

KOPRI ABSTRACTS

Volume 15 | 2023



KOPRI ABSTRACTS

Volume 15 (2023)

CONTENTS

Summary of 2023	2
------------------------	---

Abstracts

<i>Part 1.</i> Climate Sciences	6
<i>Part 2.</i> Geo Sciences	37
<i>Part 3.</i> Marine Sciences	55
<i>Part 4.</i> Life Sciences	81
<i>Part 5.</i> Policy & Technology	114

Index

Keyword Index	118
Author Index	130

Summary of 2023 Research Paper Achievement

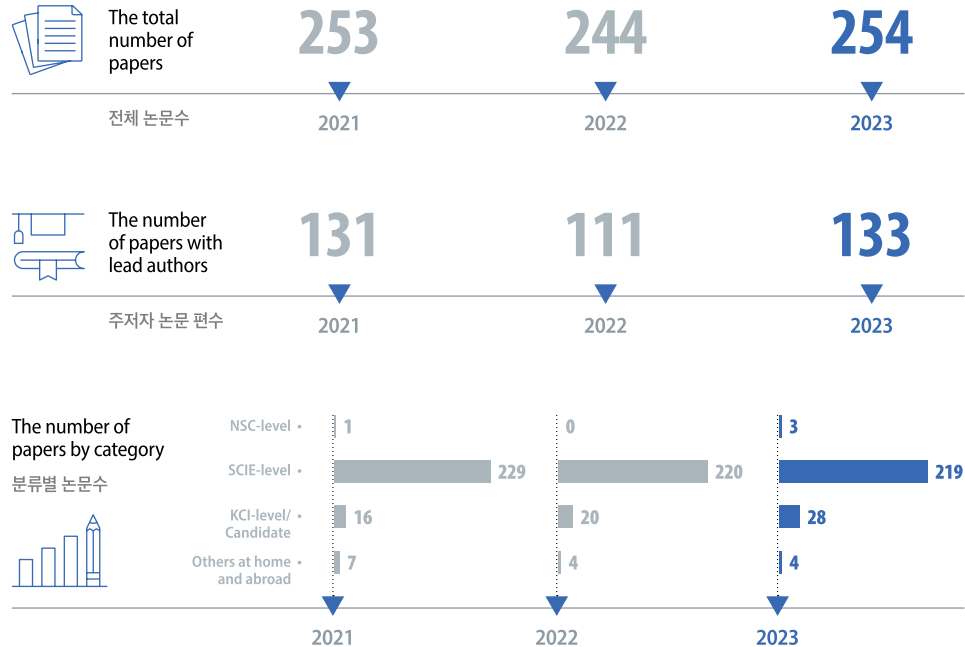
2023년 연구논문 성과 요약

최근 3년간 연구소의 연구논문 성과와 국내외 공동연구성과, 연구주제 분야 및 주요 등재 저널 동향을 살펴보았다. Clarivate Analytics의 데이터베이스인 Web of Science 지표와 데이터를 기준으로, 본 연구소의 SCIE급 논문을 대상으로 분석하였다.

We examined three years of research activities by the Korea Polar Research Institute (KOPRI), including research paper publications, domestic and international collaborative researches, and the outlook for its subject fields of research and major journals registered. KOPRI's SCIE-level papers are analyzed based on indices and data in Web of Science, a database of Clarivate Analytics.

01. Research papers in recent 3 years

최근 3년간 연구논문 성과



02. Collaborative research results at home and abroad

국내외 공동 연구성과

2023년 WoS에 등재된 SCIE급 논문 219편의 분석 결과, 극지연구소는 국내외 513개 기관, 41개 국가와 공동연구를 수행하였다.

The analysis of papers published in 2023 found that KOPRI conducted collaborative research with individuals or institutions from a total number of 513 institutes and 41 countries.

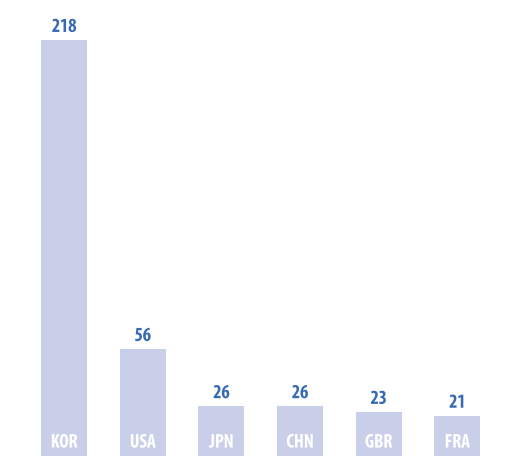
* Source: Web of Science, Clarivate Analytics



· Top 5 countries and number of research papers

공동연구 수행 국가 TOP 5 및 논문 수

Country	Number of records	% of 219
SOUTH KOREA 대한민국	218	99.5%
USA 미국	56	25.6%
JAPAN 일본	26	11.9%
CHINA 중국	26	11.9%
ENGLAND 영국	23	10.5%
FRANCE 프랑스	21	9.6%



· Top 5 Institutes and number of research papers(Domestic)

공동연구 수행기관(국내) TOP 5 및 논문 수

Institute	Number of records	% of 219
Korea Polar Research Institute (KOPRI) 극지연구소	216	98.6%
University of Science Technology (UST) 과학기술연합대학원대학교	63	28.7%
Seoul National University (SNU) 서울대학교	26	11.9%
Korea Institute of Ocean Science Technology (KIOST) 한국해양과학기술원	23	10.5%
PUSAN NATIONAL UNIVERSITY 부산대학교	14	6.4%
KOREA UNIVERSITY 고려대학교	10	4.6%

· Top 5 Institutes and number of research papers(Abroad)

공동연구 수행기관(국외) TOP 5 및 논문 수

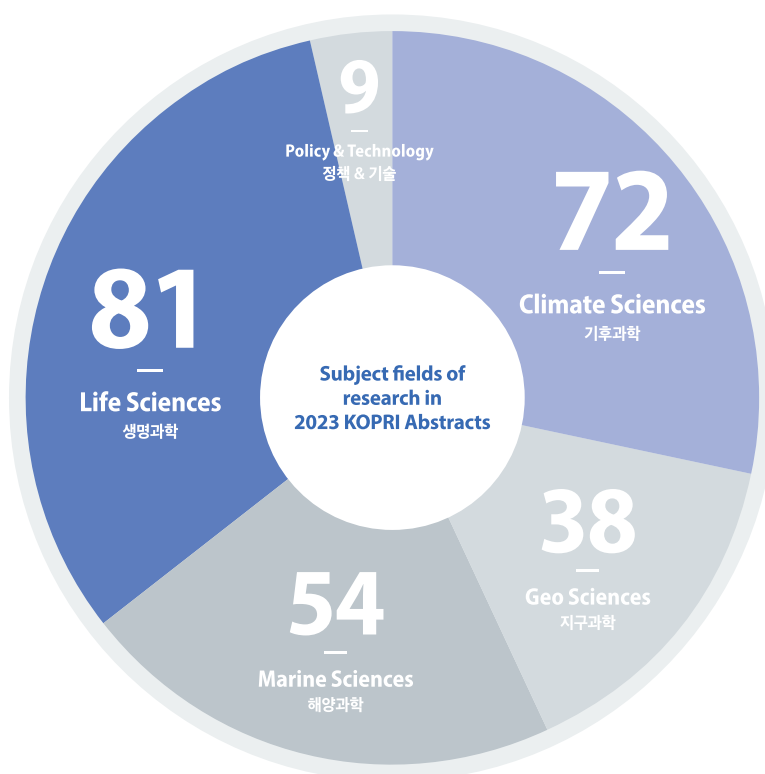
Institute	Number of records	% of 219
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE (CNRS)	19	8.7%
UNIVERSITY OF CALIFORNIA SYSTEM	17	7.8%
HOKKAIDO UNIVERSITY	15	6.9%
NATIONAL AERONAUTICS SPACE ADMINISTRATION (NASA)	13	6.4%
NAGOYA UNIVERSITY	12	5.5%

03. Subject fields of research

연구 주제 분야

2023 KOPRI Abstracts 연구 주제는 기후과학, 생명과학, 지구시스템, 해양과학, 정책&기술 분야로 분류하였다. 기후과학은 대기, 고층대기, 빙하, 고기후, 고환경, 원격탐사 등을 포함하며, 생명과학은 유전학·유전체학, 생리·생화학, 생물다양성·생태·진화, 생물공학, 지구과학은 지질, 지구물리, 수중음향, 해양과학은 해양학(물리, 화학, 생물학, 지질학)뿐만 아니라 해양환경에 따른 생태학 및 기술개발 등의 주제를 포함하였다.

Research topics in 2023 KOPRI Abstracts are categorized into Climate Sciences, Life Sciences, Geosciences, Marine Sciences, and Polar Policy. **Climate Sciences** cover paleoclimate, atmosphere sciences, glaciology, remote sensing, and space sciences; **Life Sciences** include ecology and biodiversity, genomic & biotechnology; **Geo sciences** include geology, geophysics, and underwater acoustics; and **Marine Sciences** cover oceanography(physical, chemical, biological and geological) as well as subjects in ecology and technological developments with marine environments.



