storms over the unique region of the Ukrainian Antarctic Akademik Vernadsky station (UAS) location, where, as is known, the seasonal Weddell Sea anomaly is manifested. There are also no studies that analyze the ionospheric effects of specific geomagnetic storms simultaneously over the Antarctic Peninsula and Ukraine.

This work is devoted to investigation of variations the ionospheric plasma parameters (h_mF_2 and N_mF_2) in the Southern and Northern hemispheres caused by geomagnetic storms that occurred in periods close to the summer and winter solstices (January 2–6, 2019 and June 7–9, 2019). For this purpose, the experimental data obtained by ionosonde at UAS, incoherent scatter radar and ionosonde at the Observatory of the Institute of Ionosphere (Kharkiv, Ukraine), as well as the results of physical modeling of the ionosphere were used.

Our research shows that manifestations of geomagnetic storms over the Antarctic Peninsula and Ukraine were different. There is pronounced seasonal dependence of ionospheric manifestations of geomagnetic storms (strong manifestations in January, weak ones in June) for the UAS location region, while such seasonal dependence is not observed over Ukraine. This suggests that such seasonal effects of ionospheric manifestations of geomagnetic storms over UAS are associated with seasonal restructuring of the global thermospheric circulation. At the

same time, the absence of pronounced seasonal effects of ionospheric manifestations of geomagnetic storms over Ukraine is explained mainly by the local time effects. The main hypotheses about the probable causes of differences between experimental and model variations in the ionospheric parameters h_mF_2 and N_mF_2 are presented.

RESULTS OF IONOSPHERE-PLASMASPHERE SYSTEM INVESTIGATION IN THE AMERICAN AND EUROPEAN LONGITUDINAL SECTORS FOR 2020

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A significant number of modern scientific works in the field of geospace research are devoted to study of disturbed space weather effects in the ionosphere and plasmasphere. At the same time, quiet space weather conditions (especially long-term periods with quiet space weather) can be called a rare state of the near-Earth plasma environment. It is known that even weak magnetic disturbances with $K_p = 3$ can significantly affect the plasma density in the ionosphere. As a result, international empirical models of electron density based on the observational results obtained during disturbed periods cannot be effectively applied for quiet space weather conditions.

The study of the regional features of the ionosphere–plasmasphere system in the Southern and Northern hemispheres during quiet space weather conditions ($K_p < 4$-, SYM/$H_{min} \approx -30$ nT) in September 14–24, 2020 were carried out using observational data obtained from ionosonde at the Ukrainian Antarctic Akademik Vernadsky station (UAS), ionosonde and Kharkiv incoherent scatter radar (KhISR) of the Institute of Ionosphere, international satellite missions (DMSP and Swarm), and physical modeling.

It is found that during the geomagnetically quiet period over the Antarctic Peninsula there were significant differences between observational and simulation results for daytime N_mF_2 variations. At the same time, the results of modeling are in good agreement with both daytime and nighttime experimental data for Ukrainian region. The results of observations obtained by KhISR and satellites also confirm the reliability of the simulation results. The results suggest that the neutral atmosphere model NRLMSISE-00 probably does not correctly reflect the value of the O/N_2 parameter for the UAS location region.

A comprehensive analysis of the results showed that the main regional feature of the ionosphere–plasmasphere system in the periods of quiet space weather over Antarctica and Ukraine is that the electron density in the topside ionosphere over Ukraine at nighttime is up to 2–3 times higher than the plasma density above UAS. In general, such differences in variations of the electron density can be explained by the fact that more plasma is supplied to the ionosphere from the plasmasphere at nighttime in the middle latitudes of the Northern hemisphere. Observational results from DMSP and Swarm satellites confirm this hypothesis.

Thus, the state of the near-Earth plasma environment during rare long-term periods with quiet space weather conditions should be considered as a special state along with extreme space weather conditions.

TWO POSITION ANTARCTIC-ARCTIC "COUNTER" OF INTENSE LIGHTNING DISCHARGES

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Studies of geophysical processes in the Earth-ionosphere cavity driven by the global thunderstorm activity are carried out in order both to calculate the characteristics of excitation sources and estimate field propagation parameters in the global resonator formed by the Earth 's surface and the lower ionosphere. The main sources of excitation of the Earth-ionosphere resonator are lightning discharges, which are registered as extremely low frequency (ELF) transient events of electromagnetic radiation. The total number of ELF transient and the spatio-temporal distribution of their sources reflect the dynamics of global thunderstorm activity, which, in turn, can be an indicator of global climate change.

The studies are based on the data of systematic monitoring of ELF electromagnetic fields performing simultaneously at the Ukrainian Antarctic Akademik Vernadsky station (UAS, 65.25^{o}S, 64.25^{o}W) and in the Arctic at the Sousy facility of Tromsø Geophysical Observatory of the Arctic University of Norway UiT (Svalbard island, 78.17^{o}N, 16.00^{o}E). The locations of observation points in the polar regions have significant advantages: minimal man-made interference and absence of local thunderstorms. In addition, the significant distance between the polar regions of different hemispheres provides a near-optimal spatial basis for synchronous data processing and analysis. Noctidial observations of the orthogonal horizontal components of magnetic field within the waveband 0.001-80 Hz are carried out at the UAS since March 2002. The same synchronous observations in Arctic were started in September 2013. Both sites are equipped with identical highly sensitive magnetic sensors Lemi-112E and similar acquisition systems, both produced by the Lviv Center of Institute for Space Research of the National Academy of Sciences Ukraine and the State Space Agency of Ukraine. The signals are continuously recorded and are synchronized with the Universal Time by using GPS receivers.

The authors have developed and tested a new technique of ELF transients counting. It allows to study the number of lightning strikes on the globe, to identify characteristics of diurnal, seasonal, annual and inter-annual variations of the number of lightning discharges depending on their power. In particular, the similarity of the number of the detected ELF transient with observed intensity of the first Schumann resonance (SR) mode and the level of solar activity in the 11-year cycle were detected and are discussed. With the help of the developed algorithms the database containing parameters of all events registered within the full observation period was created (~ $6.5*10^{7}$ and ~$2.4*10^{7}$ transients observed in the Antarctic and in the Arctic respectively). In addition, we have proposed an algorithm of geolocation of powerful lightning discharges. The developed technique is based on the determination of bearings and the difference in distances to the source. The last value is calculated from the time of arrival difference to the observation points. The results are compared with the optical satellite observations.

MONITORING OF THE POWER LINE EMISSION FROM NORTH AMERICA AT UKRAINIAN ANTARCTIC AKADEMIK VERNADSKY STATION

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Systematic round-the-clock observations of the horizontal orthogonal components of magnetic field variations in the ELF waveband has been performed at the Ukrainian Antarctic Akademik Vernadsky station (65.25°S and 64.25°W) since 2002. The ELF signals are recorded by the magnetometer facility consisting of two highly sensitive low noise induction-coil sensors Lemi-112E operating in frequency band 0.001-80 Hz and Lemi-419Ant acquisition system equipped with 24-bit ADC convertor and GPS receiver used for UTC timing. The device was produced by the Lviv Center of Institute for Space Research of the National Academy of Sciences Ukraine and the State Space Agency of Ukraine. The almost complete absence of technogenic activity in Antarctica provides here a unique low level of electromagnetic interference alloweing an accurate measurement of both Schumann resonance signal produced by radio emission from worldwide thunderstorms and signals of distant electrical networks with frequencies 60 Hz. It is worth noting that the diesel generator of the station with frequency 50 Hz is the main local source of interference making impossible to detect emission from remote sources at this frequency. The power line harmonic radiation (PLHR) at frequency 60 Hz has been monitored at the UAS since 2002 until now. Spectral and polarization processing technics were used to detect the signal and confirm that it is generated by the North American electrical network. Daily, weekly and interannual variations of the intensity of radiation at 60 Hz and the bearing to the source are presented and discussed. The weekend effect in the intensity of the emission at 60 Hz recorded in the Antarctic is detected and analyzed. It was shown that the weakly variations of the intensity of the PLHR signal demonstrate some decreasing at the end of the week during all years of observation. A widescale power outage in significant parts of the United States, and Canada on August 14, 2003 was detected in the Antarctic ELF records and analyzed. The long-term trends of the parameters of the power line harmonic radiation at 60 Hz and the variations of the characteristics of Schumann resonance signal observed at UAS are compared and discussed. It is proposed to use the emission produced by distant electrical networks at a frequency of 60 Hz as a "probe signal" to monitor the state of the lower ionosphere.

THE ROLE OF SPORADIC E LAYERS IN LONG DISTANCE HF PROPAGATION TOWARD THE ANTARCTIC PENINSULA

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Long-distance propagation of HF radio waves was the only way for intercontinental wireless communication for the times before space era of humanity. That is possible due to reflection of HF radio waves from the ionosphere and their propagation in the Earth-ionosphere cavity with low loss. Since 2010, a continuous Doppler monitoring of HF signals emitted by time service stations located in the Northern hemisphere, namely RWM (55.73 N, 38.21 E) and CHU (45.30 N, 75.76 W) has been conducted at the Ukrainian Antarctic Akademik Vernadsky station (UAS) (65.25 S, 64.27 W). This paper is devoted to experimental study of the impact of sporadic E layers (Es) on the characteristics of long-distance HF propagation. We analyzed the parameters of signals with carrier frequency of 9996 kHz propagating along the RWM-UAS radio path in June 2010 (the length of the straight path is about 16000 km). The comparison of the monthly averaged daily spectrogram with spectrogram calculated for the one day, June 24, 2010 permits us to conclude that the signal recorded on June 24 at 2…4 UT was not observed on other days of this month. Analysis of space weather conditions showed that geomagnetic activity at that time was extremely low, Kp = 0, Amp = 1 (with the monthly average value of Amp being 15.3 for that year). The ionosphere above the transmitting position showed no features. But over the UAS the intense Es were observed at the heights of 100...200 km. As a rule, Es are absent in the night at this season. Note also that an active cyclone was operating at the UAS position. The cyclones can impact the formation of Es by generating atmospheric gravity waves (AGW), which can propagate to the heights of the ionospheric E region. As we showed earlier, at the Antarctic Peninsula region cyclonic activity in winter increases the probability of observations of semi-transparent relatively small-scale Es, similar to those observed on June 24, 2010. Mechanism of impact of Es on long-distance HF propagation is likely to be in input/output of HF signals to/from the interlayer ionospheric waveguide by reflecting or scattering the waves on the horizontal gradients of electron concentration provided by Es. Thus, Es can contribute to improving the conditions of long-distance propagation of HF radio signals. As a result, it could also be concluded that the variability of ionospheric conditions in the vicinity of the transmitter and receiver has the main influence on the variations of long-distance propagation conditions. When propagating between the northern and southern hemispheres, the influence of ionospheric conditions in the winter hemisphere generally is larger.

The results were obtained with the partial support of the EOARD-STCU-IRA NASU Partner Project P735, as well as the series of scientific projects "Heliomax" funded by the NASC in the frames of the State target scientific and technical program for conducting the research in Antarctica for 2011-2020 (state registration numbers are 0119U103575, 0120U104223).

DEVIATIONS OF THE AZIMUTH OF ELF BURSTS ASSOCIATED WITH THE “DAY-NIGHT” NONUNIFORMITY

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Measurements of the direction of arrival of impulsive electromagnetic radiation from intense lightning discharges in the extremely low frequencies, ELF bursts, are used for determining location and parameters of powerful lightning by single- and multi-position techniques. The accuracy of determining the azimuth of the source is determined by various factors. Errors associated with the mismatch of the parameters of the channels of magnetic antennas and the anisotropy of the underlying surface conductivity at the observation point are systematic and can be investigated and corrected for a given observation point. The influence of

random and regular sources of errors, both artificial and natural, is also essential. Such errors can arise due to interference from the local power network, the background ELF field caused by the global thunderstorm activity, and the superposition of signals from other powerful lightning strikes. The influence of the propagation path due to the anisotropy of the lower ionosphere, deviations of the incident wave front because of refraction and reflection at a large-scale "day-night" nonuniformity in the Earth-ionosphere resonator were discussed in recent papers.

In our investigation, we studied daily variations of polarization parameters and arrival direction of ELF bursts to determine the accuracy of lightning location. The analysis was carried out by results of measurements of two horizontal components of the magnetic field in frequency range 4–40 Hz at the Akademik Vernadsky station. For the analysis, we use the most powerful initial part of the ELF burst with duration of about 20 ms (± 10 ms from the peak of the direct wave), which is formed by a direct wave propagating from lightning to an observer along a short path in the spherical Earth-ionosphere cavity.

In the absence of independent accurate data on the location of lightning, it is possible to estimate the deviations of the azimuth in the presence of a compact source in a narrow azimuthal sector, which is active during a day. Such case we observed during three consecutive days from March 31 until April 2, 2019 from narrow northern sector of about 10 degrees width.

The analysis revealed periodic deviations of the measured ELF bursts' azimuth, with a duration of about 4 hours and an amplitude of 8–10 degrees, from the stable direction. Such essential errors in measured azimuth can lead to the location error up to 1000 km at maximal distance of 10000 km. Negative deviations occurred when the morning terminator passed through the propagation path from the nearest world thunderstorm center in South America to the station, while positive deviations were observed when the evening terminator passed through. The observed azimuth deviations can be explained by interference between the direct and the reflected from the "day-night" nonuniformity waves. To explain the difference between the morning and evening effect we should adopt change of the reflection coefficient sign when reflection occurs from the dayside or from the night side of the terminator.

TOMOGRAPHY OF THE WORLD THUNDERSTORM ACTIVITY: MODELING FOR TWO SUBPOLAR AND ONE MIDLATITUDE SCHUMANN RESONANCE OBSERVATORIES

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Electromagnetic emissions from lightning discharges occupy very wide spectral range, but the bulk of energy is concentrated in the extremely low (ELF, 3 – 3000 Hz) and very low frequency ranges (VLF, 3 – 30 kHz). Radio waves in the ELF-VLF bands, radiated by lightning discharges, are trapped between the conductive shells that are the earth's surface and the lower boundary of the ionosphere. This natural Earth-ionosphere waveguide provides round-the-world propagation at the lower part of the ELF band with very low attenuation. It allows for unique opportunity for near the real time monitoring of the global lightning activity from single- or multi- station observations.

Analysis of the background ELF signal is based as a rule on the model three main world thunderstorm centers associated with tropical continental regions in South America, Africa and maritime continent in South-East Asia. However, the problem of accounting for oceanic lightning activity, thunderstorms over Siberia and other areas remains unsolved with such approach.

Observed in spectra of the natural electromagnetic fields resonant peaks at frequencies 8, 14, 20, 26, and 32 Hz, represent a global electromagnetic phenomenon known as Schumann resonance (SR) that is primarily connected with the worldwide lightning activity. Distance signatures in SR spectra combined with direction finding technique provide single-site locating super power lightning discharges. In the ELF band, such signals exceed the background level on about an order in amplitude and they are analyzed as isolated in time events. Multi-station observations, based on triangulation or/and "time of arrival" methods, are used to study temporal and regional variations of intense lightning occurrences, their parameters and relation to sprite activity and climate variability.