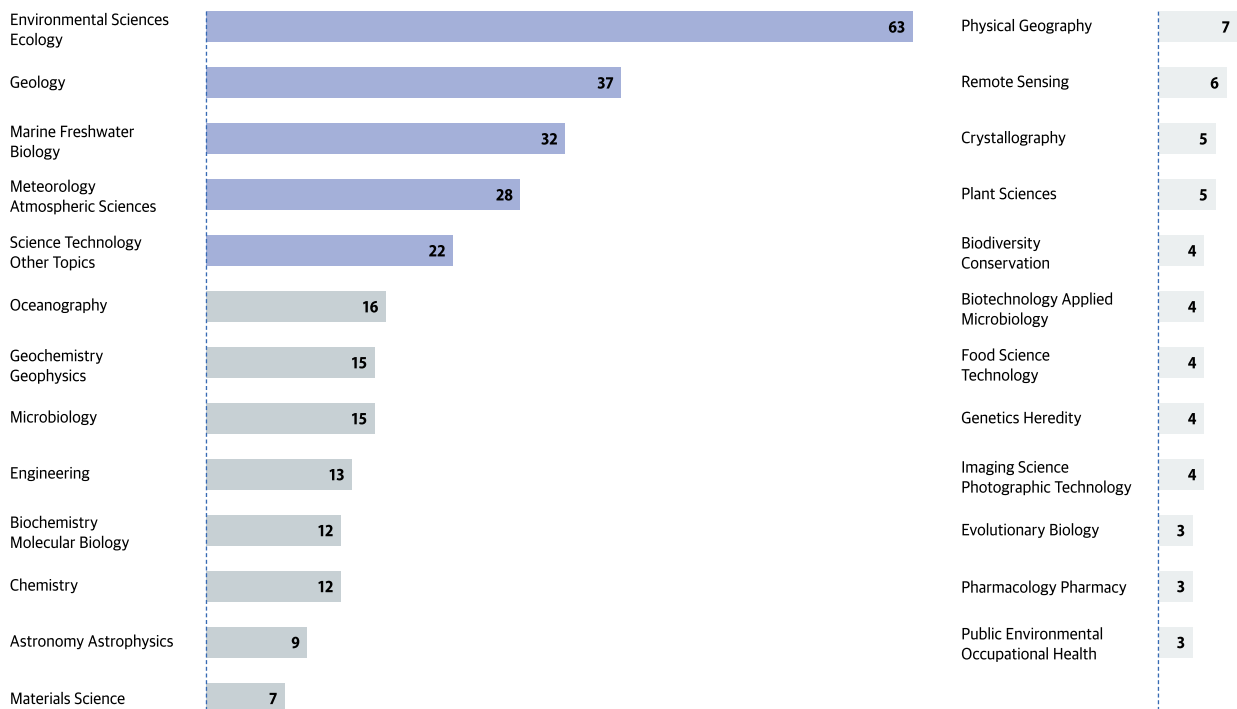
04. Web of Science Categories

WoS 연구 분야



• Top 25 Subject fields of research

Wos 연구분야 Top 25



* Source: Web of Science, Clarivate Analytics

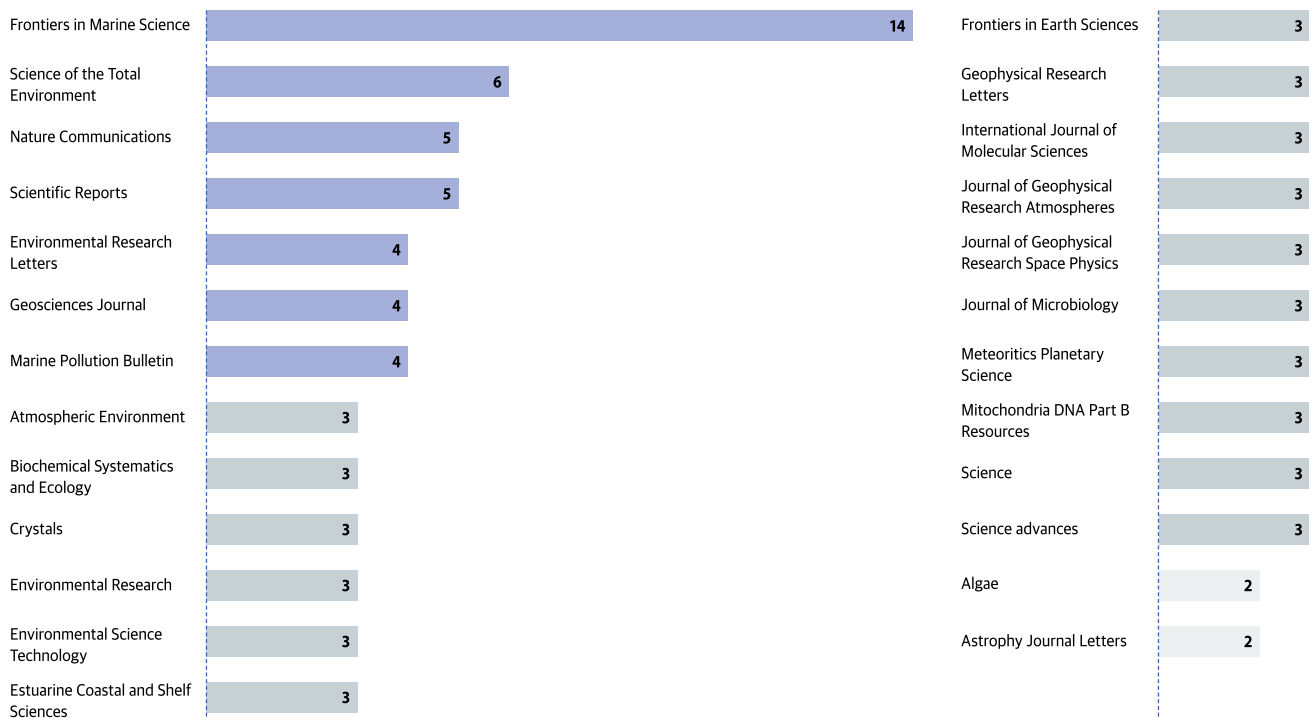
05. Major journals registered

주요 등재 저널



• Journals and the number of papers where more than 3 papers were registered.

3편 이상 등재된 저널과 논문수



* Source: Web of Science, Clarivate Analytics

1-13 Chemistry, Physical; Engineering, Environmental;
Engineering, Chemical

Degradation of organic compounds through both radical and nonradical activation of peroxymonosulfate using CoWO₄ catalysts

Nguyen, Anh Quoc Khuong., **Ahn, Yong-Yoon.**, Shin, Gwanyong.,
Cho, Younsang., Lim, Jonghun., **Kim, Kitae.** and Kim, Jungwon.
Applied Catalysis B-Environmental. 2023. 324.
doi: 10.1016/j.apcatb.2022.122266.

In this study, we synthesized high-efficiency stable CoWO₄ nanoparticles that can be used as peroxymonosulfate (PMS) activators for water treatment by adjusting the pH during hydrothermal synthesis. The CoWO₄ catalyst synthesized at pH 10 (CoWO₄-10), which had the largest surface area and the best charge transfer characteristics, showed the highest degradation efficiency for 4-chlorophenol and the highest stability for metal ion leaching. The first-order degradation rate constant was 10.9 min⁻¹, and the Co and W leaching concentrations after 1 h of catalytic reaction were 1.1 and 4.2 μM, respectively. All the 16 tested organic compounds were rapidly degraded. The degradation performance of CoWO₄-10 was 2.4–83.6 times better than those of other Co-based metal oxides. In this regard, the CoWO₄-10 can be considered a practical PMS activator. This study provides a simple strategy for the development of highly efficient and stable bimetallic oxides that can be utilized in various fields.

keywords:

Cobalt tungstate; Peroxymonosulfate activation; Sulfate radical; Nonradical mechanism; Aqueous organic compounds

NOTICE

Web of Science Subject

*If there is no Web of Science Subject in this bibliography, this article is a journal not registered in Web of Science.

Reference

*The following KOPRI authors can be seen as highlighted in bold text.

Abstract

Keywords

Part 1.

Climate Sciences

1-1 Meteorology & Atmospheric Sciences

A regime shift in the interhemispheric teleconnection between the Yellow and East China Seas and the southeastern tropical Pacific during the boreal summer

Kim, Yong Sun., Kwon, Minho., **Chung, Eui-Seok.** and 3 others.
Climate Dynamics. 2023. 60(11-12): 3661-3680.
 doi: 10.1007/s00382-022-06529-1.

A drastic regime shift is observed in the early summer connection between the Yellow and East China Seas (YECS) and the tropical Pacific in the early 2000s through statistical estimations on reconstructed datasets for the period 1982-2020. During the pre-2003 period, prior to the regime shift, the summer sea surface temperatures (SSTs) in the YECS were modulated by local oceanic and atmospheric processes, along with their marginal coupling to the tropical Pacific. In contrast, an interhemispheric coupling emerges between the YECS and southeastern tropical Pacific after the regime shift. This teleconnection is attributed to a reduced El Niño signature in the tropical Pacific, which favors the emergence of the South Pacific meridional mode (SPMM) independently from the El Niño-Southern Oscillation signals. The SPMM-related SST anomalies invoke changes in rainfall and vertical motion over the western tropical Pacific, activating the western North Pacific subtropical high over the Philippine Sea. This atmospheric circulation system acts as an atmospheric bridge to mediate the air-sea interacted variability associated with the SPMM into the YECS. The susceptibility of the YECS to atmospheric forcing highlights the role of SST in the YECS as a potential indicator of global-scale climate change.

keywords:

South Pacific Meridional Mode; El Niño-Southern Oscillation; East Asian Summer Monsoon; Western North Pacific subtropical high; La Niña-like mean state

1-2 Chemistry, Physical; Nanoscience & Nanotechnology; Materials Science, Multidisciplinary

Ammonia Adsorption on Crystalline Ice Surface: Adsorption Structure and Site Selectivity

Lee, Du Hyeong. and Kang, Heon.
Journal of Physical Chemistry C. 2023.
 doi: 10.1021/acs.jpcc.2c07375.

The structural heterogeneity of an ice surface at the atomic level is an important characteristic that influences the interactions between adsorbate molecules and the ice surface. In this study, we investigated the adsorption of ammonia on the basal (0001) surface of crystalline ice (CI) films to examine the adsorption selectivity of ammonia molecules on atomistically different sites of the ice surface. The adsorption structure and site-selectivity of ammonia adsorption on ice surfaces were examined by conducting temperature-programmed desorption, low energy sputtering, reactive ion scattering, reflection-absorption infrared spectroscopy, and surface voltage measurements. Ammonia adsorbs on ice surfaces without undergoing protonation, dissociation, or penetration into the bulk ice. At low coverages, adsorption occurs exclusively at the dangling H atom sites of the surface via N...H-O bond formation. The average orientation of the adsorbed molecular dipoles leans substantially toward the surface. After saturation of the dangling H sites, further adsorption of ammonia leads to the formation of a multilayer with isotropic molecular orientation. Titration experiment for the surface population of dangling H sites with ammonia reveals that the surface density of free O-H groups is 0.29 ± 0.04 monolayers for the CI films prepared by water vapor deposition at 140 K and postannealing at 160 K, indicating that the basal ice surface is not significantly reconstructed under vacuum conditions.

1-3 Geosciences, Multidisciplinary; Meteorology & Atmospheric Sciences

Antarctic Bedmap data: Findable, Accessible, Interoperable, and Reusable (FAIR) sharing of 60 years of ice bed, surface, and thickness data

Fremaud, Alice C., Fretwell, Peter., Bodart, Julien A., Pritchard, Hamish D., Aitken, Alan., Bamber, Jonathan L., Bell, Robin., Bianchi, Cesidio., Bingham, Robert G., Blankenship, Donald D., Casassa, Gino., Catania, Ginny., Christianson, Knut., Conway, Howard., Corr, Hugh F. J., Cui, Xiangbin., Damaske, Detlef., Damm, Volkmar., Drews, Reinhard.,

Eagles, Graeme., Eisen, Olaf., Eisermann, Hannes., Ferraccioli, Fausto., Field, Elena., Forsberg, Rene., Franke, Steven., Fujita, Shuji., Gim, Yonggyu., Goel, Vikram., Gogineni, Siva Prasad., Greenbaum, Jamin., Hills, Benjamin., Hindmarsh, Richard C. A., Hoffman, Andrew O., Holmlund, Per., Holschuh, Nicholas., Holt, John W., Horlings, Annika N., Humbert, Angelika., Jacobel, Robert W., Jansen, Daniela., Jenkins, Adrian., Jokat, Wilfried., Jordan, Tom., King, Edward., Kohler, Jack., Krabill, William., Gillespie, Mette Kusk., Langley, Kirsty., **Lee, Joohan.** and 34 others.

Earth System Science Data. 2023. 15(7): 2695-2710.

doi: 10.5194/essd-15-2695-2023.

One of the key components of this research has been the mapping of Antarctic bed topography and ice thickness parameters that are crucial for modelling ice flow and hence for predicting future ice loss and the ensuing sea level rise. Supported by the Scientific Committee on Antarctic Research (SCAR), the Bedmap3 Action Group aims not only to produce new gridded maps of ice thickness and bed topography for the international scientific community, but also to standardize and make available all the geophysical survey data points used in producing the Bedmap gridded products. Here, we document the survey data used in the latest iteration, Bedmap3, incorporating and adding to all of the datasets previously used for Bedmap1 and Bedmap2, including ice bed, surface and thickness point data from all Antarctic geophysical campaigns since the 1950s. More specifically, we describe the processes used to standardize and make these and future surveys and gridded datasets accessible under the Findable, Accessible, Interoperable, and Reusable (FAIR) data principles. With the goals of making the gridding process reproducible and allowing scientists to re-use the data freely for their own analysis, we introduce the new SCAR Bedmap Data Portal (<https://bedmap.scar.org>, last access: 1 March 2023) created to provide unprecedented open access to these important datasets through a web-map interface. We believe that this data release will be a valuable asset to Antarctic research and will greatly extend the life cycle of the data held within it. Data are available from the UK Polar Data Centre: <https://data.bas.ac.uk> (last access: 5 May 2023). See the Data availability section for the complete list of datasets.