However, due to essential overlapping between successive pulses that form the natural ELF background, those techniques are applied only to very strong events that occur comparatively rarely and relate only to small part of the total lightning activity.

We recently proposed a technique to infer the global lightning intensity distribution from the background SR signal, based on the measurements of magnetic field spectra at a few globally spaced observatories. The technique includes inversion of SR spectra of two orthogonal magnetic components into distance profiles of sources' intensity in refer to each observation station on the first step. On the second step, we apply tomography reconstruction procedure for the set of such distance profiles for obtaining lightning intensity distribution over the globe.

In this report, we present the results of tomography reconstruction of model lightning distributions with the three SR stations network, installed by the Institute of Radio Astronomy of the National Academy of Sciences of Ukraine at Akademik Vernadsky station, at Svalbard archipelago and in Kharkov region, Ukraine. We have shown the advantage of presence of two sub-polar stations for better latitudinal resolution of the reconstructed distributions. We also discuss the importance of correct accounting for the spectrum of lightning discharges, the transfer functions of receiving equipment and propagation parameters in the "Earth-ionosphere" cavity on the accuracy of reconstruction.

POLAR STRATOSPHERIC WARMINGS AND WEATHER PATTERN IN UKRAINE

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The relation of a major sudden stratospheric warming (SSW) with the mid-latitude surface weather conditions was investigated using data from the ERA-Interim and NCEP–NCAR reanalyzes. The important feature of the SSW event is impact on lower altitudes, when temperature and wind anomalies descend downward into the high- and mid-latitude troposphere during the weeks or even month and influence the surface weather. Knowing SSW impacts on the surface weather, we consider the possible relation of the SSW event in winter 2018 to cold weather anomaly in the Northern Ukraine in February 2018 and looking for the other year's similar events. The stratosphere–troposphere coupling in late February 2018 was accompanied by significant decrease of the thermal tropopause height above the cold tropospheric anomaly in the North-East Ukraine including Kharkiv region. The similar but weaker processes took place in the atmosphere at North-East China region. It is possible that this tropopause anomaly evolves similarly to the tropopause

folding with stratosphere–troposphere exchange of air masses, which can also contribute to the cold weather formation. Cool surface anomaly in late February–early March 2018 lasted about two weeks and started 10 days after the SSW onset. This time delay is consistent with the time scale of stratospheric anomaly downwelling to the surface due to the SSW influences. Downwelling of cold anomaly through the troposphere is also clearly observed and it occurs in coupling with warm anomaly in the lower stratosphere. Therefore, generally, cold surface anomaly could be interpreted as the regional midlatitude effect of the large-scale SSW event concentrated mainly in the polar region. These processes also need more detailed analysis.

MESOSCALE ATMOSPHERIC PROCESSES OVER THE AKADEMIK VERNADSKY STATION REGION BASED ON SIMULATION AND IN-SITU RESULTS

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The Region of Antarctic Peninsula near Akademik Vernadsky station has peculiar natural environment and relief structure in the context of influence on atmospheric circulation. The available descriptions of the regional atmospheric circulation are based on some guesses and analogies, direct measurements and quantitative estimation of it is very rare. To obtain such kind of information, which is needed for better understanding atmospheric processes and microclimate features the additional polygon of weather station was established. Also the atmospheric model simulation was done for a period of time. The results revealed significant variations of regional weather condition, and allowed to pre-diagnose and describe the mechanisms of their formation. Weather condition variations over the coastal ocean are primary caused by the relief's ambiguous influence on the atmospheric circulation. At the same time significant shortcomings in high resolution reproduction of polar atmosphere with one of the most popular regional model Polar WRF v4.1.1 was detected when comparing the model results and measurements.

In the *in-situ* polygon frame (30 km range) temperature variation may reach 5°C, but usually it is in range of 2-3°C. When the atmospheric perturbations and the local circulations are weak (in a calm, cloudy weather) the spatial temperature variation decreases down to 1-2°C. Temperature timeseries shows constant signs for certain locations, i.e. some places should be mostly warmer or colder than others. The wind regime considerably differs over the coastal ocean area. It forms by immediate mountain shadows as well as complex air flow interactions with islands and mountain ranges. The difference in the average wind speed can vary by 2-3 times. Typically, the wind speed can change from almost calm to stormy wind within the investigation area at the same time.

Atmospheric modeling can simulate almost full development of local real processes. These results can be used to study real cases at some approximation. But, as the result of model to *in-situ* comparison shows, simulations have an enormous deviation in some cases. That should be noted, the quality of simulations may be improved by more careful model settings, but biggest uncertainties come from initial data problems and limitation of physical description in the model itself.

In such way the polygon *in-situ* data and the model simulation data complement each other to discover the full scheme of meteorological processes and atmospheric circulation. That is needed for its understanding, evaluation, and description of meso- and microclimate condition.

Also the *in-situ* polygon data may be useful for model's developers in tasks of debugging and improvement for marine polar regions.

PRELIMINARY RESULTS OF POLARWRF APPLICATION FOR CLOUD AND PRECIPITATION STUDY AT UKRAINIAN ANTARCTIC AKADEMIK VERNADSKY STATION

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Precipitation and cloud formation is crucial for radiative properties of the atmosphere and surface mass balance in polar regions, particularly Antarctica where there is a comparatively low amount of measured data and scientific research. The new equipment has been installed during the last few years at Akademik Vernadsky station. It gives an opportunity to gain fundamentally new knowledge of clouds and precipitation characteristics. However, all measurements are performed in one place mostly from vertical profiles at the station and do not allow to assess full 3D structure of cloudiness and falling precipitation. In order to overcome this deficiency it is necessary to use atmospheric modeling for complex understanding of respective atmospheric processes. The goal of this research is to form a complex approach of applying different data sources and numeric models to developing an algorithm of precipitation phase transition study.

We chose and studied a case of observed precipitation phase transition at the beginning of December 2020. We make use of ERA5 reanalysis and PolarWRF simulation to compare and verify their outputs with measurements at Akademik Vernadsky station. Data of ERA5 hourly reanalysis with resolution 0.25° x 0.25° were taken to access synoptic scale precipitation and pressure distribution over the region and as input data for WRF simulation. PolarWRF model was launched on the domain 100*130 points with resolution 9 km centred on Akademik Vernadsky station (65°S, 64°W). For verification of PolarWRF simulated data there were taken Micro Rain Radar measurements of vertical profiles of cloud and precipitation characteristics.

Preliminary results have shown that PolarWRF overestimated precipitation totals and simulated cooler temperatures than ERA5 reanalysis data in lower troposphere. Due to predominantly colder temperature most precipitation has a solid phase at the station. However, both ERA5 and PolarWRF reasonably well represent phases of liquid or mixed precipitation in the studied case. Overally, PolarWRF significantly enhances polar cloud and precipitation study due to more detailed temporal and spatial representation of their characteristics. As a result, we have developed and tested algorithms for precipitation phase transition study based on the station measurements and numerical models. It will be applied in future estimation of other cases in different seasons to evaluate interconnections of specific atmospheric conditions and moment of precipitation phase transition.

TOTAL OZONE ANOMALY OVER ANTARCTICA AND PECULIARITIES OF THE ATMOSPHERIC CIRCULATION

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In this study, we mainly focus on the relationship between the atmospheric circulation and the depletion of the ozone layer in the Antarctic stratosphere from 1972-2021 from the point of view of changes in the daily total ozone amount (TOA) over the Faraday-Vernadsky station. The decisive role for the position and condition of the ozone hole in the spring period in our study is assigned to the nature of the circumpolar vortex (CPV). There is a profound effect of the polar vortex on the features of large-scale atmospheric processes over Antarctica and the Southern Hemisphere during the end of the polar summer and until the end of spring.

The ozone anomaly reached its maximum by the mid-1990s, and later on the area and depth of the ozone hole have approximately stabilized, with great year-to-the-next variability. The deepest ozone hole was observed in 1994, the records for the depth and size of the ozone hole were recorded in 2006, and in the recent 2020-2021 season. However, 2002 saw unusually earlier filling-in of the ozone hole, and observations in 2017 showed that the "hole" in Earth's ozone layer was the smallest.

The ozone anomaly over Antarctica was formed against the background of increasing zonal circulation within the CPV, especially during the austral winter in the Pacific sector, increasing the intensity of both thermal and dynamic vortices, against the background of the predominant planetary wave 4, as well as changes in the angular atmospheric momentum. The period of the ozone hole deepening coincides with the lower-tropospheric warming in the West Antarctic sector, in particular on the Antarctic Peninsula.

Some peculiarities in the geopotential fields within CPV during the recent decades have been noted, with division of CPV into several centers and displacement from the pole position, especially in November, the last month of the ozone anomaly; The recent anomaly in 2020-2021 season persisted until December on the background of the late CPV filling-in. Changes in the atmospheric circulation, which were responsible for the anomaly in the total ozone in Antarctica are studied by means of the classification of circulation patterns at the 50 and 100 hPa levels. The intensity of the circumpolar vortex has been analyzed by means of most probably fields, carried out for individual years. A growing anomaly in the circumpolar vortex associated with its thermal heterogeneity has been identified during the last decades with well-developed ozone anomaly. The anomaly in the CPV during austral spring is associated with the formation of a dipole in the field of air temperature anomalies between the western and eastern sectors of Antarctica, in contrast to previous decades.

The role of Akademik Vernadsky station in the identification of the ozone hole in the Antarctic Peninsula is shown - its data can be used to diagnose and predict the ozone anomaly, taking into account the shape of the CPV and its seasonal evolution. On the basis of statistical criteria of similarity, several stages of development of the CPV corresponding to the course of the daily TOA are distinguished: 1) early stage, 2) maximum CPV development, 3) start of the filling-in process, and 4) the end of CPV - filling-in. Years after the mid-1980s, when the ozone hole became sharper, clearly showed all 4 phases, with pronounced negative seasonal trend in the daily TOA between stages 1-3; whereas years before the ozone hole detection showed general positive seasonal trend with more homogeneous CPV.

It was concluded that the expected increase in the total ozone content over Antarctica occurs not so fast and against the background of negative anomalies in some years due to specific atmospheric circulation.

THE RELATIONSHIP BETWEEN LAND SURFACE TEMPERATURE AND METEOROLOGICAL CONDITIONS ON THE ARGENTINE ISLANDS

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Among all meteorological parameters, land surface temperature (LST) is much more sensitive to the impact of relief microforms and spatial orientation, hence, reflects microclimatological conditions the most. Consequently, the relationship between LST and other meteorological variables can help to link atmospheric macro-processes with the development of local flora. Based on the data of 37 temperature loggers located on the Argentine Islands, the study discusses possible connection between LST variability and meteorological conditions that might be crucial for two local plants: *Deschampsia antarctica* and *Colobanthus quitensis*. It was found that three meteorological variables could be the base for microclimatological modelling and LST strongly depends on air temperature, wind speed and sunshine duration. Their joint usage in the form of regression models explains from 50% to 74% of LST variability. However, such models underestimate real LST values because do not include all significant links with other meteorological parameters. The huge impact on LST is provided also by prevailing synoptic processes with different amount of precipitation. Usually, processes from the west and the south-west bring warmer temperatures (by 2-3℃) in comparison to cold winds from the east (from the Antarctic Peninsula). In most cases for 2019-2020, precipitation was observed during the processes with north and north-western winds, bringing wet marine air; whereas winds from the Antarctic Peninsula are characterized by dry and cold conditions.

CURRENT STATE OF GLACIOCLIMATE AT THE NORTH ANTARCTIC PENINSULA

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It is well-known that climate of Antarctic Peninsula (AP) showed significant change during the recent decades because the episode of the pronounced low-tropospheric warming at the end of the 20th century was followed by the period of the less significant cooling.

Growing surface air temperatures (SAT) at the end of the 20th century considered as part of global changes have predetermined the state in the climate system at the Antarctic Peninsula region consisting in the melting of land glaciers, the reduction in the of sea ice, changes in the state of ecosystems, etc. The greatest increase has been observed at the West coast AP stations in the late 20th century including Akademik Vernadsky station; in the first decades of the 21st century rate of warming has somewhat decreased, some tendency to cooling has been registered especially in austral spring.

The increase in the SAT and the intensification in the surface winds is a single manifestation of climate change in the region, which reflects changes in atmospheric circulation, primarily the strengthening of the zonal flow and the cyclogenesis in the Antarctic. Another important indicator of the climate change is the evolution of glaciers and its surface mass balance strongly depending on local weather settings.

According to the SAT and snow depth series at Faraday-Vernadsky, conditions for annual accumulation existed before 1970s, and subsequently ablation dominated in connection with the warming in the lower troposphere. By the data polygon measurements, restored by prof. L.S. Govorukha, the maximum ablation at the Galindez ice cap was noted in the mid-1990s, caused mainly by the increase in the duration of the ablation period due to the prevalence of positive temperatures in the summer season. Later on, in 2001-2012 annual ablation rate has been decreased, with predominating accumulation in most years, along with significant interannual variability. The leading role of summer ablation in the total annual balance has been revealed: it makes the main contribution to the total annual snow accumulation anomaly, depending on the sign of the SAT anomaly in the months of the warm period. Latest years showed insignificant snow accumulation at the Galindez ice cap due to individual cold seasons and years, e.g 2015, 2016, and predominance of snow accumulation. The given data on the mass balance of the Galindez island glacier may not be representative for the cover and shelf glaciation of the Graham Land. To clarify the state of the glaciers at the AP, further research is needed with field work inside the peninsula and the installation of automatic weather stations.

Peculiarities of the atmospheric circulation responsible for the state of the glacial objects have been studied. The increase in cyclonicity in the months of the warm half of the year leads to significant ablation due to precipitation of mainly mixed and liquid phases, at the same time, cyclogenesis in the months of the cold half of the year with prevailing negative temperatures leads to snow accumulation. The higher temporal stability of the anticyclonic circulation typical for the recent years leads to a longer preservation of cold weather (up to seasonal time scale), which in turn leads to accumulation at the Galindez ice cap.

Glacio-climatic conditions in the study area, including those at Akademik Vernadsky station, are highly dependent on the phase of the El Niño phenomenon, which is associated with the development of certain forms of atmospheric circulation in the south-west Pacific sector of . However, due to the variety of atmospheric responses to each El Niño event, only the large-scale atmospheric process can be indicated. In addition, the Antarctic Peninsula is located at the border of the Pacific-Atlantic influence, so state of the glaciation at the east AP coast can be different. Further research is needed to find more reliable links between regional climate and El Niño.

THE COMPONENTS OF SEASONAL VARIABILITY OF THE SNOW DEPTH IN THE AREA OF THE UKRAINIAN ANTARCTIC AKADEMIK VERNADSKY STATION

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Snow cover is an extremely important integral part of the difficult weather conditions in the Polar Regions, which is due to a number of physical and other characteristics: density, thermal conductivity, albedo, etc. Since the duration of the snow cover period in the polar regions is higher, compared to other territories (usually the period without snow for Ukrainian Antarctic Akademik Vernadsky station (UAS) lasts for days, and sometimes is not observed), its

influence on certain weather characteristics and the formation of weather conditions in general, certainly significant than anywhere else. The snow layer is characterized by significant temporal and spatial variability, which indicates the relevance and importance of conducting continuous observations of its characteristics and necessary of their detailed study.

The purpose of the work is to determine the individual seasonal characteristics of the snow cover in the study area.

In the work, using physical and statistical methods, we analyzed the data of daily observations of the snow cover height at the meteorological playground of the UAS for the period 1997-2020, made with 2 stationary snow depth gauges. The analysis revealed the main trends and the temporal dynamics of the snow mass at the UAS the formation of which is observed from April to August. Analysis of main dates discovered displacement of the boundaries of the beginning and end of the snow period, as well as maximum snow accumulation to later dates. At the same time, the duration of the period itself practically remained unchanged. Analysis of the snow accumulation curve showed that during the period from April to August there are formed 6-8 stable layers, the total height of which is about 250-260 cm. Because the layers are built by certain atmospheric processes, the dates of their formation from year to year are quite close. It is interesting to note that since 2006 the structure of snow cover formation has changed: the process has become slower, however, by the end of the season, the snow depth is even slightly higher.

Formation of snow thickness in the area of UAS occurs by compaction of falling snow under the influence of thermodynamic factors, as well as precipitation in the liquid phase, which are quite often recorded at the station in winter. The most powerful layers are formed in the month of July − the period of maximum snow growth. It should be noted that the curve of dynamics of the snow mass according to observations in the area of UAS against the background of the seasonal component demonstrates the presence of slower quasiperiodic component, the period of which is about 12 years.

MAIN RESULTS OF OCEANOGRAPHIC RESEARCH IN THE SOUTH ATLANTIC AND THE ATLANTIC SECTOR OF THE SOUTHERN OCEAN ACCORDING TO THE SEASON DATA 2018-2020

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The region of Antarctica is one of the regions of the Earth where the most significant climatic changes in the environment are taking place, the dynamics of which have increased significantly in recent decades.

Antarctica is strongly influenced by the Southern Ocean and therefore hydro physical changes in the Southern Ocean have consequences on a planetary scale. More than half of the World Ocean waters contact with the atmosphere in the surface layer of the Southern Ocean. We can say that the Southern Ocean is "lungs" of the Ocean.

Improving of the environmental marine monitoring including the Southern Ocean is one of the main tasks of oceanography. For this purpose, modern science uses satellite information extensively, but the creation of models also requires '*in situ*' measurement data to produce the global analyses. Expeditions on research ships are quite costly activities. One of the successful solutions to this problem is the Ferry Box (FB) approach. It combines commercial and scientific interests. The measuring FB complex provides continuous registration of the basic physical,

biological and chemical indicators of water surface layer during the whole movement of the vessel.

Such a complex was installed in 2018 on the Ukrainian trawler "More Sodruzhestva", which combines fishing with comprehensive research in the South Atlantic. For the last two seasons 2018-2019 and 2019-2020, throughout the entire route of the vessel from the port of Cape Town to the Southern Ocean and back, continuous recording of indicators of the state of the surface layer of the sea was carried out with FB complex.

The conclusions of the expert analysis of its stability and reliability are presented in the report.

As a result, we obtained unique up-to-date information on the state of the South Atlantic and the Atlantic sector of the South Ocean, which made it possible to study the variability of large-scale hydrological structures such as the Southern Subtropical Front, Sub Antarctic Front, South Polar Front in the areas of the South Orkney Islands, Elephant Island and on the transects between them.

The information of the COPERNICUS Marine Environment Monitoring System was used widely for qualitative assessment of contact measurements.

According to the obtained data, the oceanographic database of the South Atlantic and the Southern Ocean has been supplemented. It'll improve the forecasting of the ecological status and biological productivity of the waters of the Southern Ocean, assess the impact of global climate change on the ecosystems of the ocean.

THE RESULTS OF OBSERVATIONS USING AN UNDERWATER VIDEO RECORDING SYSTEM IN THE WEDDELL SEA IN 2020

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At the beginning of February 2020, the Ukrainian longline vessel CALIPSO performed the research survey with the bottom longline in accordance with the decision of the Commission for the Conservation of Marine Living Resources (CCAMLR) to estimate the biomass of Antarctic toothfish (*Dissostichus mawsoni)*. Non-extractive method for the benthic wildlife study using the underwater video system (UVS) recording was provided during the research survey in the northwestern part of the Weddell Sea. At the longline survey stations the data on wind direction and speed, state of the sea, air temperature, cloudiness, ice concentration, atmospheric pressure, precipitation, depth and coordinates of the anchor setting, direction of the longline set also were collected. It was found that the UVS with additional light during video recording did not disturb the animal behavior at depths of 700–1100 m in the study area. Three UVS observations have been described. The slope of the northwestern part of the Weddell Sea can be considered as a spawning site of squid (*Slosarczykovia circumantarctica)*. The data indicate wide distribution of Antarctic krill (*Euphausia superba)* and Antarctic jonasfish (*Notolepis coatsi)* in the area. The high density of the adult Antarctic jonasfish in a single place has never been recorded before. Preliminary observations and analysis of video recordings showed that the shooting lighting and observation distance are sufficient for observing and identifying animals, their behavior and movement. This technique will allow estimating the species relative abundance and size distribution.

HISTORY AND MODERNITY OF WORK OF FISHING VESSELS OF UKRAINE IN THE WATERS OF THE SOUTHERN OCEAN

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Historically, the main species of living resources (except for whales and seals) seized by fishing vessels were Antarctic krill and fish: Marble and Gray notothens, two species of white-blooded fish, Patagonian and Antarctic toothfish, Antarctic silverfish, Antarctic lanternfish, Blunt scalyhead. After overfishing of the main commercial species: Marble notothenia in the areas of South Georgia and South Shetland Islands, the main place in catches for several years was occupied by Green and Yellowfin notothen. Since the end of the 60s of the last century, fishing vessels annually seize part of the living resources. Catches of Marble notothenia reached 400,000 tonnes per year offshore the South Georgia Islands and 150,000 tonnes offshore the Kerguelen Islands. The catches of Antarctic lanternfish reached 100,000 tons per year. The maximum catch of Antarctic krill was 600,000 tonnes.

Since 1982, fisheries in the Southern Ocean have been regulated by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). The Commission is responsible for developing the measures needed to regulate the harvesting and conservation of marine life in the waters of the Southern Ocean. The Commission promotes research and a comprehensive study of the marine living resources of the Antarctic and the Antarctic marine ecosystem, collects data on the state of populations of marine animals, ensures the collection of statistical data on fisheries, analyzes, disseminates and publishes information received from members of the Commission, analyzes the effectiveness of measures taken , applies a system of scientific observation and international inspection for any work in Antarctic waters. Ukraine, along with the other 24 member countries of the Commission, is constantly participating in the research of living resources and in the development of measures for their conservation on the basis of rational fishing.

For the first time fishing vessels from Kerch and Odesa came to the Southern Ocean in 1967. At that time, aggregations of Marbled notothenia and white-blooded fish were discovered and recommended for fishing on the shelves of the Crozet and Kerguelen Islands. Since 1972, vessels from Kerch and Sevastopol have begun fishing for Antarctic krill and fish in the high-latitude seas off the coast of Antarctica. Ukrainian-flagged vessels fished for Patagonian toothfish in the waters of South Georgia and Kerguelen Islands, white-blooded fish off the shelf of the Kerguelen Islands, Antarctic krill in the Atlantic sector of the Southern Ocean (the maximum catch was 60,000 tonnes in 1995), Antarctic toothfish in the high-latitude Antarctic seas. In the last completed season of 2020, one Ukrainian vessel fished for krill with a midwater trawl and 5 bottom longline toothfish vessels.

PRESSING ISSUES OF TROUBLE-FREE OPERATION AND MODERNIZATION OF THE INFRASTRUCTURE OF THE UKRAINIAN ANTARCTIC AKADEMIK VERNADSKY STATION

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Ensuring trouble-free operation and modernization of the infrastructure of the Ukrainian Antarctic Akademik Vernadsky station is an important task faced by the State Institution National Antarctic Scientific Center of Ukraine (SI NASCU). In order to prevent accidents at the Ukrainian Antarctic station, the technical condition of its infrastructure was inspected and assessed in a timely manner. Particular attention was paid to the condition of the fuel tank and protective container, which are the most environmentally hazardous among the existing constructions of the station. Scientists of the Research Institute of Structural Mechanics of the Kyiv National University of Construction and Architecture (KNUCA) took an active part in the research work of the SI NASCU on behalf of the Ministry of Education and Science. With the help of mathematical modeling using modern Computer-Aided Engineering (CAE) Software the structural safety of the fuel tank and protective container against the action of operational loads was assessed. The load capacity of the fuel tank was studied taking into account metal corrosion. The influence of weld defects on stress-strain state and resistance of the structure were assessed. Recommendations as for ensuring its trouble-free operation were given. In our opinion, two issues are relevant today: ensuring the trouble-free operation of all building structures of the station, which have damage and defects accumulated over time, and the design of a modern Ukrainian Antarctic station. To solve the first task, it is necessary to ensure compliance with regulatory requirements under the regulations of inspection, maintenance and repair. Scientists and specialists of KNUCA have an extensive experience and relevant certificates to assess the technical condition of buildings with varying complexity and their reconstruction, inspection of production and quality audit of building materials and structures, scientific and technical support and monitoring of buildings at all stages of construction and operation. In just the last 5 years, about 20 inspections and monitoring of the technical condition of buildings and structures for various purposes have been performed, providing instructions for their further trouble-free operation. For example, the object of immovable cultural heritage of the National Reserve "Sophia of Kyiv" (XI century), a complex of buildings and structures of the historical and cultural reserve "Medzhibizhsky Castle" and others.

The solution to the second issue of creating a new modern Ukrainian Antarctic station is directly related to the design and construction. A review of the literature has shown that there are 49 permanent and 40 seasonal Antarctic scientific stations or bases. They have different architectural and design solutions depending on the time of their construction, location, purpose of research and the number of polar explorers. When creating modern Antarctic stations, the main trends and requirements are environmental preservation, modern design, mobility, compactness, and materials stewardship, providing more comfortable living and working conditions for polar explorers, the use of environmentally friendly energy sources (sun, wind). All this can be taken into account when designing a new modern Ukrainian Antarctic station by architects and specialists of KNUCA who have significant experience and recognition in many countries around the world.

CURRENT STATE AND PERSPECTIVES ON FUEL TANK PROTECTION

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In 2007, a vertical steel cylindrical tank for the liquid fuel storage was built at the Ukrainian Antarctic Akademik Vernadsky station. Resolution of the Cabinet of Ministers of Ukraine №1002 of November 3, 2010 "On Approval of the State Special-Purpose Research Program in Antarctica for 2011-2020" defined the research area "Development and implementation of new technologies". Within this area, one of the tasks was to develop an automated system to prevent fuel leaks from the tank, as well as the development of additional environmental protection at Ukrainian Antarctic Akademik Vernadsky station. To solve these problems, the National Antarctic Scientific Center of Ukraine in 2010 began cooperation with NTUU "KPI". Over the past five years, a number of scientific studies have been carried out on the technical condition of the tank and the possible consequences of its damage, as well as the development of an automated system to prevent fuel leakage from the tank.

However, due to a number of reasons, no cooperation has been conducted in recent years. This fact calls into question the need for further development and implementation of an automated system at UAS Akademik Vernadsky station. One of the main reasons is certain shortcomings that were present in the design of the tank (for example, the small distance between the outer and inner tanks), which makes it impossible to install and maintain an automated system in certain critical places of the inner tank. Another reason is the time that has elapsed since the construction of the tank. This is due to the fact that automated intelligent systems for monitoring and diagnostics of technical condition are usually installed on new objects or on objects that are in operation for a short period of time and have no damages. After installation, the system (within the period specified by its technical characteristics) forms a reference indicator of the technical condition of the object to track its changes in the future. The presence of defects or damage of the object before the installation of the automated system leads to distortion of the reference values, errors in diagnosis and incorrect decision-making.

As a further development of this research area, it is proposed to focus on another task, namely: research and development of additional protection of a vertical steel tank for fuel storage. There are two main loads on the tank in the Antarctic: wind and temperature. The combination of low temperature and strong wind pressure can lead to brittle destruction of the outer protective tank. Means of protection against wind load can be divided into two types, namely: active (mobile systems) and passive (stationary systems). The effectiveness of use of a particular type of protection depends primarily on shape and size of the object of control, the stage of its life cycle (design or operation), location and specific goals, to which each type of protective structures is directed. One of the first and most well-known means of passive protection of objects from wind load is fairing - a special design that facilitates the flow of gas or liquid around the object. Fairings are widely used in high-speed technical devices, such as cars, planes and missiles, as well as for stationary objects that are exposed to wind loads.

Due to the design (double walls, stiffening ribs etc.) and operation features, the tank can be considered a rigid structure, which is under the influence of complex dynamic disturbances in a hard-to-reach place of installation. Therefore, for this type of tanks, research and development of a means of passive protection of the structure from wind load are proposed.

YOUTH ECOLOGICAL PROJECT “SOLAR-HYDROGEN ENERGY FOR UKRAINIAN ANTARCTIC AKADEMIK VERNADSKY STATION”

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The Resolution of the Cabinet of Ministers *"On approval of the State Special-Purpose Research Program in Antarctica for 2011-2023"* (URL: https://zakon.rada.gov.ua/laws/show/1002-2010-%D0%BF#Text) refers to Antarctic research, which is performed not only directly at the station, but also at a considerable distance from it, on a snowy continent. In order to ensure the necessary mobility of researchers, and at the same time preserve the original nature of Antarctica, it is appropriate to use vehicles that run exclusively on environmentally friendly fuel, such as H_2, and which can be replenished directly from surrounding snow and ice near the solar station.

Green energy is a promising trend in energy development in the world. Solar-hydrogen energy is the basis for the development of Green Hydrogen in Antarctica; it has undeniable potential. After all, hydrogen is safe for the environment, non-toxic, does not emit carbon dioxide when it is burnt, and is suitable for use as fuel in internal combustion engines (ICE), compared to petroleum products (gasoline, diesel fuel, etc.). The hydrogen directed and accumulated during the Antarctic day will serve as an environmentally friendly source of energy during the Antarctic night to obtain the necessary electricity and heat.

An important technical task is to increase the efficiency of the solar system by automatically tracking the movement of the Sun. The solution of this and related problems is the goal of the project, which is proposed for the implementation of *Research and Training Center for Applied Informatics of the National Academy of Sciences of Ukraine, Kyiv* (http://www.nucpi.nas.gov.ua/).

The Cybernetic Center of the National Academy of Sciences of Ukraine (Kyiv), where the RTCAI of the National Academy of Sciences of Ukraine is located, has specialists in the development of computer models and methods for the practical implementation of optimization algorithms for controlling movable structures. Approximate computer algorithms for finding the extreme value allow to implement reliable automatic control of the orientation of the semiconductor panels of solar power plants, so that they work with the maximum possible efficiency [1, 2].

The initiator of the project - RTCAI NAS of Ukraine - cooperates with the National Transport University (NTU MES of Ukraine, http://www.ntu.edu.ua/). We can count on the participation of teachers and students of this university in the re-equipment of traditional transport and internal combustion engines, which are operated at the Antarctic Akademik Vernadsky station, for environmentally friendly hydrogen fuel.