1-4

Application of Sedimentary Neodymium Isotopes to the Reconstruction of the Arctic Paleooceanography

Jang, Kwangchul. and **Nam, Seung-il.**

Ocean and Polar Research. 2023. 45(2): 89-102.

doi: 10.4217/opr.2023005.

Climate and environmental changes in the Arctic Ocean due to global warming have been linked to extreme climate change in mid-latitude regions, including the Korean Peninsula, requiring a better understanding of the Arctic climate system based on the paleo-analog. This review introduces three paleoenvironmental research cases using neodymium isotopes ($^{143}\text{Nd}/^{144}\text{Nd}$, ϵNd) measured on two different fractions of marine sediments: silicate-bound 'detrital' and Fe-Mn oxide-dominated 'authigenic' fractions. In the first case, detrital ϵNd in core HH17-1085-GC on the continental shelf off northern Svalbard was used for tracing changes in sediment provenance and associated glacier behavior over the last 16.3 ka. The second case showed the potential use of authigenic ϵNd as a quasi-conservative water mass tracer. Three prominent ϵNd peaks and troughs observed in core PS72/410-1 from the Mendeleev Ridge in the western Arctic Ocean over the past 76 ka suggested episodic meltwater discharge events during 51~46, 39~35 and 21~13 ka BP. The last case proposed the use of the difference between authigenic and detrital ϵNd as a proxy for reconstructing glacier fluctuation. The idea is based on the assumption that enhanced glacial erosion during glacier advances can supply sufficient freshly-exposed rock substrate for incongruent weathering, potentially leading to greater isotopic decoupling between bedrock and dissolved weathering products as recorded in detrital and authigenic ϵNd , respectively. Thus, it would be worthwhile to take advantage of sedimentary ϵNd to improve our understanding of past environmental changes in polar regions.

keywords:

Neodymium Isotope; Arctic Ocean; Paleooceanography; Proxy; Glacier

1-5 *Environmental Sciences; Geosciences, Multidisciplinary; Meteorology & Atmospheric Sciences*

Arctic deep-water anoxia and its potential role for ocean carbon sink during glacial periods

Jang, Kwangchul., Woo, Kyung Sik., Kim, Jin-Kyoung. and **Nam, Seung-il.**

Communications Earth & Environment. 2023. 4(1).

doi: 10.1038/s43247-023-00708-6.

Deep water freshening beneath pan-Arctic ice shelves has recently been proposed based on the absence of excess thorium in glacial Arctic sediments. This profound proposal requires scrutiny of Arctic paleohydrology during past glacial periods. Here, we present structural and geochemical results of inorganic authigenic carbonates in deep-sea glacial marine sediments from the Mendeleev Ridge, western Arctic Ocean over the last 76 kyr. Our results suggest that Polar Deep Water in the western Arctic became brackish and anoxic during stadial periods. We argue that sediment-laden hyperpycnal meltwater discharged from paleo-ice sheets filled much of the water column depending upon the density, substantially reducing the salinity and oxygen content of the Polar Deep Water. Our findings suggest that this phenomenon was more extreme in the western Arctic Ocean and may point to the potential role of the western Arctic Ocean as an additional carbon reservoir in the global carbon cycle across glacial-interglacial cycles. Freshening and oxygen depletion of the polar deep waters of the Amerasian Basin during the last glacial periods probably resulted in significant carbon burial, according to geochemical analyses of inorganic authigenic carbonates in Arctic Ocean sediments.

1-6 *Geosciences, Multidisciplinary*

Assimilation of the AMSU-A radiances using the CESM (v2.1.0) and the DART(v9.11.13)–RTTOV (v12.3)

Noh, Young-Chan., Choi, Yonghan., Song, Hyo-Jong., Raeder, Kevin., Kim, Joo-Hong. and Kwon, Youngchae.

Geoscientific Model Development. 2023. 16(18): 5365-5382.

doi: 10.5194/gmd-16-5365-2023.

To improve the initial condition (“analysis”) for numerical weather prediction, we attempt to assimilate observations from the Advanced Microwave Sounding Unit-A (AMSU-A) on board the low-Earth-orbiting satellites. The data assimilation system, used in this study, consists of the Data Assimilation Research Testbed (DART) and the Community Earth System Model as the global forecast model. Based on the ensemble Kalman filter scheme, DART supports the radiative transfer model that is used to simulate the satellite radiances from the model state. To make the AMSU-A data available to be assimilated in DART, preprocessing modules are developed, which consist of quality control, spatial thinning, and bias correction processes. In the quality control, two sub-processes are included, outlier test and channel selection, depending on the cloud condition and surface

type. The bias correction process is divided into scan-bias correction and air-mass-bias correction. Like input data used in DART, the observation errors are also estimated for the AMSU-A channels. In the trial experiments, a positive analysis impact is obtained by assimilating the AMSU-A observations on top of the DART data assimilation system that already makes use of the conventional measurements. In particular, the analysis errors are significantly reduced in the whole troposphere and lower stratosphere over the Northern Hemisphere. Overall, this study demonstrates a positive impact on the analysis when the AMSU-A observations are assimilated in the DART assimilation system.

1-7 *Geography, Physical; Geosciences, Multidisciplinary*

Asynchronous glacial dynamics of Last Glacial Maximum mountain glaciers in the Ikh Bogd Massif, Gobi Altai mountain range, southwestern Mongolia: aspect control on glacier mass balance

Khandsuren, Purevmaa., Seong, Yeong Bae., Rhee, Hyun Hee. and 5 others.

Cryosphere. 2023. 17(6): 2409-2435.

doi: 10.5194/tc-17-2409-2023.

Mountain glacier mass balance is affected by factors other than climate, such as topography, slope, and aspect. In midlatitude high-mountain regions, the north–south aspect contrast can cause significant changes in insolation and melt, resulting in local asynchrony in glacial dynamics. This study documents the asynchronous response of two paleoglaciers in southwestern Mongolia to the local topoclimatic factors using ¹⁰Be exposure age dating and 2D ice surface modeling. ¹⁰Be surface exposure age dating revealed that the Ikh Artsan south-facing valley glacier culminated (MIA1) at 20.1 ± 0.7 ka, coinciding with the global Last Glacial Maximum (gLGM). In contrast, the north-facing Jargalant paleoglacier (MJ1) culminated at 17.2 ± 1.5 ka, around Heinrich Stadial 1 and during the post-gLGM Northern Hemisphere warming. Our temperature-index melt model predicts that ablation will be substantially lower on the north-facing slope, as it is exposed to less solar radiation and cooler temperatures than the south-facing slope. The 2D ice surface modeling also revealed that the south-facing Ikh Artsan Glacier abruptly retreated from its maximum extent at 20 ka, but the Jargalant Glacier on the shaded slope consistently advanced and thickened due to reduced melt until 17 ka. The timing of the modeled glacier

culmination is consistent within $\pm 1\sigma$ of the ^{10}Be exposure age results. Extremely old ages ranging from 636.2 to 35.9 ka were measured for the inner moraines in the Jargalant cirque (MJ2–MJ4), suggesting a problem with inheritance from boulders eroded from the summit plateau.

1-8 Multidisciplinary Sciences

Atmospheric pathway of marine heatwaves over the Northwestern Pacific

Noh, El., Kim, Joowan., Jun, Sang-Yoon., Pak, Gyundo., Kim, Joo-Hong. and Kim, Hyeong-Gyu.

Scientific Reports. 2023. 13(1).

doi: 10.1038/s41598-023-49833-4.

This study analyzes the influence of the Pacific–Japan (PJ) atmospheric teleconnection pattern and its interaction with oceanic processes on sea surface warming over the Northwestern Pacific. The PJ pattern is a thermally driven Rossby wave that originates over the tropical western Pacific through deep convection and propagates toward high latitudes. It plays a significant role in sea surface warming by inducing anticyclonic circulation and the corresponding northwestward extension of the subtropical high over the Northwestern Pacific. This study revealed that the key processes responsible for sea surface warming were an increase in insolation and a decrease in the ocean-to-atmosphere latent heat flux under the anticyclonic conditions driven by the PJ. This finding provides valuable insights into the role of atmospheric processes, we refer to it as the “*atmospheric pathway*”, in the development of East Asian marine heatwaves (MHWs). A detailed understanding of this process will contribute to the prediction and mitigation of MHWs in East Asian countries.

1-9 Environmental Sciences; Meteorology & Atmospheric Sciences

Atmospheric saccharide composition and its possible linkage with marine phytoplankton from North Pacific to the Antarctic regions

Kim, Ki Ae., Choi, Na Rae., Yoo, Ha Young., Jang, Eunho., Yoon, Young Jun., Park, Jiyeon., Jung, Chang Hoon., Kim, Yong Pyo., Park, Ki-Tae. and Lee, Ji Yi.

Atmospheric Environment. 2023. 292.

doi: 10.1016/j.atmosenv.2022.119420.

Saccharide compounds can distinguish the influence of both biogenic emissions and anthropogenic sources. In this study, the spatial distribution of 10 saccharide compounds was observed to determine the major factor for the production of organic aerosols in the pristine marine regions from the North Pacific Ocean to the Antarctic Ocean. The pristine marine atmospheric $\text{PM}_{2.5}$ (Particle matter with an aerodynamic diameter equal to or less than nominal $2.5\mu\text{m}$) samples were collected using a high-volume air sampler connected to a wind sector controller installed in the Korean Ice-breaking Research Vessel (IBRV) during the cruise through the Pacific Ocean: from the Yellow Sea, Korea on October 31, 2018 to the Antarctic Ocean on December 14, 2018.

In the pristine marine region, the total saccharides concentrations varied greatly from 0.16 to 16.57 ng/m^3 (mean: $3.02 \pm 4.76\text{ ng/m}^3$). The compositions of 10 saccharide compounds in each $\text{PM}_{2.5}$ sample changed when the marine geographic characteristics changed. The contribution of levoglucosan in the sample collected near land was higher than the sample collected in the open ocean. In addition, saccharides concentrations had a strong positive correlation with OC (Organic carbon), indicating that the increase of saccharides concentrations strongly contributes to the increase in OC concentration in the pristine marine region. The highest concentration of saccharides was observed near the New Zealand coast, which also showed highest air mass exposure to marine biology. We also found that the spatial distribution of saccharide composition was correlated with the spatial distribution of phytoplankton. From these observations, we concluded that 1) marine phytoplankton can be a significant source of organic aerosol production and 2) the type of phytoplankton in a region affects the change of saccharides composition in $\text{PM}_{2.5}$.

keywords:

Saccharides; Pristine marine aerosol; Organic aerosol; GC; MS-MS; Korean IBRV Araon; Antarctic region

1-10 Engineering, Environmental; Engineering, Civil; Geosciences, Multidisciplinary

Characterization of active layer at different degrees of patterned ground development using electrical resistivity tomography survey

Park, Keunbo., Kim, Kiju., Kim, Kwansoo. and Hong, Won Taek.
Cold Regions Science and Technology. 2023. 208.
 doi: 10.1016/j.coldregions.2022.103734.

Active layer thickness in extremely cold regions is an indicator of global climate change, but it is also affected by the terrain types. Among the different terrain types typical to cold regions, patterned ground is of interest because it develops over time. Thus, investigating the active layer at different degrees of patterned ground development is required to understand the variability in its distribution. In this study, an electrical resistivity tomography (ERT) survey is conducted at three study sites to investigate the distribution of the active layer according to the degree of patterned ground development. The results of the ERT surveys show that the active layer is thinner, and the patterned ground develops better on an active layer with a small slope and stagnant porewater. Thawing of permafrost may be accelerated around patterned ground. As the ERT survey investigates geological structures without disturbing the target ground, it may be an effective method to monitor geological structures in extremely cold regions and interactions of the active layer with the surrounding conditions.

keywords:

Active layer; Electrical resistivity tomography; Patterned ground; Permafrost; Stone circle

1-11 Environmental Sciences

Characterization of free L- and D-amino acids in size-segregated background aerosols over the Ross Sea, Antarctica

Feltracco, Matteo., Zangrando, Roberta., Barbaro, Elena., Becagli, Silvia., Park, Ki-Tae. and 6 others.
Science of the Total Environment. 2023. 879.
 doi: 10.1016/j.scitotenv.2023.163070.

The study of airborne chemical markers is crucial for identifying sources of aerosols, and their atmospheric processes of transport and transformation. The investigation of free amino acids and their differentiation between the L- and D- enantiomers are even more important to understand their sources and atmospheric fate. Aerosol samples were collected with a high-volume sampler with cascade impactor at Mario Zucchelli Station (MZS) on the coast of the Ross Sea (Antarctica) for two summer campaigns

(2018/19 and 2019/20). The total mean concentration of free amino acids in PM₁₀ was $4 \pm 2 \mu\text{mol m}^{-3}$ for both campaigns and most of free amino acids were distributed in fine particles. The coarse mode of airborne D-Alanine and dimethylsuloniopropionate in seawater showed a similar trend during both Antarctic campaigns. Thus, the study of D/L Ala ratio in fine, coarse and PM₁₀ fractions indicated the microlayer as the local source. This paper demonstrated that free amino acids follow the trend of DMS and MSA release occurred in the Ross Sea, confirming their applicability as markers for phytoplankton bloom also in paleoclimatic studies.

keywords:

Amino acids; Aerosol; Antarctica; Phytoplankton bloom

1-12 Meteorology & Atmospheric Sciences

Concentration and Isotopic Composition of Atmospheric N₂O Over the Last Century

Ghosh, Sambit., Toyoda, Sakae., Buizert, Christo., Etheridge, David M., Langenfelds, Ray L., Yoshida, Naohiro., Kim, Seong-Joong. and Ahn, Jinho.
Journal of Geophysical Research-Atmospheres. 2023. 128(12).
 doi: 10.1029/2022jd038281.

Temporal changes in the magnitude and geographic distribution of different sources of nitrous oxide (N₂O) are not well constrained. To better understand the dynamics of N₂O in the atmosphere over the last century, we have reconstructed the mole fraction, $\delta^{15}\text{N}^{\text{bulk}}$, $\delta^{18}\text{O}$, and $\delta^{15}\text{N}^{\text{SP}}$ values of N₂O from ice cores, firn air archives, and modern atmospheric samples. We have provided new firn air records from the Styx Glacier, Antarctica, and the North Greenland Eemian Ice drilling Project, and updated the firn air transport modeling of the published records. The composite reconstruction shows that the N₂O growth rates were 0.26 ± 0.05 , 0.15 ± 0.05 and $0.75 \pm 0.01 \text{ ppb yr}^{-1}$ 1850–1930 (P1), 1931–1965 (P2) and 1966–2021 CE (P3), respectively. The temporal slope found in a linear least squares fit in $\delta^{15}\text{N}^{\text{bulk}}$ and $\delta^{18}\text{O}$ were -0.010 ± 0.025 and $-0.004 \pm 0.031\text{‰ yr}^{-1}$, -0.014 ± 0.013 and $-0.009 \pm 0.017\text{‰ yr}^{-1}$, and -0.040 ± 0.013 and $-0.022 \pm 0.005\text{‰ yr}^{-1}$ during P1, P2 and P3 phases, respectively. Overall, a significant long-term trend was not observed in $\delta^{15}\text{N}^{\text{SP}}$ data. Two-box model calculations using N₂O mole fraction suggest that the total N₂O flux (FT) at 2015 CE was $17.5 \pm 1.1 \text{ TgN yr}^{-1}$, where flux from the natural (FN) and anthropogenic (FA) sources were ~60% and 40%

of FT, respectively, and the contribution of FA was ~30% of FT at 1900 CE. Estimated FA and $\delta^{15}\text{N}^{\text{bulk}}$ of atmospheric N_2O suggest that the anthropogenic emissions from continental regions were 12%, 25% and 76% of FA during P1, P2 and P3 phases, respectively.

keywords:

nitrous oxide; site-specific N-15 isotopomer; nitrification and denitrification processes; anthropogenic emission; greenhouse gas

1-13 *Chemistry, Physical; Engineering, Environmental; Engineering, Chemical*

Degradation of organic compounds through both radical and nonradical activation of peroxymonosulfate using CoWO_4 catalysts

Nguyen, Anh Quoc Khuong., **Ahn, Yong-Yoon.**, Shin, Gwanyong., Cho, Younsang., Lim, Jonghun., **Kim, Kitae.** and Kim, Jungwon. *Applied Catalysis B-Environmental*. 2023. 324.
doi: 10.1016/j.apcatb.2022.122266.

In this study, we synthesized high-efficiency stable CoWO_4 nanoparticles that can be used as peroxymonosulfate (PMS) activators for water treatment by adjusting the pH during hydrothermal synthesis. The CoWO_4 catalyst synthesized at pH 10 (CoWO_{4-10}), which had the largest surface area and the best charge transfer characteristics, showed the highest degradation efficiency for 4-chlorophenol and the highest stability for metal ion leaching. The first-order degradation rate constant was 10.9 min^{-1} , and the Co and W leaching concentrations after 1 h of catalytic reaction were 1.1 and $4.2 \mu\text{M}$, respectively. All the 16 tested organic compounds were rapidly degraded. The degradation performance of CoWO_{4-10} was 2.4–83.6 times better than those of other Co-based metal oxides. In this regard, the CoWO_{4-10} can be considered a practical PMS activator. This study provides a simple strategy for the development of highly efficient and stable bimetallic oxides that can be utilized in various fields.

keywords:

Cobalt tungstate; Peroxymonosulfate activation; Sulfate radical; Nonradical mechanism; Aqueous organic compounds

1-14

Detoxification of arsenite by iodide in frozen solution

Nguyen, Quoc Anh., **Kim, Bomi.**, **Chung, Hyun Young.**, **Ahn, Yong-Yoon.**, and **Kim, Kitae.** *Chemosphere*, Volume 340, 2023, 139903.
doi: 10.1016/j.chemosphere.2023.139903.

The oxidation of arsenite (As(III)) to arsenate (As(V)) has received significant attention because it helps mitigate the hazardous and adverse effects of As(III) and subsequently improves the effectiveness of arsenic removal. This study developed an efficient freezing technology for the oxidative transformation of As(III) based on iodide (I^-). For a sample containing a very low concentration of $20 \mu\text{M}$ As(III) and $200 \mu\text{M}$ I^- frozen at -20°C , approximately $19 \mu\text{M}$ As(V) was formed after reaction for 0.5 h at pH 3. This rapid conversion has never been achieved in previous studies. However, As(V) was not generated in water at 25°C . The acceleration of the oxidation of As(III) by I^- in ice may be attributed to the freeze-concentration effect. During freezing, all components (i.e., As(III) , I^- , and protons) are highly concentrated in the ice grain boundary regions, resulting in thermodynamically and kinetically favorable conditions for the redox reaction between As(III) and I^- . The efficiency of the oxidation of As(III) using I^- increased at high I^- concentrations and low pH values. The low freezing temperature (below -20°C) hindered the oxidative transformation of As(III) by I^- . The efficiency of the oxidation of As(III) significantly increased using a fixed initial concentration of I^- by subjecting the system to six freezing–melting cycles. The outcomes of this study suggest the possibility of the self-detoxification of As(III) in the natural environment, indicating the potential for developing an eco-friendly method for the treatment of As(III) -contaminated areas in regions with a cold climate. It also demonstrates radical remediation to almost completely remove a very small amount of As(III) that was input in As(III) -contaminated wastewater detoxification, a benchmark that existing methods have been unable to achieve

1-15 *Environmental Sciences; Meteorology & Atmospheric Sciences*

Difference in boreal winter predictability between two dynamical cores of Community Atmosphere Model 5

Kim, Ha-Rim., Kim, Baek-Min., Choi, Yong-Sang., Jun, Sang-Yoon. and Son, Seok-Woo.

Environmental Research Letters. 2024. 19(1).

doi: 10.1088/1748-9326/ad0fbf.

This study investigates the sensitivity of the boreal winter prediction skill of Community Atmosphere Model 5 to the choice of the dynamical core. Both finite volume (FV) and spectral element (SE) dynamical cores are tested. An additional FV with the SE topography (FVSE) is also conducted to isolate the possible influence of the topography. The three dynamical core experiments, which ran from 2001/2002–2017/2018, are validated using Japanese 55 year reanalysis data. It turns out that the SE (–4.27 °C) has a smaller cold bias in boreal-winter surface air temperature (SAT) than the FV (–5.17 °C) and FVSE (–5.29 °C), particularly in North America, East Asia, and Southern Europe/Northern Africa. Significant North Atlantic Oscillation-like biases are also identified in the mid-troposphere. These biases affect seasonal prediction skills. Although the overall prediction skills of boreal-winter SAT, quantified by the anomaly correlation coefficient (ACC), and root-mean-square error (RMSE), are reasonably good (ACC = 0.40 and RMSE = 0.47 in the mean values of SE, FV, and FVSE), they significantly differ from one region to another, depending on the choice of dynamical cores. For North America and Southern Europe/Northern Africa, SE shows better skills than FVSE and FV. Conversely, in East Asia, FV and FVSE outperform SE. These results suggest that the appropriate choice of the dynamical cores and the bottom boundary conditions could improve the boreal-winter seasonal prediction on a regional scale.

keywords:

dynamical core; seasonal predictability; boreal-winter climate; Community Atmosphere Model 5

1-16 Astronomy & Astrophysics

Dynasonde Observations of Ionospheric Polar Holes Under Quiet Geomagnetic Conditions at Jang Bogo Station, Antarctica

Kim, Khan-Hyuk., Kim, Dong-Hee., Back, Junho., Kwon, Hyuck-Jin., Jee, Geonhwa., Ham, Young-Bae., Lee, Changsup. and Kim, Jeong-Han.

Journal of Geophysical Research-Space Physics. 2023. 128(8).

doi: 10.1029/2023ja031563.

Noticeable F-region electron density (NmF2) depletions were observed in the winter-nighttime polar

cap ionosphere during solar minimum from the Vertical Incidence Pulsed Ionospheric Radar (VIPIR) with Dynasonde analysis at Jang Bogo Station (JBS) in Antarctica. We focus on the F-region density depletion events (known as polar holes) following a steady quiet condition that is defined with Kp values $\leq 1+$ during 6 hr. Forty-five polar holes were identified by JBS VIPIR/Dynasonde (JVD) in 2019. All of the events started over a wide range of nightside magnetic local time (22-05 MLT) with a peak occurrence at 01-03 MLT. JVD measured exponential NmF2 decrease in the nightside MLT (~19–2.5 hr) zone with e-fold decay times distributed in the range of ~0.5–~3.5 hr before the onset of a polar hole. The e-folding times decrease along the longitude from dusk toward midnight. The horizontal ion drift velocity (Vhor) estimated from JVD monotonically goes down from ~190 m/s at 18 MLT to ~100 m/s near magnetic midnight, and the NmF2 is depleted as Vhor decreases prior to the polar hole formation. The observations of the exponential NmF2 decrease and the positive correlation between NmF2 and Vhor prior to the polar holes are discussed in light of possible formation mechanisms of polar holes, including temporal variations and spatial structure of the polar ionosphere.

1-17 Meteorology & Atmospheric Sciences

Effects of assimilation of YOPP-SH additional radiosonde observations on analyses and forecasts over Antarctica in austral summer

Choi, Yonghan., Kim, Seong-Joong., Bromwich, David H., Powers, Jordan G., Kwon, Hataek. and Park, Sang-Jong.

Quarterly Journal of the Royal Meteorological Society. 2023. 149(756): 2719-2741.

doi: 10.1002/qj.4528.