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POSTERS

HEAT STRESS RESPONSE OF PSEUDOGYMNOASCUS SPP. ISOLATED FROM DIFFERENT BIOGEOGRAPHIC REGIONS

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In line with the challenges of climate change and global warming, elucidating the heat stress responses of soil microfungi is becoming an important research focus. Temperature may alter the abundance of soil microfungi species in the soil ecosystem, leading to consequential changes in microbial communities. Under heat stress, soil microfungi undergo various physiological changes to maintain cell stability and use protective mechanisms to repair resulting damages. Knowledge on the mechanism of heat stress responses will contribute to the understanding of the specific roles of soil fungi in extreme environments. *Pseudogymnoascus* fungi are commonly isolated from polar and temperate soils and have shown high similarities in their temperature-dependant growth profiles between species. This characteristic makes them a good candidate to search for heat stress biomarkers. Therefore, the present study determined the changes in the protein abundance of isolates of *Pseudogymnoascus* spp. from polar and temperate regions in response to heat stress. Proteomic analyses were carried out to profile the proteome of six *Pseudogymnoascus* spp. towards heat stress. Many hypothetical proteins remained unidentified or uncharacterised, suggesting that the *Pseudogymnoascus* spp. proteome comprised a high number of novel proteins. GO enrichment analysis of all six isolates was performed to identify any biogeographical pattern of heat stress response from *Pseduogymnoascus* spp. The protein profiles of all isolates in response to heat stress varied greatly, in terms of the significantly up- and down-regulated proteins. Enrichment of multiple protective mechanisms, including the modulation of protein homeostasis, regulation of energy production and activation of DNA damage and repair pathways, mean that these metabolic pathways could be a part of the heat stress response mechanism. However, the proteomics analysis of *Pseudogymnoascus* spp.'s response to heat stress did not show any clear correlation with the biogeographical regions of the isolates. It is hoped that by understanding the mechanism of fungal heat stress response, the adaptation process of *Pseudogymnoascus* spp. to global climate change that might affect decomposition processes could be explained more comprehensively.

ANTARCTIC BACTERIAL CONSORTIUM DIESEL DEGRADATION OPTIMISATION VIA STATISTICAL APPROACH

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Human activities in Antarctica have been made possible by diesel combustion; however, the ever-increasing Antarctic expeditions rendered the environment more vulnerable to pollution. Precautionary steps encompassing the Madrid Protocol and heavy fuel oil (HFO) ban have been implemented to minimise diesel pollution effect. Physical, chemical and biological treatment methods have been applied to mitigate the contamination upon the occurrence of oil spills. Among the methods used, biological method using microorganisms is the most sustainable approach. Compared to single-strain bacteria, conglomerations of several bacterial species enhance the bioremediation approach with proven synergistic effect. However, the study of diesel degradation using bacterial consortium in Antarctica is limited. In this study, optimisation of hydrocarbon-degrading ability was conducted using Antarctic bacterial consortium BS9 sampled from soil in General Bernado O'Higgins Base. The objective of this study is to maximise bacterial diesel-degrading capability by studying the effects of salinity, nitrogen source and concentration, temperature, pH and initial diesel concentration. Observations revealed that diesel degradation was maximum at 0% (w/v) NaCl, 1 g/L NH_4Cl as sole nitrogen source, pH 7 and temperature of 10°C, where 90.79% of diesel was degraded within 7 days of incubation Since the Antarctic Treaty System has impeded the introduction of foreign microorganisms to the region, the discovery of bacterial consortium with high hydrocarbon-degrading ability is of great importance to combat the diesel contamination issue.

EFFECT OF HEAVY METALS ON PHENOL DEGRADATION BY AN ANTARCTIC BACTERIAL CONSORTIUM

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Antarctica is not free from environmental pollutants although it is often perceived to be the last pristine continent on Earth. Fuel combustion, accidental oil spills, waste incineration and sewage disposal are among the primary sources of hydrocarbons, phenolic compounds and heavy metal contaminants in Antarctica, besides natural sources including animal excrement, volcanism, and specific geological minerals. Phenol, a substance that is extremely poisonous to most living organisms, is one such contaminant associated with the human pollution (e.g. oil and chemical spills) and sewage disposal in Antarctic. Phenol degradation by a native Antarctic bacterial consortium was studied in media containing 1 ppm of one of seven different metal ions, namely arsenic (As), cadmium (Cd), aluminium (Al), nickel (Ni), silver (Ag), lead (Pb) and cobalt (Co). Bacterial growth was inhibited by these ions in the rank order of Al < As < Co <Pb < Ni < Cd < Ag. Greatest bacterial growth occurred in 1 ppm Al, achieving an OD_{600} of 0.985,

and lowest in 1 ppm Ag with an OD_{600} of 0.090. However, while Ag had a considerable inhibitory effect on the bacterial consortium's ability to degrade phenol, 100% removal of phenol was achieved in the presence of the other metal ions. This pilot study highlights the differing influence of different metal ions on the biodegradation of phenol by native Antarctic bacteria.

GROWTH EVALUATION OF ANTARCTIC FILAMENTOUS ALGAE IN MOLYBDENUM AS HEAVY METAL

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The primary contributors to heavy metal pollution in the precarious Antarctic ecosystem of Earth's Southern Pole are a huge surge of anthropogenic emissions, tourism, scientific work, and coastal traffic in the recent times. Heavy metals accumulated in the polar region as a result of domestic contamination and long-range transportation of global contaminants via the Southern Ocean. These factors would last indefinitely and also have a significant impact on the wildlife and water bodies. Molybdenum (Mo) is a trace element whose toxicity to the ecosystem, especially in colder climate, has not been thoroughly investigated. In comparison to indigenous bacteria consortia, the algae populations in Antarctica were less oriented and studied in terms of their response towards heavy metals. At optimum conditions, several cold-adapted indigenous bacterial strains were identified and exhibit the capability to reduce complex Mo to molybdenum blue (Mo-blue), in the soluble colloidal form. The goal of the study is to use a traditional one-factor-at-a-time (OFAT) and growth kinetics approach via an exponential model by optimising the conditions designed to enhance the maximum growth of an Antarctic alga, *Klebsormidium* sp. The freshwater Bold's Basal media (BBM) was supplemented with 10% of algal culture and their growth was assessed in two culture systems: with and without aeration. The standard growth pattern of *Klebsormidium* sp. was plotted based on the cell density at 620 nm for 14 days. The growth parameters were integrated with low phosphate media (LPM) treated with 10 mM of molybdenum to ascertain factors that influence algae growth in molybdenum through one-factor-at-a-time (OFAT). Growth kinetics was investigated by using the exponential growth model. As a result, the *Klebsormidium* sp. reached an exponential phase on the third day in both culture systems. The algal culture with aeration exhibited elevated growth rate (μ= 0.2352 d^{-1}) contrasted to those without aeration (μ= 0.1976 d^{-1}). Based on OFAT, the total biomass harvested in two culture systems were equivalent to each other ($P>0.05$). *Klebsormidium* sp. demonstrated maximal growth in conditions of biomass at 20 g/L of sucrose, 2 g/L of ammonium nitrate, 4 g/L NaCl concentration and pH 7.5. Growth rate of *Klebsormidium* sp. with aeration (0.020 ± 0.0018 h^{-1}) and without aeration (0.020 ± 0.0015 h^{-1}) was not substantially different ($p>0.05$) as per the exponential growth model.

ESTABLISHING A CEMP CAMERA NETWORK IN ANTARCTIC PENINSULA: PROJECT RESULTS

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The gentoo penguin survey was provided in the framework of the National Antarctic Scientific Center project "Support and development of the CEMP network in the Antarctic Peninsula". This project is a logical extention of the work that has been done in the 2015/16 season on the installation and maintenance of CEMP cameras for study of chronology and the reproduction success of gentoo (*Pygoscelis papua*) and Adélie penguins (*Pygoscelis adeliae)*, during winter 2016 and the 2016/17 season, winter 2017 and 2017/18 season provided by the biologists at Akademik Vernadsky Station. The aim of the study is to support and develop the CEMP camera network and to monitor the distribution, breeding chronology and breeding success of penguin populations, predator-dependent krill needs during the winter season in Subarea 48.1, in particular, in the Argentine Islands Archipelago (AIA), Petermann and Yalour Islands, in accordance with international CEMP projects "Establishing a CEMP Camera Network in Subarea 48.1" (Hinke et al., 2018), and "Tracking the overwinter habitat use of krill dependent predators from Subarea 48.1". In addition to the research according these two CEMP projects, the detailed observations on the penguin population seasonal behavior/dynamics have been provided in CEMP sites GBV and GPP at Galindez Island, where CEMP cameras were operated. The survey work was done during the end of 2017/18 season, during the winter 2018 and the 2018/19 season. According the 2019/20 survey in area from Petermann Island at norths to Green Island in south of area the 7 largest colonies consist of 11000 adult gentoo penguins and 8230 juveniles. At Galindez Island the number of gentoo nests changed from 1130 to 1220 in two years. The ornithological study covered the entire Argentine Island archipelago, as well as some adjacent territories.

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AN EXAMPLE OF ORNITHOCHORY: *CATHARACTA MACCORMICKI* IN THE REGION OF THE ARGENTINE ISLANDS, THE MARITIME ANTARCTIC

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In spite of the low diversity and isolation of Antarctic ecosystems, birds are one of the most likely vectors of vegetation transfer in the region. Skuas are among the most common birds on the Antarctic Peninsula. The accidental use of vegetation by these birds during nesting seasons in the northern part of the maritime Antarctic is evidenced in some papers. Given to the previously shown differences in the nesting materials usage in the distant Antarctic regions by kelp gulls (*Larus dominicanus*), we studied the nesting behavior of south polar skua (*Catharacta maccormicki*) in the more south Argentine Islands region in the context of probable ornithochory.

The total number of analyzed nests of *C. maccormicki* was 186. Nest samples were collected during 2009-2020 years in the Argentine Islands region that in our study included all islands and coasts of the Graham Land from the Lemaire Channel to the Berthelot Islands from north to south and extending from west to east from the Roca and Cruls Islands to the Antarctic Peninsula coastal sites. The most typical nests of *C. maccormicki* in the region were located on the moss banks and the components of the nests were mostly mosses (63-88%), often with lichens *Usnea* sp., *Umbilicaria* sp. (up to 20.5%). In contrast, only 8% nests included significant amounts of *Nacella concinna* limpet shells as nest component. Mosses *Polytrichum strictum* Brid., *Sanionia* sp., *Pohlia nutans* (Hedw.) Lindb., *Bryum* sp. were found in all the nests of south polar skua in every season. The amount of *P. strictum* in the moss fraction was 60 to 100%, *Sanionia* sp. 80.8-100%, *P. nutans* 10.6-83.3%, *Bryum* sp. 2.1-25%. Other species were rarer. Significant diversity of mosses in *C. maccormicki* nests in the Argentine Islands region was not observed indicating that the birds choose certain massively prevailing materials to build their nests. Most nests were on moss banks (Tall moss turf subformation), fewer on areas with Bryophyte mat and carpet subformation. Sometimes birds bred on bare rock. The mosses composition of most nests corresponded to the vegetation composition at the nest site. *D. antarctica* was found in only 9.1% of the studied nests. In the Argentine Islands region *D. antarctica* is not as common as in the more northern areas. On all islands where *D. antarctica* was found in the south polar skua nests relatively big populations of *D. antarctica* are known, though in some cases the plants grew at considerable distance from the nest. In our study we suggest C. *maccormicki* in the region are not picky while choosing the nesting materials and so do not spread *D. antarctica* between different islands or coasts, but could distribute some vegetation components locally, thus furthering the ornithochory at least of *D. antarctica*.

TEMPERATURE SURVIVAL OF DAPHNIA (CTENODAPHNIA STUDERI (RUHE, 1914) (ANOMOPODA, CRUSTACEA: CLADOCERA) FROM COASTAL LAKES AT LARSEMANN OASIS (LARSEMANN HILLS, EAST ANTARCTICA)

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The work was carried out on freshwater lakes located at Larsemann Hills, East Antarctica near the Russian Antarctic Progress station. Inhabitants of the lake bottom and plankton are represented by algae, protozoa and one species of Cladocera, the main and largest invertebrate in the local lakes, *Ctenodaphnia studeri* (Ruhe, 1914) (Anomopoda, Crustacea: Cladocera Daphnia (*Ctenodaphnia studeri*). *Ctenodaphnia studeri* was found in 10 lakes - Lake Stepped, Lake Reid, Lake Scandrett, Lake Discussion, Gornoe Lake LH 73, Gornoe South Lake, Lake Nella, Lake Boulder, Lake Sibthorpe, Lake Progress. Water temperature in lakes littoral in summer was within 13.9-0.4°C, with an active environmental reaction ranging from neutral 7.2 to highly alkaline 9.2. The maximum concentration of daphnia was observed not in the water column, but

near the bottom, in places of bottom algae growth, the main type of their food. Method of determining maximum and minimum temperature at which 100% animals are died was used for investigation of the temperature threshold of Antarctic daphnia existence. All experiments were carried out at different rates of temperature change on experimental daphnia of minimum, medium, maximum body size and on egg-laying females. The water temperature was changed at a rate of 0.3 to 2.4° C per minute, that is quite high. This experiment has shown that temperature of +33-34°C is 100% lethal for this species. However, such temperatures causing somatic cell and tissue damage (in the experiment) are significantly higher than the inhabitat temperature and the organism in natural conditions does not encounter it. Determination of the lower survival limit has shown that the species is active in the aquatic environment up to its freezing point. The possibility of prolonged existence of daphnia was noted at constantly high temperatures. They were found to be able to live actively at temperatures of 23-24°C for about two weeks. It should be noted that such temperatures can't be in local lakes. The equation of dependence of the maximum lethal temperature on the temperature of animals habitat on example of the lowest water crustaceans in the temperature limits of their existence - from minus 7,5°C up to plus 39°C was derived for the first time taking into account the data on Antarctic invertebrates, including the sea crustaceans living at negative temperatures in the sea. Note that although this value in most cases depends on habitat temperature, as we have shown earlier, there are some hydrobionts, for example the mollusk *Lymnaea stagnalis*, that have a maximum lethal temperature within 43°C that doesn't depend on habitat temperature.

BIOINFORMATIC ANALYSIS OF GENE PROMOTER OF *DESCHAMPSIA ANTARCTICA* DaDREB2B STRESS-INDUCIBLE TRANSCRIPTION FACTOR

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D. antarctica is one of the two vascular plant species that have undergone adaptation to survive in unfavourable conditions of low temperatures, high soil salinity, low humidity, etc. typical of the Maritime Antarctic. We analysed known regulatory cis-elements in the gene promoter of DREB2B transcription factor (TF), which is involved in response to drought, salinity, cold, and heat stresses.