Radiosonde observations over Antarctica and the surrounding oceans were enhanced during the Year of Polar Prediction in the Southern Hemisphere (YOPP-SH) summer Special Observing Period (SOP). Observing System Experiments (OSEs) were conducted in a continuous cycling framework using the Weather Research and Forecasting (WRF) Model and its data assimilation system. Routinely available observations were assimilated in the CTL (control) experiment, and special radiosonde observations from the YOPP-SH SOP were additionally assimilated in the YOPP experiment. The results were compared to investigate the effects of additional radiosonde observations on analyses and forecasts over and around Antarctica. Verifications against ERA5 re-analysis, radiosonde observations, and

Automatic Weather Station (AWS) observations show overall positive effects of additional radiosonde observations. These positive effects are most noticeable in temperature at lower levels at earlier forecast lead times; afterward, wind forecast improvements at upper levels are the most noticeable. Although routine and special radiosonde observations are concentrated over the eastern and coastal regions of Antarctica (compared to the western and inland regions), the effects of the extra data spread in longitudinal and latitudinal directions; therefore, the effects on the forecasts are not limited to only the areas near the radiosonde observations. A case study reveals how cyclone forecasts are improved through the assimilation of the additional YOPP-SH SOP radiosonde observations. This study provides insights into future observation strategies in Antarctica, such as horizontal/vertical observation locations, observation variables, and so forth to maximize effects of new observations on forecasts over Antarctica.

keywords:

Data assimilation; radiosonde observations; verification; YOPP-SH SOP

1-18 *Environmental Sciences; Geosciences, Multidisciplinary; Meteorology & Atmospheric Sciences*

Emergent Constraint for Future Decline in Arctic Phytoplankton Concentration

Noh, Kyung Min., Lim, Hyung-Gyu., Yang, Eun Jin. and Kug, Jong-Seong.

Earths Future. 2023. 11(4).

doi: 10.1029/2022ef003427.

In recent decades, the Arctic Ocean has experienced continuous warming and freshening, affecting biogeochemical factors such as nutrient supply, light availability, chlorophyll, and productivity. While Arctic marine productivity is projected to increase due to the expansion of the open ocean and increased chlorophyll concentration, uncertainties related to chlorophyll and nutrients may distract the fidelity of productivity in current Earth system models (ESMs). Here, we analyze the existing uncertainty in the Arctic chlorophyll projections using the 26 ESMs participating in Coupled Model Intercomparison Projects 5 and 6 (CMIP5 and CMIP6). We found that the uncertainty in the Arctic chlorophyll projections in the CMIP6 ESMs is greater than in the CMIP5 ESMs due to increasing uncertainty in the background nitrate concentration. A

significant relationship between background nitrate and projected chlorophyll ($r = 0.86$) is demonstrated using the observational climatology of nitrate. Based on this strong relationship, the emergent constraint is applied to reduce the uncertainty of future chlorophyll projections. Declines in chlorophyll concentration based on emergent constraint are estimated to be further decreased in the future ($44.9\% \pm 29.1\%$ to $50.9\% \pm 27.6\%$) than at present, which is about three-fold larger than the multi-model mean projection ($-13.5\% \pm 48.7\%$). Comparing cumulative density functions before and after the emergent constraint, the probability of the decreasing chance of chlorophyll is increased by approximately 36% from 60% in prior CMIP5,6 to 93%–96% after constraint. Our results imply that reducing the uncertainty in background nitrate concentration can improve the fidelity of future projections of the Arctic ecosystem in the ESMs.

keywords:

chlorophyll; CMIP5; CMIP6; Earth System Model; Arctic warming; nutrient

1-19 *Environmental Sciences; Meteorology & Atmospheric Sciences*

Empirical projection of global sea level in 2050 driven by Antarctic and Greenland ice mass variations

Lee, Donghyuck., Kim, Byeong-Hoon., Seo, Ki-Weon., Lee, Won Sang., Lee, Choon-Ki., Jeon, Taehwan. and Jin, Emilia Kyung.

Environmental Research Letters. 2024. 19(1).

doi: 10.1088/1748-9326/ad13b8.

Global mean sea level rise, driven by ice mass loss in Antarctic and Greenland Ice Sheets (AIS and GrIS), is a significant consequence of global warming. Although various ice sheet models have attempted to predict the ice mass balance and subsequent sea level changes, non-trivial disagreements between models exist. In this study, we employ an empirical approach to estimate the future (2050) ice mass changes for both ice sheets, assuming their historical patterns of ice dynamics would persist in the coming decades. To achieve this, we estimate decadal-scale ice discharge variations by subtracting the surface mass balance (SMB) from the observed ice mass changes and extrapolate linear trend and acceleration components of ice discharges up to 2050. We also consider future SMB data from Coupled Model Intercomparison Project phase

6 models to estimate net ice mass balance. Our estimates suggest that from 2021 to 2050, the global sea level rise due to AIS and GrIS ranges between 6–19 mm and 15–31 mm, respectively. Additionally, we investigate regional sea level variability resulting from geoid changes induced by ice mass changes in both regions, highlighting that heterogeneous sea level changes may cause more pronounced sea level rises in lower latitude regions, where major cities are located.

keywords:

ice mass balance; sea level change; Antarctica; Greenland

1-20 *Earth Science*

Establishment of Geographic Information Data of Greenland Glacier Using Fixed-wing Unmanned Aerial Vehicle

Lee, Sungjae., Kim, Seung Hee. and Kim, Hyun-Cheol.

Geo Data. 2023. 5(1): 34-39.

doi: 10.22761/gd.2023.0007.

In recent decades, the Greenland glacier has experienced significant changes in the environment near the surface due to the increase in surface melting on glacier. In order to quantify these environmental changes, precise spatial information data is necessary. Although digital elevation models using satellite data are widely used to secure data, it is difficult to observe the polar regions by satellite alone due to limitations such as spatial resolution, revisit period, and weather. To overcome these shortcomings, many field geographic surveys using unmanned aerial vehicles are being conducted. In this study, a field survey was conducted on September 14, 2021 to produce high-resolution spatial information in the Russell glacier area located in the Greenland Kangerlussuaq. By matching the acquired aerial image data, orthorectification image with a spatial resolution of about 13 cm/pixel and a digital surface model are produced. This data is expected to be utilized as basic spatial data for Russell glacier runoff and topographical changes, and it is expected to be used as data that can grasp changes in time and spatial through continuous data accumulation.

keywords:

Greenland; Glacier; Fixed-wing unmanned aerial vehicle; Orthorectification image; Digital surface model

1-21 *Environmental Sciences; Remote Sensing; Imaging Science & Photographic Technology*

Estimation of summer pan-Arctic ice draft from satellite passive microwave observations

Kim, Jong Min., Kim, Sang Woo., Sohn, Byung-Ju., Kim, Hyun-Cheol., Lee, Sang-Moo., Kwon, Young-Joo. and 2 others.

Remote Sensing of Environment. 2023. 295.

doi: 10.1016/j.rse.2023.113662.

Pan-Arctic observations of summer sea ice thickness have been a challenging problem despite their global significance in weather/climate analysis and prediction. To solve this problem, this study developed a method for estimating the pan-Arctic ice draft (depth of sea ice below sea surface level) using spaceborne passive microwave measured brightness temperatures (TBs). This study found that the time series of TBs is highly correlated with the corresponding time series of ice draft (D)s measured by three upward-looking sonar (ULS) sites over the Beaufort Sea during the ice melting season. Based on this finding, a D estimation equation was derived by relating satellite-measured TBs at microwave frequencies to D s. Pan-Arctic D distributions from June to August obtained from this study describe well the general thinning process of Arctic sea ice during the summer of 2021. The validation of estimated D s with other ULS measurements, which were not used for training data, showed good agreement between them suggesting the robustness of the developed estimation method over the Arctic basin. In addition, validation was made against ice mass balance buoy-measured sea ice thickness, and result shows a good agreement between buoy-measured ice thickness and estimated ice thickness converted from the D . Meanwhile, relatively high uncertainty in D estimation above 2 m shown in the result and validation suggests the potential for future improvement of D estimation in the early melting period. As the proposed method can provide summer pan-Arctic D distributions on a daily basis, the D from this study can be applied for generating the initial field for the sea ice and global climate models through data assimilation.

keywords:

Sea ice thickness; Summer ice draft; Summer sea ice; Passive microwave

1-22

Evaluation of the Marine Ice Sheet/Ice Cliff Instabilities on the Glaciers of Terra Nova Bay, Antarctica

Rhee, Hyun Hee.

Journal of the Korean Geographical Society. 30 June 2023. 318-329.

doi: 10.22776/kgs.2023.58.3.318.

Thickly developed Antarctic ice sheet flows over Antarctica, and transformed into ice shelf or ice tongue with mass wasting into the ocean. Marine Ice Sheet Instability and Marine Ice Cliff Instability caused by geomorphological and oceanic factors are accelerating the glacial mass loss in addition to the climate factor, Global Warming. Subglacial landforms behind the glacial grounding line affect the ice buttressing on the sea, and the supraglacial fractures in front of the grounding line cause the collapse or calving of the ice cliff. Using a digital elevation model, the morphological analysis of subglacial bed and supraglacial ice would find potential danger zones and assess the risks. Predictions and preparations for additional crises of sea level rise must be made by tracking, observing, and assessing research on risky factors which cause the ablation of the terminal of the Antarctic ice sheet.

keywords:

Antarctic Ice Sheet; Marine Ice Sheet Instability; Marine Ice Cliff Instability; Subglacial Landform; Glacial Collapse; Sea Level Rise

1-23

Evidence of Paleo-glacier Left on the Glaciomarine Landforms on the Terra Nova Bay, Antarctica: Reconstructing Terra Nova Ice Shelf

Rhee, Hyun Hee.

Journal of the Korean Geographical Society. 31 August 2023. 438-451.

doi: 10.22776/kgs.2023.58.4.438.

The existence of glacial landforms provides clues and insights into past glacier shapes and flow directions, and physical interactions between glacier drainages. The recent development of various topographical analyses and surveying technologies has made it possible to acquire bathymetric data and analyze topography even in a glaciomarine environment with poor accessibility. This study

detected glaciomarine landforms in various scales developed on the continental shelf of the Antarctic Ross Sea through Surface Roughness and Bathymetric Position Index analyses, and the distribution and structural characteristics of Mega-Scale Glacial Lineations, Drumlinoids, Moraines, Grounding Zone Wedges, Ridges, Troughs, and Banks were analyzed. The existence of a paleo-glacier "Terra Nova Ice Shelf" was found based on the records of glaciomarine and onshore glacial landforms, and its detailed ice dynamics were reconstructed through the interpretation of multi-dimensional scales of paleo-glacier drainages and physical interactions between the drainages.

keywords:

Antarctic Ice Shelf; Glaciomarine Landform; Surface Roughness; Bathymetric Position Index; Paleo-glacier Reconstruction

1-24 *Meteorology & Atmospheric Sciences*

Explicitly determined sea ice emissivity and emission temperature over the Arctic for surface-sensitive microwave channels

Kang, Eui-Jong., Sohn, Byung-Ju., Tonboe, Rasmus Tage., Noh, Young-Chan., Kwon, In-Hyuk., Kim, Sang-Woo., Maturilli, Marion., Kim, Hyun-Cheol. and Liu, Chao.

Quarterly Journal of the Royal Meteorological Society. 2023. 149(754): 2011-2030.

doi: 10.1002/qj.4492.

Data assimilation of satellite microwave measurements is one of the important keys to improving weather forecasting over the Arctic region. However, the use of surface-sensitive microwave-sounding channel measurements for data assimilation or retrieval has been limited, especially during winter, due to the poorly constrained sea ice emissivity. In this study, aiming at more use of those channel measurements in the data assimilation, we propose an explicit method for specifying the surface radiative boundary conditions (namely emissivity and emitting layer temperature of snow and ice). These were explicitly determined with a radiative transfer model for snow and ice and with snow/ice physical parameters (i.e. snow/ice depths and vertical distributions of temperature, density, salinity, and grain size) simulated from the thermodynamically driven snow/ice growth model. We conducted 1D-Var experiments in order to examine whether this approach can help to use the surface-sensitive microwave temperature channel measurements over the

Arctic sea ice region for data assimilation. Results show that (1) the surface-sensitive microwave channels can be used in the 1D-Var retrieval, and (2) the specification of the radiative boundary condition at the surface using the snow/sea ice emission model can significantly improve the atmospheric temperature retrieval, especially in the lower troposphere (500 hPa to surface). The successful retrieval suggests that useful information can be extracted from surface-sensitive microwave-sounding channel radiances over sea ice surfaces through the explicit determination of snow/ice emissivity and emitting layer temperature.

keywords:

1D-Var retrieval; Arctic winter sea ice; data assimilation; emissivity; emitting layer temperature; microwave temperature sounding; snow and sea ice model

1-25 *Astronomy*

Fundamentals of Numerical Modeling of the Mid-latitude Ionosphere

Jee, Geonhwa.

Journal of Astronomy and Space Sciences. 2023. 40(1): 11-18.

doi: 10.5140/jass.2023.40.1.11.

The ionosphere is one of the key components of the near-Earth's space environment and has a practical consequence to the human society as a nearest region of the space environment to the Earth. Therefore, it becomes essential to specify and forecast the state of the ionosphere using both the observations and numerical models. In particular, numerical modeling of the ionosphere is a prerequisite not only for better understanding of the physical processes occurring within the ionosphere but also for the specification and forecast of the space weather. There are several approaches for modeling the ionosphere, including data-based empirical modeling, physics-based theoretical modeling and data assimilation modeling. In this review, these three types of the ionospheric model are briefly introduced with recently available models. And among those approaches, fundamental aspects of the physics-based ionospheric model will be described using the basic equations governing the mid-latitude ionosphere. Then a numerical solution of the equations will be discussed with required boundary conditions.

keywords:

ionosphere; physics-based ionospheric model; numerical solution

1-26 *Multidisciplinary Sciences*

Future Indian Ocean warming patterns

Sharma, Sahil., Ha, Kyung-Ja., Yamaguchi, Ryohei., Rodgers, Keith B. B., Timmermann, Axel. and Chung, Eui-Seok.

Nature Communications. 2023. 14(1).

doi: 10.1038/s41467-023-37435-7.

Strong negative climatological air-sea interactions effectively damp warming over the eastern Indian Ocean, resulting in weakening of the winds therein. This, in turn, changes the strength of ocean currents, which is considered as the primary mechanism responsible for modulating warming patterns. Most future projections conducted with coupled general circulation models simulate a non-uniform Indian Ocean warming, with warming hotspots occurring in the Arabian Sea (AS) and the southeastern Indian Ocean (SEIO). But little is known about the underlying physical drivers. Here, we are using a suite of large ensemble simulations of the Community Earth System Model 2 to elucidate the causes of non-uniform Indian Ocean warming. Strong negative air-sea interactions in the Eastern Indian Ocean are responsible for a future weakening of the zonal sea surface temperature gradient, resulting in a slowdown of the Indian Ocean Walker circulation and the generation of southeasterly wind anomalies over the AS. These contribute to anomalous northward ocean heat transport, reduced evaporative cooling, a weakening in upper ocean vertical mixing and an enhanced AS future warming. In contrast, the projected warming in the SEIO is related to a reduction of low-cloud cover and an associated increase in shortwave radiation. Therefore, the regional character of air-sea interactions plays a key role in promoting future large-scale tropical atmospheric circulation anomalies with implications for society and ecosystems far outside the Indian Ocean realm.

1-27 *Remote Sensing*

Geometric and Radiometric Quality Assessments of UAV-Borne Multi-Sensor Systems: Can UAVs Replace Terrestrial Surveys?

Chi, Junhwa., Kim, Jae-In., Lee, Sungjae., Jeong, Yongsik., Kim, Hyun-Cheol., Lee, Joohan. and Chung, Changhyun.

Drones. 2023. 7(7).

doi: 10.3390/drones7070411.

Unmanned aerial vehicles (UAVs), also known as drones, are a cost-effective alternative to traditional surveying methods, and they can be used to collect geospatial data over inaccessible or hard-to-reach locations. UAV-integrated miniaturized remote sensing sensors such as hyperspectral and LiDAR sensors, which formerly operated on airborne and spaceborne platforms, have recently been developed. Their accuracies can still be guaranteed when incorporating pieces of equipment such as ground control points (GCPs) and field spectrometers. This study conducted three experiments for geometric and radiometric accuracy assessments of simultaneously acquired RGB, hyperspectral, and LiDAR data from a single mission. Our RGB and hyperspectral data generated orthorectified images based on direct georeferencing without any GCPs. Because of this, a base station is required for the post-processed Global Navigation Satellite System/Inertial Measurement Unit (GNSS/IMU) data. First, we compared the geometric accuracy of orthorectified RGB and hyperspectral images relative to the distance of the base station to determine which base station should be used. Second, point clouds could be generated from overlapped RGB images and a LiDAR sensor. We quantitatively and qualitatively compared RGB and LiDAR point clouds in this experiment. Lastly, we evaluated the radiometric quality of hyperspectral images, which is the most critical factor of the hyperspectral sensor, using reference spectra that was simultaneously measured by a field spectrometer. Consequently, the distance of the base station for post-processing the GNSS/IMU data was found to have no significant impact on the geometric accuracy, indicating that a dedicated base station is not always necessary. Our experimental results demonstrated geometric errors of less than two hyperspectral pixels without using GCPs, achieving a level of accuracy that is comparable to survey-level standards. Regarding the comparison of RGB- and LiDAR-based point clouds, RGB point clouds exhibited noise and lacked details; however, through the cleaning process, their vertical accuracy was found to be comparable with LiDAR's accuracy. Although photogrammetry generated denser point clouds compared with LiDAR, the overall quality for extracting the elevation data greatly relies on factors such as the original image quality, including the image's occlusions, shadows, and tie-points, for matching. Furthermore, the image spectra derived from hyperspectral data consistently demonstrated high radiometric quality without the need for in situ field spectrum information. This finding indicates that in situ field spectra are not always required to guarantee the radiometric quality of hyperspectral data, as long as well-calibrated targets are utilized.

keywords:

geometric evaluation; hyperspectral; LiDAR; multi-sensor system; radiometric evaluation; UAV

1-28 *Astronomy & Astrophysics*

Hemispheric Asymmetry of the Polar Ionospheric Density Investigated by ESR and JVD Radar Observations and TIEGCM Simulations for the Solar Minimum Period

Kim, Eunsol., Jee, Geonhwa., Wang, Wenbin., Kwak, Young-Sil., Shim, Ja Soon., Ham, Young-Bae. and Kim, Yong Ha.

Journal of Geophysical Research-Space Physics. 2023. 128(2).

doi: 10.1029/2022ja031126.

The ionospheric density displays hemispheric asymmetries in the polar region due to various hemispheric differences, for example, in the offset between geographic and geomagnetic poles and in the geomagnetic field strength. Using ground-based ionospheric measurements from Vertical Incidence Pulsed Ionospheric Radar with Dynasonde analysis at Jang Bogo Station (JBS), Antarctica and from EISCAT Svalbard Radar (ESR) where both sites are located mostly in the polar cap, we investigate the hemispheric differences in the ionospheric density between the northern and southern hemispheres for geomagnetically quiet and solar minimum condition. The results are also compared with Thermosphere Ionosphere Electrodynamics Global Circulation Model (TIEGCM) simulations. The observations show larger density and stronger diurnal and seasonal variations at JBS in the southern hemisphere than at Svalbard in the northern hemisphere. The diurnal variations of the density peak height are also observed to be much larger at JBS. In both hemispheres, the ionospheric density is significantly reduced in winter due to the limited solar production at high geographic latitudes, but TIEGCM considerably overestimates winter density, which is even larger than summer density, especially in the northern hemisphere. Also existed are the differences in the equinoctial asymmetry between the observations and the simulations: the daytime F-region density is observed to be larger in fall than in spring in both hemispheres, but TIEGCM shows the opposite. In general, most of the observed asymmetrical density are much weaker in the model simulation, which may result from lack of proper magnetospheric forcings and neutral dynamics in the model.

1-29 *Ecology; Geosciences, Multidisciplinary*

High snow accumulation on Amundsen Sea coastal ice rise, West Antarctica

Hong, Sang Bum., Nyamgerel, Yalalt., Lee, Won Sang. and Lee, Jeonghoon.

Polish Polar Research. 2023. 44(4): 365-384.

doi: 10.24425/ppr.2023.145440.

Polar snow and its accumulation preserve valuable information derived from the atmosphere on past climate and environmental changes in high resolution, particularly in coastal sites. A 2.5-m snow-pit was excavated from the coastal ice rise (Moore Dome) near Amundsen Sea region in February 2012. This study evaluated the isotopic and chemical compositions in the snow-pit and compared them with meteorological variables. Based on the seasonal peaks of the MSA and nssSO_4^{2-} together with $\delta^{18}\text{O}$, δD , and d -excess, the snow-pit record was corresponded to accumulation during austral winter 2011 to summer 2011/2012. The annual mean accumulation rate was assumed thus to be as large as or even higher than $1.03 \text{ m w.e. yr}^{-1}$ at this site. A relatively warm winter temperature in 2011 was traceable in the variations of $\delta^{18}\text{O}$, δD , and d -excess. This study emphasizes the importance of the high snow accumulation observed at this site in providing valuable information on sub-annual variations in climate and environmental changes through the study of longer ice cores.

keywords:

Antarctica; Bear Peninsula; Moore Dome; snow-pit

1-30 Geosciences, Multidisciplinary

Hunting paleoceanographic archives of ice sheet-ocean interaction in the northwestern Ross Sea, Antarctica

Kim, Sookwan., De Santis, Laura., Hong, Jong Kuk., Colizza, Ester., Kim, Sunghan., Bergamasco, Andrea., Lee, Sang-Hoon., Kang, Seung-Goo., Lee, Min Kyung., Kim, Hyoungjun., Choi, Yeonjin., Geniram, Andrea., Choi, Hyoung Gyu., Lee, Jae Il., Yoo, Kyu-Cheul. and Park, Yongcheol.

Frontiers in Earth Science. 2023. 11.

doi: 10.3389/feart.2023.1234347.

The analysis of sedimentary deposits influenced by bottom currents in glaciated continental margins provides crucial insights into paleo-depositional and oceanographic conditions. These reconstructions enable the assessment of interactions between advance and retreat of grounded ice sheets and past ocean circulation patterns. However, questions regarding these interactions and their specific

mechanisms remain largely unanswered due to a lack of data in this remote area. In this study, we conducted a comprehensive analysis by integrating marine geophysical data, surficial sediment cores, oceanographic measurements, and ocean circulation models. Our aim was to understand spatial and temporal variations in sedimentary and oceanographic conditions during the past glacial and interglacial periods in combination with the long-term stratigraphic evolution. By integrating and cross-referencing diverse datasets, we were able to infer how bottom-current-controlled deposits (i.e., contourites) developed along the western bathymetric high of the Central Basin in the northwestern Ross Sea margin, Antarctica. Contouritic deposits lying over and along the flanks of bathymetric highs were identified through their mound-shaped external geometry and acoustically stratified facies, characterized by reflectors pinching toward the moat. Acoustic facies and multi-beam backscatter results, in conjunction with sedimentary core data, revealed contrasting patterns. Bathymetric highs exhibited thin (<10 m thick) coarser-grained sedimentary layers with higher backscatter, while the lower slope and rise displayed thick (>10 m thick), finer-grained stratified sediments with lower backscatter. These findings indicate that seabed winnowing occurred by strong bottom current during past glacial periods as supported by sedimentological analysis. The pathways of the westward-deflected dense shelf water outflow and the westward-flowing along-slope current, as simulated by oceanographic models, explain the distinctive development of contourites influenced by bottom-current processes. Moreover, the large accumulations of sediment in the contourites, resulting from bathymetric barriers in the north of the Central Basin, may contribute to submarine slope failures.

keywords:

contourite; bottom current; Antarctica; Ross Sea; seismic stratigraphy; seafloor morphology

1-31 Environmental Sciences

Ice-templated synthesis of tungsten oxide nanosheets and their application in arsenite oxidation

Nguyen, Anh Quoc Khuong., Kim, Kitae., Ahn, Yong-Yoon. and 5 others.