The 1000 bp upstream sequence of putative *DaDREB2B* gene was assembled as a consensus through multiple alignment of short reads found using BLAST search against *DaDREB2B* gene in the SRX465632 archive containing *D. antarctica* genomic DNA sequencing data available from the GenBank. For comparative analysis, we included 13 grass species from three subfamilies differing in cold and drought tolerance: *D. antarctica*, *Hordeum vulgare*, *Aegilops tauschii*, *Secale cereale*, *Brachypodium distachyon* (Pooideae), *Setaria italica*, *S. viridis*, *Cenchrus americanus*, *Zea mays*, *Sorghum bicolor* (Panicoideae) and *Oryza sativa*, *O. coarctata*, *O. officinalis* (Oryzaceae). Using the BLAST tool, the *DREB2B* promoter sequences were searched for in genomes of these species available in GenBank.

Analysis of regulatory elements in *DREB2B* promoters of 13 grass species performed using the PlantCare database revealed 54 cis-acting elements involved in response to abiotic and biotic stresses, light, and hormones (including abscisic acid, auxin, methyl jasmonate, ethylene, gibberellin, and salicylic acid), as well as tissue-specific cis-elements. Among the found cis-elements, the most abundant were those related to abiotic stress response that is consistent with the function of DREB2B TF.

In *DaDREB2B* gene promoter, basal cis-acting elements CAAT-box and TATA-box were found. Among those associated with abiotic stress we found a number of hormone sensitive cis-acting elements as follows: ABRE (abscisic acid); TGA-box and TGA-element (auxin); CGTCA-motif and TGACG-motif (methyl jasmonate); ERE (ethylene); P-box (gibberellin); and TCA-element (salicylic acid), as well as the binding site of MYB TF, and STRE stress-response element, associated with the response to heat, osmotic, and nutrient stress. In the group of biotic stress-associated cis-acting elements, jasmonic acid- and elicitor-responsive element (JERE) was found, which was absent in other species. Light-responsive cis-acting elements included GATA-motif and G-box. Tissue-specific cis-acting elements CAT-box and dOCT are related to meristem expression. *DaDREB2B* gene promoter was found did not contain some abiotic stress-related cis-acting elements such as CCAAT-box, DRE and MYC (binding sites for TF MYBHv1, DRE and MYC, respectively) which were identified in *DREB2B* promoters of a number of other analysed species.

Except for some individual variations, *DREB2B* promoters of the studied grass species which have different cold and drought tolerance and Antarctic extremophile *D. antarctica* were found to contain a similar set of cis-acting elements which suggests the similarity of the regulation of *DREB2B* expression and its potential functions in response to stress in the studied species.

This study of regulatory elements of *DREB2B* promoter in grass species contributes to the understanding of the regulation of this gene and form the basis for further studies of the interactions among DREB2B and other TFs in stress-induced signalling pathways.

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ENDOPHYTIC BACTERIAL COMMUNITIES' COMPOSITION OF ANTARCTIC VASCULAR PLANTS DERIVED BY 16S rRNA METAGENOMICS

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Deschampsia antarctica É. Desv. and *Colobanthus quitensis* (Kunth) Bartl are the only vascular plants that inhabit coastal regions of the Western Antarctic Peninsula (WAP) and face unfavorable conditions, such as low temperatures, thaw-freezing cycles, permanent exposure to UV light during the summer season, as well as deficiency of water. Microorganisms inhabiting the plant interior, endophytes, have plant-growth promoting properties and enhance tolerance of plants against biotic and abiotic stresses. **The aim** was to study taxonomic composition of endophytic bacterial communities of the vascular plants *D. antarctica* and *C. quitensis* growing along the WAP. **Methods.** Samples of plants were collected along the WAP (points at South Shetland Islands, Argentine Islands, Anvers Island and Lagotellerie Island) in February-March 2019. Plants were collected aseptically in the sterile plastic boxes and proceeded in the laboratory of the Ukrainan Antarctic Akademik Vernadsky station. Surface of the plants' aboveground part was sterilized by washing in distilled water, ethanol (70%) and sodium hypochlorite (5,6%). DNA was extracted by DNeasy Plant mini kit (Qiagen, Germany) according to manufacturer's protocol. V4 region of the 16S rRNA gene was sequenced on

Illumina MiSeq (MR DNA, Shallowater, USA) with primers S-D-Bact-0341-b-S-17 та S-D-Bact-0785-a-A-21 with barcode on the forward primer. Bioinformatic analysis was provided in QIIME2 2020.8. Taxonomic assignment of the OTUs was performed according to the Greengenes 13_8 database with the threshold of 97%. **Results.** *Proteobacteria* (78-83%), *Bacteroidetes* (10-15%) and *Actinobacteria* (2-4%) are dominant phyla in the endosphere bacterial communities. *Firmicutes, Armatimonadates* and non cultured OD1 were much less abundant. The most widespread classes were those belonging to *Proteobacteria: Alpha-*, *Beta-* and implicitly dominant *Gammaproteobacteria* (12-95%). *Sphingobacteria*, *Actinobacteria, Cytophagia*, and *Bacilli* are well distributed as well, and along with proteobacteria comprise from 85 to 100% of the community. *Saprospiare*, *Flavobacteria* and *Bacteroidi* were less abundant classes comprising less than 4% in the communities. *Pseudomonadaceae* and *Oxalobacteraceae* are the most numerous families in the communities, while other families have a patchy distribution. Endophytic communities of *D. antarctica* and *C. quitensis* are composed presumably by the bacterial taxa commonly found in the soil, which assumes involvement of the rhizosphere microbiota in the development of endophytic communities. Yet, mainly bacteria belonging to *Pseudomonadaceae*, *Oxalobacteraceae* and more rare *Shingobacteriaceae* have features enabling the endophytic lifestyle in Antarctic environments. **Conclusions.** Taxonomic composition of bacterial communities inhabiting the endosphere of *D. antarctica* and *C. quitensis* was analysed with the means of 16S rRNA sequencing and showed the dominance of *Gammaproteobacteria*, which usually dominate in endophytic communities.

OPTIMIZED PROTOCOL FOR DNA EXTRACTION FROM LOW-ABUNDANCE ANTARCTIC BACTERIOPLANKTON SAMPLES FOR INCREASED YIELD

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DNA extraction from low-abundance environmental samples is challenging and it strongly influences the abundance of rare taxa skewing the overall community structure. Three commercial DNA extraction kits - DNeasy Blood and Tissue, DNeasy Power Soil (QIAGEN, Germany) and Higher Purity Soil DNA Isolation kit (Canvax Biotech, Spain), have been tested for bacterioplankton samples collected during February-March 2020 within marine monitoring polygon at Ukrainian Antarctic Akademik Vernadsky station. Additionally, different sample homogenization approaches have been applied in order to enhance microbial cell lysis - with and without grinding in liquid nitrogen. The resulting DNA quality and concentration was assessed using DeNovix DS-11 spectrophotometer. PCR was performed with primers targeting 464 bp fragment of bacterial 16S V4 region with the purpose to check for the target gene amplification success and the results were examined with agarose gel electrophoresis. The spectrophotometric estimation of the resulting DNA quantity and quality showed that Higher Purity Soil DNA Isolation kit performed significantly better than the other kits yielding up to 57.2 ng/ul of DNA with the average 230/260 ratio being 1.7 and the average 260/280 ratio being 2.05. The use of DNeasy Power Soil kit resulted in high DNA concentration reaching 212.9 ng/ul, yet the purity ratios were 0.5 and 1.63 for 230/260 and 260/280 respectively indicating the possible contamination of DNA extracts with organic substances (guanidine thiocyanate, phenol etc.) or proteins. DNeasy Blood and Tissue kit yielded insufficient DNA concentration (5.61 ng/ul on

average) with low purity ratios. The homogenization modifications, such as the use of liquid nitrogen for filter grinding did not influence DNA yield and purity, and additional wash did not result in removal of contaminants from the DNA extracts. The only significant factor identified by the Kruskal-Wallis analysis was the extraction kit used (p-value = 0.0014 for DNA concentration, p-value = 6.659e-07 for 230/260 ratio and p-value = 3.877e-06 for 260/280 ratio). Ethanol precipitation time (p-value = 0.0008 for DNA concentration, and filter size (p-value = 0.016 for DNA concentration, p-value = 0.03 for 230/260 ratio) were significant factors when Higher Purity Soil DNA Isolation kit procedures were analyzed separately. The PCR results revealed the presence of strong target fragment amplification from DNA extracted with Higher Purity Soil DNA Isolation kit only. Based on DNA extraction protocols performance the use of Higher Purity Soil DNA Isolation kit (Canvax Biotech, Spain) with 2 hour ethanol precipitation and 1 full filter is recommended for optimal DNA extraction from low-abundance Antarctic bacterioplankton samples.

PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERISTICS OF YEAST ISOLATED FROM DIFFERENT ECOSYSTEMS OF EASTERN ANTARCTIDA

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As a study, we used 8 fine earth samples (hypoliths and endoliths) from East Antarctica (Enderby Land, Molodezhnaya station and the Vechernyaya Mountain field base, Mac Robertson Land, Prince Charles Mountains). As a result of the study, it was possible to isolate 20 yeast isolates. The purpose of further work was to study the physiological and biochemical functions of the isolated cultures.

As a result of the conducted studies, it was found that among the yeasts, psychrophiles were not found and the temperature optimum for all was in the range from 10 to 22 ^{0}C. As a result of staining with ink, the presence of capsules was found in all the investigated isolates.

The response of microorganisms to stressful influences can be considered an example of adaptive capabilities. One of these is resistance to various concentrations of heavy metal in the medium (copper sulfate), but when the metal was added to the medium, the expected high resistance was not found in the isolates. The investigated isolates were also kept for different times under the conditions of UV radiation (5, 10, 15, 20, 25 minutes) and the presence of viable cells was observed. In this case, 4 isolates were identified with high resistance to UV radiation.

Most of the studied isolates were characterized by the presence of lipolytic, amylolytic, DNase, urease activities and ester production. A much smaller number of isolates exhibit proteolytic, cellulose, and pectolytic activity, secrete organic acids, and form starch-like compounds.

When growing in liquid media, yeast causes turbidity, forms a precipitate, a ring, or a different film character. Studies have shown that about half of the isolates are capable of forming films of various shapes on a liquid medium, the other part of the isolates show growth in the form of a ring at the air / liquid interface, and 2 isolates are not characterized by growth in a liquid medium.

The physiological state of yeast was determined by the presence of storage carbohydrates, one of which is glycogen. According to the results obtained, 11 out of 20 presented cultural indicators accumulated insignificant amounts of glycogen, in 8 out of 20 this indicator was average and 1 showed a high ability to accumulate glycogen.

Carotenogenic yeast can be fortified with lipids (up to 70 % by weight). The study of this property was carried out at various stages of culture growth and it was found that most of the studied cultures after a long period of incubation go to the accumulation of lipid droplets in cells, which have reached 2/3 of the cell volume or more.

In order to search for promising producers of glycolipid biosurfactants, it performs screening of yeast synthesizing metabolites with emulsifying and wetting properties. It was shown that a number of studied cultures synthesize compounds with properties characteristic of glycolipids when grown in special media. The study of the emulsification index of the culture liquid showed that in 3 out of 20 samples the index is higher than 50 %, in 7 out of 20 it is in the range from 20-50 %, in 10 cultural samples – less than 20 %. When droplets of suspensions were applied to a hydrophobic surface, it was found that they wet the surface more significantly than water. It was found that suspensions of 5 out of 20 studied cultures have the highest wetting ability. Is known that the higher emulsification index correlates with the higher destructive activity of microorganisms.

Natural utilization of hydrocarbon mixtures is essential for biotechnology and ecology. One of the sources is mineral motor oil. A study of the ability of yeast to break down the oil layer revealed 8 isolates with high destructive activity.

PRESERVATION OF INFECTIVITY OF BACTERIOPHAGE LYSATES ISOLATED FROM SOIL BIOTOPES OF THE ANTARCTIC REGION DEPENDING ON STORAGE TIME AND TEMPERATURE

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Viruses are powerful engines of microbial diversity and the evolution of ecosystems as a whole, while Antarctic biotopes remain largely unexplored in terms of the physicochemical conditions that support virus biodiversity. In the course of research, we were able to characterize the temperature optima of storage and viability of bacteriophages isolated from low-temperature terrestrial environments, and to establish a relationship of infection with growth temperatures of bacterial hosts, taken from Antarctic samples collected in 2019 at the Ukrainian Antarctic Akademik Vernadsky station, Argentine Islands.

We have successfully described the temperature limits of the growth activity of six bacterial isolates isolated from Antarctic soil samples. Based on the experimental cultural, morphological and biochemical properties, all bacteria identified in the study belonged to the genus *Pseudomonas*. For most of these bacteria, the optimum cultivation temperature was within + 16°C - + 28°C, indicating their psychotolerance. Bacterial hosts were used to analyze the viral–host interactions. Six lithic phages were successfully isolated from soil samples in Antarctica and then cultivated, purified and described.The morphological features of the families *Sipho-*, *Myo-* and *Podoviridae* of the *genus Caudovirales* was determined and established by electron microscopy. Later, the task was to determine the optimal temperature for bacterial culture with isolated phages. The influence of the temperature on the replication of phages (i.e., the formation of negative colonies) was tested at temperatures supporting the growth of the hosts. All phage isolates had biological activity to natural hosts only at moderate temperatures from + 4°C to + 20°C.The temperature in Antarctica during the year usually remains below 0 °C, except during the summer months when the frozen soil thaws. Thus, the data obtained are likely to show a rather limited period of (summer) phage infection of bacterial hosts, the rest of the time (autumn-spring) phages are only stored in the frozen soil without causing infection. We have experimentally established that phages retain their infection rate at +20 - -10°C for a long time.

The mechanisms and causes that affect the replication and retention of low-temperature latitudes require detailed study and study in the future.

ELEMENT ACCUMULATION IN MARITIME AND CONTINENTAL ANTARCTIC LICHENS

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Lichens, like other poikilohydric organisms, are characterized by slow metabolism and growth, and the absence of specialized organs for the absorption of nutrients and water. As a result, they can absorb water and minerals across much of the thallus surface as well as concentrate various elements from their immediate environment, including the atmosphere. Thus, element accumulation in lichen thalli can reflect the chemical composition of their local environment, and this phenomenon has formed the basis of bioindication studies of environmental pollution. We found that a range of lichens from the maritime Antarctic accumulated more macro- and micro-elements compared with those from the continental Antarctic. The elemental composition differences observed in the lichens studied suggest generally higher bioavailability of nutrients in the maritime than in the continental Antarctic, consistent with greater nutrient limitation being typical of the latter. The relatively high N content in thalli of *Physcia caesia* and *Thamnolecania brialmontii* may indicate a significant influence of ornithogenic factors for lichens in the maritime Antarctic. Based on the data obtained, we suggest that some of the studied lichen species (*Usnea sphacelata*, *P. caesia*, *T. brialmontii*, *Ramalina terebrata*) have potential applications as bioindicators of environmental pollution and in long-term monitoring of such pollution in Antarctica. For example, continental Antarctic *U. sphacelata* has potential for use as an indicator of Pb and Hg pollution. Similarly, several maritime Antarctic species have potential as indicators of elemental accumulation: *R. terebrata* concentrated Hg; *P. muscigena* concentrated As; *P. caesia*, *Physconia muscigena* and *T. brialmontii*, Cd; *P. caesia* and *T. brialmontii*, N.