Science of the Total Environment. 2023. 865.

doi: 10.1016/j.scitotenv.2022.161104.

Tungsten oxide (WO₃) nanosheets were prepared as catalysts to activate hydrogen peroxide (H₂O₂) in arsenite (As(III)) oxidation. Ice particles were employed as templates to synthesize the WO₃ nanosheets, enabling easy template removal via melting. Transmission electron microscopy and atomic force microscopy revealed that the obtained WO₃ nanosheets were plate-like, with lateral sizes ranging from dozens of nanometers to hundreds of nanometers and thicknesses of <10 nm. Compared to that of the WO₃ nanoparticle/H₂O₂ system, a higher efficiency of As(III) oxidation was observed in the WO₃ nanosheet/H₂O₂ system. Electron spin resonance spectroscopy, radical quenching studies, and As(III) oxidation experiments under anoxic conditions suggested that the hydroperoxyl radical (HO₂•) acted as the primary oxidant. The WO₃ nanosheets possessed numerous surface hydroxyl groups and electrophilic metal centers, enhancing the production of HO₂• via H₂O₂ activation. Various anions commonly present in As(III)-contaminated water exhibited little effect on As(III) oxidation in the WO₃ nanosheet/H₂O₂ system. The high oxidation efficiency was maintained by adding H₂O₂ when it was depleted, suggesting that the catalytic activity of the WO₃ nanosheets did not deteriorate after multiple catalytic cycles.

keywords:

Ice particle template; WO₃ nanosheet; As(III) oxidation; Hydroperoxyl radical

1-32

Identifying the Mechanism of Campbell Glacier Sudden Collapse in Antarctica: Ice and Fire

Rhee, Hyun Hee.

Journal of the Korean Geographical Society. 30 April 2023. 122-134.
doi: 10.22776/kgs.2023.58.2.122.

Studies of glacial landforms storing the Antarctic Ice Sheet thickness change history are essential to building up accurate and important information to be prepared for future climatic crises. Campbell Glacier moraine on the terminal area of the East Antarctic Ice Sheet was developed since the MIS 6 downwasting dominant glacial lowering (PGM: >640 masl, LLGM: 150~90 masl, LGM: 90 masl). The main mechanisms of the lowering stages were 'restricted glacial thickening due to the arid glacial period' and 'rapid glacial wasting due to the warm interglacial period'. Furthermore, the timing of the

rapid glacial ablation of 170 m thick ice (97.0~90.8 ka) during mid-MIS 5 is coincident with the Mt. Melbourne eruption (118.2~94.4 ka), and the geomorphological-geological evidences on moraine also imply the sudden glacial collapse caused by glaciovolcanic (ice and fire) interactions.

keywords:

East Antarctic Ice Sheet; Cosmogenic Nuclides Surface Exposure Dating; Glaciovolcanic Landform; Glacial Collapse; Local Last Glacial Maximum

1-33 *Geography, Physical; Geosciences, Multidisciplinary*

Increased dust transport from Patagonia to eastern Antarctica during 2000-2020

Shi, Cuicui., Mao, Rui., Gong, Dao-Yi., Kim, Seong-Joong. and 3 others.

Global and Planetary Change. 2023. 227.

doi: 10.1016/j.gloplacha.2023.104186.

Patagonia is an important dust source for Antarctica due to its proximity. However, the changes in the dust transport from Patagonia to Antarctica during the last two decades remain poorly understood. In this study, we used in-situ observations, remote sensing data, and reanalysis data to show changes in the frequency of dust events in Patagonia and their influence on the dust deposition in eastern Antarctica during the austral springs of 2000–2020. An increasing trend in the frequency of Patagonian dust events was observed from 2000 to 2020, with average frequencies of 3.1 and 8.1 in 2000–2006 and 2007–2020, respectively. The increased dust event frequency in Patagonia was caused by an increase in both the mean wind speed, the downslope wind frequency and air temperature and a decrease in the local soil moisture. The increased Patagonian dust event led to an increasing trend in dust deposition in austral spring from the eastern coast of Patagonia to the northeast of the Antarctic Peninsula and northern Weddell Sea, indicating increasing dust transport from Patagonia to eastern Antarctica from 2000 to 2020. This increased dust transport was related to enhanced westerly winds from Patagonia to the northern Weddell Sea. The increased frequency of circulation patterns conducive to dust events also contributed to the increased transport of Patagonian dust to the Weddell Sea and East Antarctica during 2000–2020.

keywords:

Dust event frequency; Variation of dust; Climate change

Indian monsoon variability in the Mahanadi Basin over the last two glacial cycles and its implications on the Indonesian throughflow

Lee, Jongmin., Kim, Sunghan., and 5 others.

Geoscience Frontiers. 2023. 14(1).

doi: 10.1016/j.gsf.2022.101483.

The orbital-scale variability of the Indian summer monsoon (ISM) has been influenced by multiple factors, such as atmospheric CO₂ concentration, global ice volume, and insolation. Proxies for weathering activity and paleo-productivity provide potential insights into the driving forces of its variability. We documented multi-proxy data at IODP Site U1445, located in the Mahanadi Basin of the northwestern Bay of Bengal, to find out ISM variability over the last 200 ka. The proxy records, such as Nd/Sr isotopes of detrital particles, clay mineral compositions of the fine-grained sediments, biogenic opal and CaCO₃, organic carbon contents, and carbon isotopes of organic matter, represent sediment sources, weathering patterns, and paleo-productivity related to the ISM variability. Detrital Nd/Sr isotope data and clay mineral compositions suggest that the sediments at Site U1445 originated mainly from the Ganges, Brahmaputra, and Meghna rivers without dramatic provenance change between the glacial and interglacial periods. The weathering activity inferred from clay mineral compositions and the paleo-productivity shift reconstructed by biogenic opal and CaCO₃ contents suggest that the land-sea interactions were closely linked to the ISM precipitation between the glacial and interglacial periods. High precipitation by the strong ISM resulted in intense chemical weathering and dominant biogenic opal deposition during the interglacial periods. In contrast, low precipitation by the weak ISM led to reduced chemical weathering and predominant CaCO₃ deposition during the glacial periods. Further, the ISM variability driving the land-sea interactions in the Mahanadi Basin was modulated by the Indonesian throughflow (ITF). Our study emphasizes the role of low-latitude forcing of climatic changes in the strong relationship between the ISM and ITF over orbital periods, providing a base for future investigations.

keywords:

Provenance; Weathering activity; Paleo-productivity; Indian summer monsoon; Bay of Bengal; Indonesian throughflow

Long-Term Characteristics of the Meteor Radar Winds Observed at King Sejong Station, Antarctica

Song, Byeong-Gwon., Chun, Hye-Yeong., Song, In-Sun., Lee, Changsup., Kim, Joo-hong. and Jee, Geonhwa.

Journal of Geophysical Research-Atmospheres. 2023. 128(1).

doi: 10.1029/2022jd037190.

The characteristics of the horizontal wind in the mesosphere and lower thermosphere (MLT) at King Sejong Station (KSS) in the Antarctic Peninsula are investigated using approximately 15-year (March 2007–November 2021) meteor radar (MR) observations. The 15-year climatology and variability of the MLT winds at KSS are analyzed for the first time, and comparisons with the observations at other Antarctic stations are performed. The short-period oscillations (periods between 2 hr and 10 days) of the winds, including tides and several planetary wave components, are examined for each month. Temporal and altitudinal variations in the amplitudes of the semidiurnal and diurnal tides, the two largest short-period components, are analyzed. Annual and semiannual oscillations of the wind are distinct below and above $z = 90$ km, respectively. The long-term trend of the zonal wind is estimated through a multiple linear regression analysis. Statistically significant trends of the zonal wind of ~ 0.5 – $0.8 \text{ m s}^{-1} \text{ yr}^{-1}$ appear above $z = 90$ km in July. To understand observed MLT wind trends, the gravity-wave momentum flux and gravity-wave drag (GWD) in the MLT region are estimated from the MR observations at KSS for the 15 years. Similar seasonal variations are found between the trends of the zonal winds and zonal GWDs, especially above $z = 94$ km. In July where a strong positive zonal wind trend appears, positive correlation between the zonal wind and zonal GWDs is found to be statistically significant above $z = 94$ km.

keywords:

meteor radar; Antarctica; MLT; King Sejong Station; mesospheric wind; long-term trend

Low-Frequency Wave Activity in the Ocean—Ross Ice Shelf—Atmosphere System

Zabotin, N., Godin, O. A., Bromirski, P. D., Jee, Geonhwa., Lee, Won Sang., Yun, Sukyoung. and Zabolina, L.

Earth and Space Science. 2023. 10(6).
doi: 10.1029/2022ea002621.

The main subject of this study is the low-frequency (with the periods longer than 2 hr) wave processes in the coupled regional system of the Ross Ice Shelf (RIS), the Ross Sea and the atmosphere above them. We investigate possible causal relationships between the wave activity in the three media using a unique set of geophysical instruments: a hydrophone measuring pressure variations on the seafloor, a network of seismometers measuring vertical displacements of the RIS surface, and a Dynasonde system measuring wave characteristics at the ionospheric altitudes. We present an extension of the previously introduced theoretical model of the coupled resonance vibrations of the RIS that quantifies the connection between the ocean tide and the resonance vibrations of the RIS. The ocean tide is confirmed as the most significant source of excitation of the resonances. Analysis of average power spectra in year-long data sets reveals multiple harmonics of the tide (eight) detected by the RIS seismometers while only three are detected by the seafloor sensor. This may represent a confirmation of the effect of resonance-related broadband amplification predicted by the model. Several peaks in the spectrum of RIS vibrations have periods different from the periods of nearby tidal constituents and may be associated with broad-scale resonance RIS vibrations. Resonances may play a role in maintaining the coupled atmosphere-ocean wave activity. Our results reveal a statistically significant correlation between the spectra of the vertical displacements of the RIS and the spectra of the atmospheric waves.

keywords:

Ross Ice Shelf; ocean; atmosphere; coupled wave activity; resonances; ionosphere

1-37 *Earth Science*

Meteorological and Sea Surface Water Measurement Data from Icebreaker Research Vessel ARAON for 2020-2021 Arctic Research Expeditions

Sungjae, Lee., Kim, Hyun-Cheol., Shin, Dongseob., Kim, Suhwan. and Choi, HyunGyu.

Geo Data. 2023. 5(1): 26-33.

doi: 10.22761/gd.2023.0005.