PHOTOPROTECTOR FUNCTIONS OF UV-ABSORBING PHENOLIC COMPOUNDS OF BRYOPHYTES FROM ANTARCTICA

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In Antarctica bryophytes are dominant among higher plants in localities with high levels of UV radiation due to an adaptive morpho-physiological strategy for its influence (Glime, 2007). To determine the resistance potential of Antarctic mosses to stress factors, the effect of UV radiation with an intensity of 4 kW/m^2 on the content of soluble (vacuolar) and insoluble

(bound in the cell wall) fractions of UV-absorbing phenolic compounds and flavonoids in moss gametophyte *Polytrichum arcticum* Sw. ex Brid. and *Bryum caespiticium* Hedw. from Antarctica were experimentally investigated. For comparison, we used plants of *Bryum caespiticium* Hedw., collected in Lviv region. A higher concentration of the total phenolic compounds content was determined in plants from Antarctica both in control (without irradiation) (4.08 mg/g d.w.) and after UV exposure (5.86 mg/g d.w.), compared to plants of Lviv population (2.54-3.36 mg/g d.w.), which indicates greater adaptability of Antarctic mosses to the stress factor. Analysis of the content of vacuolar and cell-bound fractions of phenolic compounds indicated, that both samples of *B. caespiticium* were characterized by 1.5-1.8 times higher concentration of UV-absorbing phenolic compounds localized in the cell wall. It was shown, that after UV irradiation, their content also increased more significantly compared to the amount of soluble vacuolar fraction. For the Antarctic sample of *P. arcticum*, a higher concentration of UV-absorbing compounds bound to the cell wall was also indicated both under control conditions (3.02 mg/g d.w.) and under the influence of UV radiation (3.85 mg/g d.w.), compared with the content of the vacuolar fraction (1.64-1.87 mg/g d.w.) Therefore, it can be assumed that UV-absorbing phenolic compounds bound to the cell wall play a key role in the cells protection from UV radiation. It was shown that flavonoids play a major role among phenolic compounds in the absorption of UV rays (Hollozy, 2002; Fabón et al., 2012). Induction of their synthesis under the influence of UV radiation was detected both in plants of *B. caespiticium* (4.56 mg/g d.w.) and in *P. arcticum* (5.71 mg/g d.w.) from Antarctica and in shoots of *B. caespiticium* of the Lviv population (3.18 mg/g d.w.). However, higher concentrations of flavonoids after stressors' influence were determined for Antarctic plants. The absorption spectra of flavonoid extracts of both samples of *B. caespiticium* and *P. arcticum* in a solution of aluminum chloride were analyzed and their similarity was noted. Absorption maximums were recorded in the spectrum range of 420-440 nm, 470 nm, and 2 maximums in the long-wavelength range (620 and 670 nm). It should be noted that the interaction of flavonoid extract with aluminum chloride leads to a bathochromic shift of the absorption maximum of the starting reagents by 66–67 nm (Pękal, Pyrzynska, 2014), which was taken into account in the identification of flavonoids. These maximums of the absorption spectrum match to the flavonols rutin and quercetin, which are the most effective reductants of the superoxide radical among flavonoids (Jovanovic et al., 1994) and the flavone luteolin. Peaks in the long-wavelength range of the spectrum may match to the anthocyans, which absorb less in the UV spectrum area, but perform the function of an optical filter that protects the electron-transport chain of chloroplasts from high-energy quanta (Jansen, Urban, 2019). Thus, the obtained results indicate increased resistance of Antarctic mosses *B. caespiticium* and *P. arcticum* to UV radiation, which formed during long-term plants adaptation to extreme conditions and provided by significant antioxidant potential and accumulation UV-absorbing phenolic compounds in cells.

BIOLOGICAL CHARACTERISTICS GRAVIMORPHOSES THAT ASSIST OF MOSS SPECIES TOLERANCE IN ANTARCTICA CONDITIONS

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Gravisensitivity of mosses at the different stages of ontogenesis has the adaptive importance, promotes the gametophyte functional activity and stability in the extreme habitations. Gravity like light is an inducer of not only tropism, but also it is an important factor

in plant morphogenesis (Khorkavtsiv et al., 2017; Lobachevska et al., 2019). Samples of mosses *Bryum caespiticium and Polytrichum arcticum* were collected in 2019 on the west coast of the Antarctica (Galindez Island) during the 24th Ukrainian Antarctic Expedition. *B. caespiticium* growing in the Roztochia Nature Reserve, Lviv region on sandy moist soil were collected to compare with the Antarctic samples. The subject of our work was to determine the participation of gravimorphoses in the adaptive of moss species to extremes conditions in Antarctica. Apical cells of gravitropic stolons of both *B. caespiticium* and *Polytrichum arcticum* intensively branched on the light resulting in the formation of protonemata with short chloronema stolons on their tops, which could disintegrate into numerous 2–3-celled fragments. Fragmentation, as a form of asexual reproduction, enables one moss plant to produce genetically identical offspring most adapted to the habitation and quick colonization of a large area. Bud primordia, which developed in gravisensitive gametophores, also initiated on the branches. In *B. caespiticium*, gametophores and the secondary caulonema are gravisensitive, but gravitropic growth of the secondary protonema from moss shoots from Antarctica was slower than in control. In *P. arcticum* from Antarctica, only the secondary caulonemal stolons were gravisensitive. Stolons formed as a result of shoot regeneration, which is one of the methods of moss rapid vegetative propagation in nature. Chloronemal stolons, which were obtained from isolated young leaves or their small fragments, did not respond to gravity. Buds of gametophores initiated rather on the gravitropic protonemata of *P. arcticum*, than on the non-gravistimulated one, also developed the larger protonemata. In natural conditions, morphological variations of protonema stolons promote to form more vigorous protonemata and then the moss cover to occupy the area of distribution. It is important to note that 30% branches of the *P. arcticum* gravitropic protonemata initiated at right angles to the main stolon and grew plagiotropically without showing gravitropism. Such type of branching facilitates horizontal overgrowth of the underground caulonemata, which store nutrients and provide water retention in terrestrial gametophytes. So, on the same stolon of the caulonema there are gravisensitive apical cells and lateral branches that do not respond to gravity. In general, a life form of the moss gametophyte, adapted to the ecological factors of habitation, was formed with the involvement of the gravitational signaling system and the morphological heterogeneity of stolons. Gravity-dependent morphoses and formation cells branched on the tops of gravitropic stolons of antarctic mosses. *P arcticum* and *B. caespiticium* as well the rapid development of shoots on it are a manifestation of the participation of gravimorphoses in the moss adaptation to stressful enviromental conditions. The gravisensitivity and gravimorphogenesis are determinative features of the secondary caulonema which is the most stable and plastic stage of the protonemata development of the investigated mosses under ecological stress. Gravimorphoses enrich the phenotypic plasticity of mosses that ensures their viability in the extreme environment.

SOCIO-SPATIAL ISOLATION AND PSYCHOLOGICAL STATE OF UKRAINIAN ANTARCTIC EXPEDITIONS PARTICIPANTS

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Conditions of socio-spatial isolation significantly affect the psychological state and professional activity of participants in long-term polar expeditions. Specialists of various profiles of Ukrainian Antarctic expeditions (UAE) are forced to be in limited space, have depleted sensory stimuli and constant interaction with the same people. This leads to the development of emotional and volitional disorder such as: emotional instability, low normative behavior, relationship tension, anxiety, loss of self-control etc. Therefore, the study of the psychological

states of winterers in the Antarctic station is important both for the successful conduct of expeditions and for understanding the peculiarities of the interaction of people in a small isolated group.

The goal of our work is to identify the emotional and strong-willed psychological states of winterers on Ukrainian Antarctic Akademik Vernadsky station.

According to the method of multifactorial research of personality by R. Cattell (Sixteen Personality Factor Questionnaire, (16PF) №105) in the dynamics (at the beginning, at the middle and at the end of the expedition) we studied the degrees of emotional and strong-willed psychological states of winterers by factors: C "emotional instability – emotional stability"; G "low normative behavior – high normative behavior"; I "rigidity – sensitivity"; O "calm – anxiety"; Q3 "low self-control – high self-control".

As a result it was found that UAE winterers have high (66.7%) and medium (33.3%) levels of emotional stability, which indicates a fairly high endurance, efficiency, emotional maturity, realistic moods. Under the influence of socio-spatial isolation, starting from the middle to the end of the winter year, more than a third (36.4%) of the team has low normative behavior, which can manifest itself in the form of disorganization, irresponsibility, lack of principle, sabotage of team norms and desire for self-insulation. At the end of winter, only 27.2% of the team has a high normative behavior. They are characterized by a high level of awareness in achieving goals and making important decisions, responsibility, compliance with norms and rules in accordance with all values.

Most of the winterers (58,3%) have a high level of self-control by factor Q3 "low self-control – high self-control". They are characterized by discipline, purposefulness, fulfillment of social requirements and integration of individuals in the process of interpersonal interaction. Predominant rigidity and calmness (54.5%) indicate self-confidence and the fact that extreme conditions and isolation do not contribute to the sweet disposition. High (58.3%) and medium (41.7%) levels of self-control and a balance between tension and relaxation are a required rate for Antarctic activity. Generalized data indicate the predominance (48.6%) of the average level of emotional and strong-willed characteristics of the team.

This data can help in the development selection criteria and psychological support of groups of specialists working in conditions of long-term isolation such as members of polar expeditions, oil platform teams and crews of long-distance ships, submarines and space missions.

SHORT-TERM COLD LOADS AS AN ELEMENT OF REHABILITATION ACTIONS AFTER THE INFLUENCE OF EXTREME FACTORS

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The use of short-term cold loads stimulates the body's adaptation to environmental factors that go beyond the optimum, which leads to increased resistance of people to work in extreme conditions. A special danger is the combined effect of various stressors. For combatants, the force of stress is such that it threatens health. There is no doubt that they need sound, consistent and effective rehabilitation measures. Cold effects can be used as an element of rehabilitation.

One of the most important links involved in the process of acclimatization to the cold is the cardiovascular system, which provides increased needs for thermoregulatory homeostasis on the background of adaptation. The level of stress, the degree of stress adaptation mechanisms, as well as the dosage and control of the dynamics of rehabilitation effects are physiological indicators, the definition of which is always associated with significant difficulties. Today, the determination of heart rate variability (HRV) is recognized as the most informative non-invasive

method of quantitative assessment of autonomic regulation of heart rate. In the analysis of HRV, you can not only assess the functional state of the organism, but also to monitor its dynamics. Therefore, the aim of the study was to evaluate the effectiveness of rehabilitation of combatants by the method of general air cryotherapy by determining HRV under functional loads.

Cryotherapy sessions for combatants were conducted in accordance with the guidelines in the field of physical rehabilitation at a temperature of -70 ^{o}C for 3 minutes with constant monitoring of the cardiovascular system in LLC "Institute of Applied Cryology". Patients' HRV was recorded before and after the procedure using respiratory and active orthostatic functional tests using a computer system CardioLab (Ukraine, KHAI-Medica). According to the indicators of adequacy of regulatory processes, autonomic balance index, power of high-frequency, low-frequency and very low-frequency components of the heart rate spectrum, short-term cold loads significantly increase the adaptability of the cardiovascular system to traumatic injuries, head injuries. Indicators of the adequacy of the response of the regulatory systems of the heart indicate that a sufficient number of procedures are 5-6 sessions of general air cryotherapy. The adaptive effect lasts for 2-3 months.

Thus, it is shown that short-term cold loads are an important element of rehabilitation for combatants after exposure to damaging factors of various etiologies.

AGE FEATURES OF PSYCHOLOGICAL READINESS OF WINTERERS TO LIFE IN ANTARCTICA

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There is research on the problem of readiness for many activities. However, some issues remain poorly covered, including the peculiarities of the psychological readiness of winterers to live in Antarctica. Therefore, we consider it relevant to study the process of readiness and age indicators of adaptation to extreme activities. Psychological readiness for activity includes the assessment of opportunities in relation to future difficulties, self-confidence, purposefulness, independence in decision-making, self-control, the ability to manage their emotions and others. It is the readiness of the winterer to live in extreme conditions which plays an important role in the process of adaptation to these conditions.

According to our research, psychological readiness is based on two main components: the psychophysiological qualities of the individual and the motivation of the individual to work. Psychophysiological qualities of workers in extreme conditions must meet serious requirements. This is high emotional stability; resistance to fatigue; clear indicators of a strong, balanced type of higher nervous activity (signs of sanguine or phlegmatic temperament). Also, polar explorers must have high rates of sensorimotor reactions, developed cognitive processes. We have been conducting research for 10 years. Of the 71 winterers of the Ukrainian Antarctic expeditions, 53.5% are winterers with pronounced signs of sanguine temperament (strong, balanced, mobile type of nervous activity). There are also 35.5% of winterers of phlegmatic temperament (strong, balanced, sedentary type of nervous activity). Such data meet the high requirements for life in Antarctica.

In order to study the age-related peculiarities of psychophysiological qualities, we divided them into three age categories: senior (46-62 y.o.), average (36-45 y.o.) and younger (23-35 y.o.). Winterers of the senior group (12 people) number 8.3% cholerics, 25.5% sanguine, 58.3% phlegmatics, 8.3% melancholics. The average group (30 people) has 6.7% cholerics, sanguine - 63.3%, phlegmatics - 30.0%. The younger group (29 people) has 10.7% cholerics, sanguine - 55.2%, phlegmatics - 31.0%, melancholics - 3.4%. As you can see, the exposure, restraint and prudence of phlegmatics are characteristic of representatives of the senior group.

Merriness, mobility and optimism of the sanguine are characteristic of the middle age group of winterers. Choleric temperament is most represented among the younger ones. Cholerics are characterized by inflammatory style of behavior, perseverance, incontinence. This is more typical of youth. There have been only two representatives of the melancholic temperament among the participants of the expeditions for the entire study period. This suggests that the representatives of this temperament are not prone to long journeys. Adaptation to extreme conditions is difficult for melancholics, and life in Antarctica requires careful preparation.

In our opinion, the process of adaptation is based on the phenomena of psychological readiness. This process includes the activity of the subject of activity and the search for their own solutions to the specific conditions of life. Analysis of the characteristics and results of interaction with other winterers is important. Based on research, we draw the following conclusions. A well-adapted person is a person who has the appropriate psycho-physiological qualities, optimal professional productivity, mental balance and readiness to work in difficult conditions.

NEW SIGHTINGS OF THE SOUTHERN RIGHT WHALES NEAR THE WESTERN COAST OF THE ANTARCTIC PENINSULA, IN 2018 AND 2020

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Southern right whale (SRW; *Eubalaena australis*, Desmoulins, 1822) in the southwest Atlantic is recognized as slowly recovering after the massive population decline induced by human harvesting. SRW spend summer in high latitude feeding grounds and migrate to mid-latitude wintering grounds in autumn, where breeding occurs. Only few sightings are known for the Antarctic waters as far south as 65°S. The purpose of the present study was to reveal the austral summer presence of the SRWs in the waters of West Antarctic Peninsula. Vessel surveys were conducted in waters of West Antarctic Peninsula, in frames of the 23 and 24 Ukrainian Antarctic Expeditions, based at Akademik Vernadsky station (65˚15'S, 64˚16'W), in 2018, 2019 and 2020. Two sightings of SRW occurred during our studies. On April 7, 2018, one SRW was sighted in a group with four humpback whales. Intense interspecies social interactions happened: swimming together at a close distance, different patterns of surface movement, synchronous dives, intense loud breathing, and pushes. Second encounter of the SRW happened on April 24, 2020, in Gerlache Strait, near the southeastern coast of the Brabant Island – single right whale adult was noticed while travelling. Images of the SRW encountered in 2018 could be used for the photo-identification of the specimen, however no matches were found yet. Results of our study indicate the autumn presence of some SRWs in the West Antarctic Peninsula – on the edge of the southern limit of known distribution for the species. It is likely that the whales were taking advantage of changing climate conditions, and used ice-free areas during the austral summer to move far south to feed on krill.

THE CONCEPT OF ANTARCTIC GLACIER MELTING PROCESSES MONITORING ORGANIZATION

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It is generally believed that the main cause of global warming is human activity, and therefore, in order to "slow it down", quotas are introduced for emissions of carbon dioxide into the atmosphere, and "dirty" industrial technologies are banned. But there are alternative points of view on this problem, which are not directly related to human activities. The authors of the report substantiate the arguments that the nature of warming is significantly related to the activation of heat energy from inland sources in certain parts of the earth's interior or to the activation of extraterrestrial sources, primarily due to increased solar activity. In the latter situation, alternative models are being developed, the basis of which is seen in the activation of quasi-periodic processes in the solar subsoil, which can be manifested in increased power and changes in the composition of solar radiation. In the study of signs of global warming, it is important to monitor the current state of subpolar glaciers, as their melting processes are largely due to increased seismic activity of volcanic zones and increased heat release from subglacial volcanoes. Observation of volcanoes under cryocover is difficult due to the fact that according to the latest data, the thickness of the ice can reach up to 3 km. It is known that the thick polar cryocoats of the surface of Antarctica isolate the rock base beneath them from the cold temperatures that exist on the surface of the glacier. The small amount of geothermal heat emitted by the earth under the glacier can have a great influence on the heating of the lower layers of ice and their melting. For these reasons, it is clear that there is a dependence of the melting process of the glacier on the topography of its bottom.

Researchers at Johns Hopkins University have recently proposed a promising method for studying glacier melting: their method is based on a statistical model of this phenomenon to assess the effect of glacier ice bottom topography on geothermal heat flow and applied this model to digital subglacial relief models. Antarctica (William Colgan et al. Topographic correction of geothermal heat flux in Greenland and Antarctica, Journal of Geophysical Research: Earth Surface (2021), DOI: 10.1029 / 2020JF005598). According to scientists, they have obtained a more detailed map of geothermal heat flow, which will allow "to make correct forecasts for 2050 and 2100 years." However, each model reflects the real picture only partially. The application of this model requires updated data on the topography of the glacier bed, they can be obtained, according to the authors of the report, from hyperspectral aerospace sounding (from the trajectory of the artificial satellite of the Earth, which conducts the survey) along a polar orbit. Also, when studying the relief of the glacier bottom, it is necessary to identify the ridges for the presence of activated subglacial volcanoes. Exacerbation of the shape of the apex may indicate their activation. In this case, the coordinates of the "heat spot" at the location of this volcano, measurements of the thickness of the ice layer (according to remote sensing of the glacier from a spacecraft, UAV, or aircraft), will provide updated information about the coordinates and state of the subglacial volcano. Operational measurements from the Earth's special satellite of the concentration of surface space plasma ions above the detected zone of possible earthquake or volcanism will be appropriate (according to the detected deviation of the ion concentration value from "normal values" judge the measure of current seismic activity).

Such detailed tracking of the activity of new and existing subglacial volcanoes makes it possible to more accurately predict the occurrence of dangerous environmental events.

IS GIANT STRUCTURE AT WILKES LAND (EAST ANTARCTICA) METEORITE CRATER OR VOLCANO?

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More than two hundred large craters with varying degrees of reliability attributed to meteorite (impact) structures have been discovered in various regions of the Earth (excluding the waters of the World Ocean), and in total there are more than 1500 such structures of various sizes that range from the first tens of meters up to 300 km and more. Most of them are found in America and Europe. Craters are known in Africa, Asia, and Australia too. Traditionally, the Wilkes Land meteorite crater, discovered more than 60 years ago in East Antarctica, is among the largest impacts. Hidden under a layer (up to 3 km) of ice, it was investigated in detail according to space research data in 2006-2009. However, known geologic and geophysical observations give the only limited possibility of crustal features modeling of the Wilkes Land meteorite crater zone. The results of the space gravity-magnetic survey showed that the crater has an estimated diameter of more than 500 km, and the possible size of the meteorite that formed the Wilkes Land crater could reach 50-60 km. Therefore, this impact crater basin is unique for its size. It is much larger than the well-known Chicxulub crater, located in the Gulf of Mexico (the diameter of this crater is about 170 km), as well as the Vredefort crater (South Africa), the diameter of which reaches 300 km. Crater Vredefort is considered one of the oldest. Its diameter reaches 250-300 km, and its age exceeds 2 billion years.

The used direct-search express-technology methods provide a real opportunity to fill the studied section with reference sedimentary, metamorphic, and igneous rocks directly in the process of signals registration with specially developed instrumentation and measuring devices. We have studied the frequency-resonance characteristics of the Wilkes Land crater, as well as a number of other large craters (Chicxulub, Popigay, Vredefort, etc.), attributed to a single group of impact structures on the Earth's surface. According to these studies, the Wilkes Land crater is a large volcanic formation of endogenous origin, and its frequency-resonance characteristics differ from those for the deep craters Chicxulub and Vredefort, which we also refer to as large volcanic formations of endogenous origin. The presence of granite volcanoes with roots at a depth of 470km and 996km was determined in the Chicxulub and Vredefort craters deep section. The root of the Wilkes Land salt volcano is located at a depth of 723 km. These results are experimental but unusual from the point of view of existing ideas about the composition and deep structure of the Earth. The reality of the obtained characteristics is confirmed by the data of the lithosphere and mantle structure geophysical studies, carried out in Antarctica in recent years. It is known that many discovered and studied the impact and ring craters are characterized by the presence of a number of minerals (diamonds, gold, nickel, lead, zinc) as well as oil and gas deposit formation. We suppose that these data confirm the endogenous nature of most of the known large craters. Therefore, interest in studying the morphology, genesis, and deep structure of large craters in various regions of the Earth is constantly growing.

The obtained results of experimental studies can serve as an additional criterion for studying the genesis of the known large impact and ring endogenous structures. They can also be

used to assess the impact of large-scale volcanic processes on the formation and structure of various geospheres of the Earth.

THE FIRST ACTIVE METHANE SEEPS IN ANTARCTICA: NEW EXPERIMENTAL DATA

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In recent years, new experimental data have been obtained on the modern active processes of the centers of gas release formation (seeps) - places of methane emission and other gases into sedimentary rocks, and the Earth's atmosphere. Methane (CH_4) belongs to the group of the main greenhouse gases that have a significant impact on the temperature rise in the atmosphere. The growth rate of the methane concentration in the atmosphere is about three to four times higher than that of carbon dioxide (CO_2), and the volume of its emission is constantly increasing. Greenhouse gases transported into the World Ocean and atmosphere could influence this carbon budget system, its chemistry and Earth's climate. Cold seeps have a wide geographic distribution and depth levels range in the crust. Most of them are confined to the continental margins of the World Ocean and inland seas, as well as areas of "permafrost" and lakes. Gas flares are mainly composed of CH_4, CO_2, and sometimes hydrogen sulfide. Therefore, studies of methane seep areas' active manifestation are of particular importance for a more reliable assessment of the consequences of the methane content in the atmosphere increasing on the enhancement of the greenhouse effect and the role of geologically derived methane in the global methane cycle. The used direct-search express-technology includes modified methods of frequency-resonance processing and decoding of Earth remote sensing (ERS) data and photographs, as well as vertical electro-resonance sounding (scanning) of the section. These frequency-resonance methods provide a real opportunity to fill the studied section with reference sedimentary, metamorphic, and igneous rocks directly in the process of signals registration with specially developed instrumentation and measuring devices. Satellite data frequency resonance processing was carried out for selected structures in Cumberland Bay (South Georgia Island, Subantarctic) and the Ross Sea (West Antarctica) to determining the possible nature of recently identified modern Antarctic gas emission centers (seeps). Series of volcanoes were also investigated to study the depth of the location of the roots of volcanic edifices and the types of rocks filling the channels of large volcanoes. The obtained results are experimental but extraordinary from the point of view of existing ideas about the composition and the modern active processes at the Antarctic centers of methane emission.

These results confirm our assumption that some of the deep-seated gases are involved in the pulsed emission of thermogenic methane in cold seeps, supplementing the long-term gas emissions of biogenic methane found in the Ross Sea. The reality of the obtained characteristics is confirmed by the data of geophysical studies, carried out in Antarctica in recent years. The results obtained show the presence of a deep gas-fluid system and the existence of vertical crustal-mantle channels for the migration of melts. It is shown that deep gases (including abiogenic methane) recorded with gas frequencies in the shelf structures of Cumberland Bay and the Ross Sea. They play an important role in the modern emission of gas flows formation that to a depth of 6 km traced. It is assumed that in the seeps of the Antarctic region, there are processes of emission of deep gases that are not associated with global warming. They are an integral and

significant part of gas seeps, supplementing the detected gas emission of biogenic methane and increasing its total amount, part of which can enter the atmosphere.

PETROGRAPHIC AND MINERALOGICAL STUDY OF MAGMATIC ROCKS IN UKRAINIAN ANTARCTIC AKADEMIK VERNADSKY STATION AREA

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The study of the mineralogical and petrographic composition of magmatic rocks around the Ukrainian Antarctic Akademik Vernadsky station shows that the area located in Andean intrusive complex formation zone. This complex has a rather complicated history of geological development and a wide range of rocks. The gradual formation of a large magmatic body is the main scientific problem of that work. Therefore, the object of research is magmatic rocks around the Ukrainian Antarctic Akademik Vernadsky station. The subject of research are features of mineralogical composition and textural and structural pattern of magmatic rocks.

Conditions and features of magmatic rocks crystallization in Ukrainian Antarctic Akademik Vernadsky station area is the main goal of that study.

Obtained results shows that the main magmatic rocks in studied area presented by diorite, granodiorite, tonalite, andesite and dolerite. Granodiorites are the most distributed rocks on Argentine Islands. In addition, the main rock-forming salic minerals ratio allows to identify some varieties of these rocks as tonalites, when the amount of potassium feldspar and plagioclase is approximately the same. As result detected amount and set of magmatic rocks allows to suggest the existence of tonalite - trondhjemite – granodiorite rocks complex. These types of magmatic complexes usually located in subduction zones with melting of oceanic slab in upper part of mantle in high temperature conditions and low participation of contaminated mantle material. Besides, tonalite - trondhjemite – granodiorite rocks most often belong to Archean crust, but sometimes they can be connected with present subduction zones with high velocity of plate movements and high temperature melting processes in relatively small depth. As result of melting material differentiation in upper part of section and not far from the surface the number of magmatic rocks from dolerite to diorite and andesite and further to granodiorite can be detected around the Ukrainian Antarctic Akademik Vernadsky station.

As a result, the idea of tonalite - trondhjemite – granodiorite magmatic complex location under the Argentine Islands can be proposed for high diversity of magmatic rocks in studied area explanation.

SPATIAL-TIME STRUCTURE OF GEOMAGNETIC FIELD FOR THE TERRITORIES OF UKRAINE, OF YAMAL (RUSSIA) AND AROUND THE UKRAINIAN ANTARCTIC AKADEMIK VERNADSKY STATION: ECOLOGICAL ASPECT

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The geomagnetic field, along with other environmental factors, is a necessary component of life on the Earth. Currently, there are relevant ecological standards for the values of constant and variable fields. Taking them into account, it is possible to determine the conditions necessary for the normal functioning of biological objects in general and humans in particular. In a number of regulations, certain limit values for a constant magnetic field are introduced, as well as the maximum permissible time of a human being stay in such fields. In this regard, the article considers the spatiotemporal change in induction B on the Earth's surface using the example of its main magnetic field according to the international model IGRF-13 for the time interval 1950–2020. In more detail for this time interval, the induction module B and its perturbation were analyzed for geomagnetically different regions that are, namely, the territories of Ukraine, of Yamal (Russia) and around the Ukrainian Antarctic Akademik Vernadsky station («AV»). For the planet in whole, a significant decrease in the geomagnetic field is shown, against the background of which its sharp jumps are observed (in 1960-1965, 1980-1985 and in 2000-2005), and after 2005 to the present, a deceleration in the decrease of the geomagnetic field is observed. Against the background of a decrease in the geomagnetic field of the planet, areas with extreme changes both in the direction of increase (Ukraine, Yamal) and decrease («AV» station) are distinguished. The spatiotemporal changes in the geomagnetic field detected on the Earth's surface determine the structure and dynamics of its magnetosphere, which by-turn affects the nature of the interaction with it of solar wind substance and of cosmic radiation, as well as the flow altitudes of magnetospheric and ionospheric currents. According to the distribution of the geomagnetic field anomalies on the surface of the planet, as well as to their changes over the studied time interval, regions with different (as compared with proposed ecological norms) values of the constant magnetic field and its disturbances are distinguished. In particular, for the epoch of 2020, for the territory in the vicinity of the «AV» station, the induction vector module B is on average 15,000 nT less than its value for the territory of Ukraine and 25,000 nT – of Yamal. Significant changes in the geomagnetic field were determined: an increase of 1765 nT for Ukraine, 1418 nT for Yamal and a decrease of -7081 nT in the vicinity of «AV» station. At the same time, the perturbation of the geomagnetic field of the territory of Ukraine is within its ecological norm, deviates from it in the direction of increase on the Yamal Peninsula, and near the «AV» station it will soon go beyond its limits in the direction of decrease, while maintaining modern field changes.

PHYSICAL SCIENCES

VERTICAL DISTRIBUTION OF OZONE IN THE ATMOSPHERE OVER KYIV AND OVER THE UKRAINIAN ANTARCTIC AKADEMIK VERNADSKY STATION ACCORDING TO UMKEHR DATA

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The measurements of the total ozone content (TOC) and the ozone concentration vertical distribution (Umkehr observations) are provided at WMO station No. 498 Kyiv–Goloseyev (KGV). Dobson 040 spectrophotometer is used for ozone measurements. Umkehr observations were used to retrieve and analyse the vertical distribution of ozone over Kyiv. The Umkehr measurements have been pre-processed using the UMK92 software package proposed by the World Ozone and UV-radiation Data Center (WOUDC). As the result, the set of the calculated vertical ozone distribution profiles in 2011–2021 have been obtained. Analysis of the profiles indicates that the maximum ozone concentration observed in the range of 15–25 km altitudes with an average height of 19.8±1.4 km. That corresponds to the layer of maximum ozone concentration in the mid-latitude stratosphere. The maximum ozone values for most of years are of 60–80 DU/layer. There also are days with the maximum ozone values significantly larger than the average. For example, on February 7, 2016, the maximum ozone value in the maximum is about 120 DU/layer. The study of ozone vertical distribution in the Polar Regions also is in the sphere of our interest. To analyse the vertical profiles of ozone in this area, we use Umkehr data from observations at the Akademik Vernadsky Antarctic station with Dobson 123 spectrophotometer. The data processing and the calculation of profiles of the altitudinal distribution of ozone are carried out according to the methodology developed for the data from the Kyiv–Goloseyev station. According to the calculations, the ozone values at maximum of distribution are changing dramatically from date to date in the Antarctic region during periods of ozone hole.

SPECTRA OF TWEEK ATMOSPHERICS AND THE IMPACT OF THEIR PATHS' ORIENTATION REGARDING THE GEOMAGNETIC FIELD THROUGH OBSERVATIONS AT UKRAINIAN ANTARCTIC AKADEMIK VERNADSKY STATION

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Tweek-atmospherics (tweeks), along with radio transmission by VLF radio stations, are used to study the lower ionosphere. Tweeks are pulse signals of natural origin in the ELF – VLF frequency range propagating in the Earth – ionosphere waveguide. Lightning as a signal source

and purely nighttime propagation limit the use of such atmospherics, but simultaneously create an opportunity to study geophysical and climatic conditions by them.

The single position method for lightning location and estimation of the ELF waves' reflection heights in the lower ionosphere by tweeks has been implemented into the computational algorithm. It has been applied to map the foci of thunderstorms. For this, a procedure is applied based on the Density-based spatial clustering of applications with noise (DBSCAN). The DBSCAN algorithm was proposed in 1996 as a solution to the problem of partitioning (initially spatial) data into clusters of arbitrary shape. The large ensemble of experimental records of tweeks, obtained in 2019 at Akademic Vernadsky station, is made use of. These data refer to the end of February – the beginning of March, so, depict approximately the period of the equinox. The climatically conditioned location of the planetary thunderstorm centers leads to the fact that tweek routes reach great lengths when the receiving point lies in Antarctica. The closest to it is the thunderstorm center in the tropics of South America. Also, a number of tweek routes cross the Atlantic Ocean, having sources in the tropics of Africa along the coast of the Gulf of Guinea, or in southern Africa and Madagascar. Receiving tweeks from west azimuths is rare. There are also observed irregular nighttime thunderstorms over the Atlantic Ocean of lesser thickness and unstable nature, associated with local weather phenomena. The total number of records received is up to 30 000 per night.

A significant difference in the spectra of tweeks from remote foci for the eastern and northern azimuths has been shown, the percentage of tweeks with the 2nd harmonic is obtained 45...85% for tweeks from southern Africa and 0...10% for paths from the equatorial region of the Atlantic Ocean. The total number of harmonics in tweeks with long paths (over 8 000 km) has ranged from 1 to 3. Large clusters of tweek sources observed in southern Africa in terms of the number of records made it possible to determine the average number of harmonics (it ranged from 1.46 ± 0.05 to 2.02 ± 0.02) and the dispersion σ^2 of this value (from 0.15 to 0.25). At the same time, the overwhelming majority of tweeks with long paths and meridional direction of propagation had a single (fundamental) harmonic, with an average number of harmonics of 1.043 ± 0.008 and a dispersion of 0.04. It has been suggested that the effect of east-west and west-east propagation non-reciprocity of ELF – VLF waves is manifested in such differences. The influence of the underlying surface at the lower boundary of the waveguide can be excluded; the paths of tweeks from both groups run almost entirely over the ocean. The nature of the EW asymmetry in tweek signals at long ranges is due to different attenuation under the influence of the geomagnetic field outside the critical harmonic frequencies and is similar to the well-studied asymmetry of the propagation of VLF waves with frequencies ≥10 kHz.

ANNUAL CYCLE IN THE NORTHERN HEMISPHERE POLAR-TO-MIDLATITUDE OZONE AND ITS RELATION TO STATIONARY WAVE STRUCTURE

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Continuous measurements of the total ozone with Dobson spectrophotometers are carried out at two Ukrainian stations: Akademik Vernadsky in Antarctica (since 1996) and Kyiv–Goloseyev in the northern middle latitudes (since 2010). In many works of Ukrainian researchers, local ground-based ozone variations were analyzed in comparison with satellite data, as well as with regional and global ozone tendencies. This study investigates the effects of stationary atmospheric centers of action in polar, middle and subtropical latitudes on the annual

cycle of total ozone in the northern mid-latitudes. The SBUV merged ozone dataset (MOD), Version 8, and the NCEP–NCAR reanalysis data are used. The 5°×10° latitude×longitude gridded means from the MOD data over 1979–2011 were analyzed. The zone 50–55°N, which includes Northern Ukraine and the station Kyiv–Goloseyev (50.4°N) was chosen. This zone passes through large-scale total ozone anomalies, which are zonally asymmetric and are associated with stationary planetary wave structure. The results of sequential analysis of the seasonal total ozone tendencies in the 36 longitudinal segments of the zone 50–55°N have been presented. The longitudinal ranges of the main regional anomalies in the total ozone annual cycle have been determined. The larger annual cycle amplitude in the Aleutian Low region is associated with its earlier development by about one season (2–3 months) in comparison with that in the Azores High region. In general, this is consistent with previous studies based on shorter time series. Unlike them, more differentiated and systematic attribution of possible sources of the anomalous annual cycle has been made. The specific role of the troposphere, tropopause and stratosphere in the formation of the annual cycle in the northern mid-latitudes has been accentuated. The main factors contributing to the significant zonal asymmetry in the total ozone annual cycle have been identified: (1) different tropopause seasonality in the mid-latitude Aleutian Low and subtropical Azores High regions; (2) zonal asymmetry in the lower stratospheric ozone accumulation with more intense and faster Brewer–Dobson circulation in the Aleutian Low region, where the earlier (February) and higher (300 Dobson Units) maximum in the lower-stratospheric ozone (10–25 km) is observed; in the Azores High region, the weaker and slower ozone build-up forms the later (April) and lower (220 Dobson Units) ozone maximum; (3) impacts of stationary wave 1 and wave 2 on stratospheric polar vortex location relative to the North Pole; vortex displacements towards the European sector bring the low-ozone polar air to the mid-latitude zone, where it merges with low-ozone subtropical air; this forms the main zonal ozone minimum, which is under influence of seasonal changes in both polar and subtropical atmospheric processes, whereas annual cycle in the Aleutian Low region is sensitive mainly to the mid-latitudinal processes. Future studies are needed to assess the influence of the seasonality of the tropopause and zonally asymmetric annual cycle in ozone on regional stratosphere–troposphere exchange and regional climate.

UPGRADE OF THE GEOMAGNETIC OBSERVATORY "ARGENTINE ISLANDS": NEW TECHNOLOGIES AND EQUIPMENT

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Geomagnetic observatory (AIA) at the Antarctic Peninsula (Ukrainian Antarctic Akademik Vernadsky station, former Faraday) has the longest in Antarctica observation sequence. Because of this, and also that the observatory enters in the INTERMAGNET community, the quality of observation data is of primary importance. The available at the moment of the observatory transfer in 1996 basic and reserve magnetometers La Cour and EDA were replaced in 2000 and in 2003 by new ones LEMI-008#02 and LEMI-008#16, developed and produced in Ukraine. LEMI-008#02 operated successfully till May, 2019. LEMI-008#16 operates till now, however the detailed study of measurements parameters (particularly high noise level and a lack of proper synchronization with UTC) showed the necessity to replace it by a novel one. To this, the INTERMAGNET network demands also changed: because of the space era needs to have more detailed data of Earth's magnetic field variations, additionally to 1-minute mean data in the year 2013 the requirements for a new 1-second data were added. This necessitated the replacement of LEMI-008 by a modern basic magnetometer which provides true 1-second data in the IAGA-2002 INTERMAGNET format. Besides variometer change, there was also necessary to provide UTC synchronization of the Overhauser scalar magnetometer POS-1, which continuously records the total magnetic field.

These tasks were solved by the new magnetometric system based on LEMI-025 variometer, also developed and manufactured in Ukraine, which has following advantages: low level of intrinsic noise; baseline stability; high accuracy of magnetometer calibration and orientation of its sensor in a geographic coordinate system; high precision of synchronization of the LEMI-025 variometer and POS-1 scalar magnetometer instruments mutually and with the UTC scale; high sensitivity of the GPS channel - there is no need now to move the antenna outside the observatory, which eliminates the risk of the cable damage by ice; stability of work (small percentage of lost data).

The new magnetometric system was deployed in March 2019. Test operation of the new LEMI-025 variometer showed the need to change the magnetic cleanliness conditions inside the measuring pavilion of Vernadsky Observatory. They were originally designed with the expectation of low requirements for photographic registration of the components of the geomagnetic field. New digital magnetometers (especially the latest generations) are more demanding in terms of operating conditions.

First of all, it was found that the three power supply units used for variometers and scalar magnetometer produced irregularly magnetic interference (with amplitude up to 4 nT). A set of on-site experiments and computer simulation allowed us to estimate their magnetic moments and to propose for these units the new optimal locations. Since they were moved to the new place, the level of magnetic disturbances in the recorded variometer data was significantly decreased.

The second important problem was also revealed – significant temperature drift along X and Z axes of both variometers LEMI-008#16 and LEMI-025#63. Till the moment it is not clear what is the reason of unexpectedly high and simultaneous temperature drift of both variometers.

First successful attempt was made to reduce temperature fluctuations of the basic LEMI-025 variometer: a special thermoinsulating box was installed over its sensor in September, 2020. As a result, the thermal drift in its magnetic records was reduced by a factor of two. Further study is expected to continue until the identified problems are resolved.

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MONITORING OF TECHNICAL CONDITION OF TANKS AT UKRAINIAN ANTARTIC AKADEMIK VERNADSKY STATION

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In 2016, work began on, and in 2019, work on monitoring the technical condition and preventive repair of tanks at Ukrainian Antarctic Akademik Vernadsky station on Galindez Island of Argentine Islands archipelago. At the station there are two tanks designed for receiving and storing diesel fuel: RGS-150 and RVS-200.

The RGS-150 tank was built in 1978-79 using BRAITHWAITE technology, which involves assembling a wall of square stamped steel elements measuring 1220 × 1220 × 5 mm, with diagonal stiffeners 40 mm high. This technology allows to assemble tanks of different volume without welding and lifting mechanisms, and its elements are fastened together with screws using elastic sealing gaskets and sealant. In 1986, an inner sealed shell made of 3 mm thick corrosion-resistant steel sheets was mounted and welded in the tank. The structural strength of the tank, which has the shape of a parallelepiped with a size of 7340 × 7340 × 3660 mm, is given by internal oblique and transverse rods. The inclination of the bottom towards drain branch pipes makes 100 mm.

The metal surface of the outer and inner shell of the tank has no defects of rolling or deviation of shape. There are no traces of corrosion and fuel leaks on the surface.

The second tank, RVS-200, was built at the station in 2007 in the form of a double-walled vertical cylinder, with two bottoms and two roofs, on the principle of tank-in-tank. Dimensions of the inner tank: wall height - 5.96 m; inner diameter - 6.63 m; wall and bottom sheet thickness - 5 mm; the distance between the walls is 0.16 m.

The walls of the tank are mounted from separate sheets measuring 3000 × 1500 × 5 mm and connected by manual double-sided arc welding on the assembly site.

Visual inspection of the bottom of the inner tank in 2016 showed the need for priority anti-corrosion protection - welds and the surface of metal sheets are affected by ulcerative corrosion to a depth of 2 mm. Corrosion pits of different depths are grouped in separate areas with an area of 10… 30 cm^2 and are located mainly along the welded joints.

The tightness of the welded joints of the bottom is checked by means of a vacuum chamber. There are no leaks in the bottom of the inner tank.

In the welds and the base metal of both tanks, no unacceptable operational defects were detected: cracks, corrosion ulcers in the wall, etc. The most common disadvantages of welded joints are the uneven shape of the weld reinforcement, minor undercuts, and so on.

Deviations of the walls from the initial line of both tanks are within acceptable limits.

During the diagnosis of the bottom, eddy current control and recording of visual information by a device equipped with a video camera and a unit for wireless transmission of information to a smartphone was performed. This device allows you to record information about the status of welded joints inaccessible or out of reach of specialists objects, and analyze and archive it using computer technology in the laboratory.

The bottom was coated with a combined coating, the first layer of which is a suspension of scaly metallic non-oxidized zinc in a system of polymeric binders, the so-called "cold

galvanizing" material Liquid Zinc®. The next three layers are a two-component liquid-ceramic coating "ZingaMetall CeramCoat CN1-N".

Analysis of the results of technical diagnostics of tanks, allowed us to conclude that all elements of the tanks are in satisfactory technical condition, the walls, bottom and roof do not have unacceptable deformations or defects.

ON THE ANTARCTIC RESEARCH DATA INFORMATION SYSTEM CONCEPT

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In 2020, the authors of this report have examined the Antarctic data storage system on the request by the National Antarctic Scientific Center of Ukraine. The special aims set for the investigations were to pinpoint the reasons that impede the efficient use of data, to study the scientific community demand for the respective information system creation or modernization and to develop the prospective system concept. The goal of the report is to present the results of the conducted study. More in-depth analysis materials are available at [1].

The implementation of the Antarctic data information system faces a number of issues that are of objective nature and are neither specific to Antarctic research nor to one conducted by Ukraine. To name a few discrepancies between the ideas on how the Antarctic data resource is supposed to function and the actual state of affairs:

(I) It is commonly assumed that data is properly archived and are in general available for users. In actuality, however a majority of data is being stored in source formats the way they were initially collected on the digital media by devices or researchers themselves. Oftentimes, the only place of storage is the personal computer. This hinders the way data can be searched even for the authors who produced the data in first place, not to mention their colleagues from other fields or the wider scientific community;

(II) It is commonly assumed that the most of the data is processed for further analysis. But only a narrow slice of “fresh” data is ever exposed to the researchers, one being relevant for the current project at hand which is later superseded by a new project and respectively a new data collection;

(III) The situation being described is evidently illogical as the expenses for the data archiving only take a minor fraction in the overall Antarctic expedition budget. However, most of the players involved do not perceive the state of affairs as erroneous having accepted it as a given that cannot be feasibly improved.

These problems have certain underlying causes. Without having accounted them any new implementations of the information system would inevitably be nothing more than a visual upgrade over the existing one. The data will still be of little scientific use and not widely distributed just as it was before.

The survey of the Antarctic researchers did confirm that the information system is considered ripe for modernization. However, there is a distinct lack of consensus on the overall vision of the upcoming system. Given the heterogeneity of the data structures that need to be stored, the differences in the processing between different fields of Antarctic study, and variance of the user demands, the methodology of the further development must be based on an iterative approach with cyclical stages of implementation, and feedback collection as opposed to an immutable specification laid out ahead of time. In any case, the success of the development endeavour depends on whether or not the scientists behind the Antarctic research will see the

system as a valuable tool that eases and automates common data access and processing operations.

[1] Report of R&D "Development of initial data for the modernization of the information system of Antarctic research data". № 0120U104733. Kyiv. 2020. 85 p. (in Ukrainian) (Terms of receipt of the report: on request. State institution National Antarctic Scientific Center of Ukraine).