Since its construction in 2010, the icebreaker ARAON

has been conducting regular polar field surveys to observe changes in the atmosphere and marine environment in polar regions. The Arctic Ocean, a major research area, is directly affected by changes in the ocean, atmosphere and energy circulation system due to the continuous decrease in sea ice. During the Arctic summer season, when sea ice becomes smaller and thinner, the ARAON passes through East Sea, Bering Sea, Chukchi Sea, and Beaufort Sea to investigate the marine environment on the high latitude high seas. The Arctic Ocean is important not only for scientific research due to climate change, but also for economic research such as undersea energy, mineral resources, and Northern Sea route. However, it is difficult to access the Arctic and conduct long-term and continuous field surveys. ARAON carries out Arctic research voyages using various research equipment, and the most basic observation among them is meteorological information and sea water observation data. Weather data include solar radiation, atmospheric temperature, humidity, wind speed and wind direction, and seawater observations include sea water temperature, salinity, conductivity and fluorescence substances. In addition, three-dimensional location information of the research line was obtained. The data will be used as inspection data for satellite data and polar field survey data.

keywords:

Icebreaker ARAON; Arctic ocean; Meteorological information; Sea water observation

1-38 *Engineering, Environmental; Environmental Sciences*

MnO₂-Induced Oxidation of Iodide in Frozen Solution

Du, Juanshan., Kim, Kitae., and 4 others.

Environmental Science & Technology. 2023. 57(13): 5317-5326.

doi: 10.1021/acs.est.3c00604.

Metal oxides play a critical role in the abiotic transformation of iodine species in natural environments. In this study, we investigated iodide oxidation by manganese dioxides (β -MnO₂, γ -MnO₂, and δ -MnO₂) in frozen and aqueous solutions. The heterogeneous reaction produced reactive iodine (RI) in the frozen phase, and the subsequent thawing of the frozen sample induced the gradual transformation of in situ-formed RI to iodate or iodide, depending on the types of manganese dioxides. The freezing-enhanced production of RI was observed over the pH range of 5.0–9.0, but it decreased with increasing pH.

Fulvic acid (FA) can be iodinated by I^-/MnO_2 in aqueous and frozen solutions. About 0.8–8.4% of iodide was transformed to organoiodine compounds (OICs) at pH 6.0–7.8 in aqueous solution, while higher yields (10.4–17.8%) of OICs were obtained in frozen solution. Most OICs generated in the frozen phase contained one iodine atom and were lignin-like compounds according to Fourier transform ion cyclotron resonance/mass spectrometry analysis. This study uncovers a previously unrecognized production pathway of OICs under neutral conditions in frozen environments.

keywords:

reactive iodine; redox cycle of iodine species; manganese dioxide; chemical reactions in ice; organoiodine compounds

1-39 *Environmental Sciences; Public, Environmental & Occupational Health*

Molecular-level chemical composition of aerosol and its potential source tracking at Antarctic Peninsula

Jang, Jiyeon., Park, Ki-Tae., Yoon, Young Jun., Ha, Sun-Yong., Jang, Eunho., Cho, Kyung Hwa, Lee, Ji Yi and Park, Jiyeon.

Environmental Research. 2023. 239.

doi: 10.1016/j.envres.2023.117217.

Marine organic aerosols play crucial roles in global climatic systems. However, their chemical properties and relationships with various potential organic sources still need clarification. This study employed high-resolution mass spectrometry to investigate the identity, origin, and transportation of organic aerosols in pristine Antarctic environments (King Sejong Station; 62.2°S, 58.8°W), where complex ocean-cryosphere-atmosphere interactions occur. First, we classified the aerosol samples into three clusters based on their air mass transport history. Next, we investigated the relationship between organic aerosols and their potential sources, including organic matter dissolved in the open ocean, coastal waters, and runoff waters. Cluster 1 (C1), in which the aerosols mainly originated from the open ocean area (i.e., pelagic zone-influenced), exhibited a higher abundance of lipid-like and protein-like organic aerosols than cluster 3 (C3), with ratios 1.8- and 1.6-times higher, respectively. In contrast, C3, characterized by longer air mass retention over sea ice and land areas (i.e., inshore-influenced), had higher lignin- and condensed aromatic structures (CAS)-like organic aerosols by 2.2- and 3.4-times compared to C1. Cluster 2 (C2) has intermediate characteristics between C1

and C3 concerning the chemical properties of the aerosols and air mass travel history. Notably, the chemical properties of the aerosols assigned to C1 are closely related to those of phytoplankton-derived organics enriched in the open ocean. In contrast, those of C3 are comparable to those of terrestrial plant-derived organics enriched in coastal and runoff waters. These findings help evaluate the source-dependent properties of organic aerosols in changing Antarctic environment.

keywords:

Marine organic aerosol; High-resolution mass spectrometry; Orbitrap-MS; Antarctica

1-40 *Environmental Sciences; Meteorology & Atmospheric Sciences*

New particle formation leads to enhanced cloud condensation nuclei concentrations on the Antarctic Peninsula

Park, Jiyeon., Kang, Hyojin., Gim, Yeontae., Jang, Eunho., Park, Ki-Tae., Park, Sangjong., Jung, Chang Hoon., Ceburnis, Darius., O'Dowd, Colin. and Yoon, Young Jun.

Atmospheric Chemistry and Physics. 2023. 23(21): 13625-13646.

doi: 10.5194/acp-23-13625-2023.

Few studies have investigated the impact of new particle formation (NPF) on cloud condensation nuclei (CCN) in remote Antarctica, and none has elucidated the relationship between NPF and CCN production. To address that knowledge gap, we continuously measured the number size distribution of 2.5–300 nm particles and CCN number concentrations at King Sejong Station on the Antarctic Peninsula from 1 January to 31 December 2018. Ninety-seven NPF events were detected throughout the year. Clear annual and seasonal patterns of NPF were observed: high concentration and frequency of nucleation-mode particles in summer (December–February: 53 NPF cases) and undetected nucleation-mode particles in winter (June–August: no NPF cases). We estimated the spatial scale of NPF by multiplying the time during which a distinct nucleation mode can be observed at the sampling site by the locally measured wind speed. The estimated median spatial scale of NPF around the Antarctic Peninsula was found to be approximately 155 km, indicating the large scale of NPF events. Air back-trajectory analysis revealed that 80 cases of NPF events were associated with air masses originating over the ocean, followed by sea-ice (12 cases), multiple (3 cases), and land (2 cases) regions.

We present and discuss three major NPF categories: (1) marine NPF, (2) sea-ice NPF, and (3) multiple NPF. Satellite estimates for sea-surface dimethylsulfoniopropionate (DMSP; a precursor of gaseous dimethyl sulfide) data showed that the production of oceanic biogenic precursors could be a key component in marine NPF events, whereas halogen compounds released from ice-covered areas could contribute to sea-ice NPF events. Terrestrial sources (wildlife colonies, vegetation, and meltwater ponds) from Antarctica could affect aerosol production in multiple air masses. Out of 97 observed NPF events, 83 cases were characterized by the simultaneous increase in the CCN concentration by 2 %–270 % (median 44 %) in the following 1 to 36 h (median 8 h) after NPF events. Overall, Antarctic NPF events were found to be a significant source of particles with different physical characteristics and related to biogenic sources in and around the Antarctic Peninsula, which subsequently grew to cloud condensation nuclei.

to ~116 m/yr) when regional atmospheric temperatures exceeded modern values. Coupled with field observations, this finding directly supports a non-linear response of glacial melting to summer air temperature increases. In addition to suggesting that ice-sheet loss and sea-level rise may further accelerate in the near future, this study paves the way for the use of sedimentary Fe-(oxyhydr)oxide layers in subarctic environments for reconstructing past glacial dynamics.

keywords:

iron (oxyhydr)oxides; high Arctic environments; glacier retreat; tipping point; accelerated glacier melting; neodymium isotopes

1-41 Geochemistry & Geophysics

Non-linear response of glacier melting to Holocene warming in Svalbard recorded by sedimentary iron (oxyhydr)oxides

Jang, Kwangchul., Bayon, Germain., Vogt, Christoph., Forwick, Matthias., Ahn, Youngkyu., Kim, Jung-Hyun. and Nam, Seung-Il. *Earth and Planetary Science Letters*. 2023. 607. doi: 10.1016/j.epsl.2023.118054.

The recent acceleration of ice-sheet loss with its direct impact on sea-level rise and coastal ecosystems is of major environmental and societal concern. However, the effect of atmospheric temperature increases on long-term glacier retreat remains poorly defined due to limited historical observations and uncertainties in numerical ice-sheet models, which challenges climate change adaptation planning. Here, we present a novel approach for investigating the time-transgressive response of Arctic glaciers since the last deglaciation, using glacially-derived Fe-(oxyhydr)oxide layers preserved in glacialmarine sediments from a large fjord system in Svalbard. Glacial weathering releases large amounts of Fe, resulting in the deposition of Fe-(oxyhydr)oxide particulates in nearby marine sediments, which can serve as fossil indicators of past glacial melting events. Our results indicate that Svalbard glaciers retreated at a rate of 18 to 41 m/yr between 16.3 and 10.8 kyr BP, synchronously with the progressive rise in atmospheric and oceanic temperatures. From 10.8 kyr BP, glacier retreat markedly accelerated (up

1-42 Environmental Sciences; Remote Sensing; Imaging Science & Photographic Technology

Observation of spatial and temporal patterns of seasonal ground deformation in central Yakutia using time series InSAR data in the freezing season

Jung, Yoon Taek., Park, Sang-Eun. and Kim, Hyun-Cheol. *Remote Sensing of Environment*. 2023. 293. doi: 10.1016/j.rse.2023.113615.

The seasonal freeze/thaw variations of the active layer cause seasonal ground deformation, such as thaw subsidence in summer and frost heave in winter due to the cyclic phase changes of soil water. The Synthetic Aperture Radar (SAR) remote sensing, especially interferometric SAR (InSAR) techniques, has been proven to be a very useful tool for observing surface displacements of permafrost environments. Most previous studies on seasonal InSAR displacement have been concentrated in several study sites in the Arctic tundra regions. The objective of this study is to extend the InSAR analysis of seasonal ground deformations to boreal forest regions, where monitoring ground deformation is particularly important in terms of better understanding active layer dynamics under various ecological and geological conditions. In this study, we presented a strategy to analyze the time series SAR data in the freezing season to estimate the differential phase for seasonal ground deformation while overcoming the problem of coherence losses due to the rapid growth of vegetation during the short growing season. We applied the SBAS-based InSAR processing method to Sentinel-1 SAR in the central Yakutian lowlands, where boreal forests and thermokarst landforms are widely distributed, and retrieved frost-

related displacement signals successfully. In addition to the magnitude of ground deformation in the freezing season, we further examined the temporal deformation pattern related to the progression of the freezing front in the soil during active freezing. Based on the Stefan solution, we proposed a piecewise linear model for the time series deformation. The proposed model divides the time series displacement according to the progression of freezing into three linear segments, and the slope parameter of each linear model can be interpreted as indicating the hydrological characteristics of the upper, middle, and lower parts of the soil. The results for the Yakutian lowlands illustrated the potential of SAR remote sensing to observe and quantify spatial details of the thermal and hydrological properties inside the active layer soil even in highly vegetated subarctic boreal forest areas.

keywords:

Synthetic Aperture Radar; Permafrost; Active layer; Thaw subsidence; Frost heave; SAR interferometry; SBAS; Sentinel-1; Thermokarst; Lake

1-43 Environmental Sciences

Observational evidence linking ocean sulfur compounds to atmospheric dimethyl sulfide during Icelandic Sea phytoplankton blooms

Lee, Kitack., Kim, Jun-Seok., **Park, Ki-Tae.**, Park, Min-Ji., **Jang, Eunho.**, Gudmundsson, Kristinn., Olafsdottir, Solveig R., Olafsson, Jon., **Yoon, Young Jun.**, **Lee, Bang Yong.** and 2 others.
Science of the Total Environment. 2023. 879.
doi: 10.1016/j.scitotenv.2023.163020.

In two Icelandic Sea spring blooms (May 2018 and 2019) in the North Atlantic Ocean (62.9–68.0°N, 9.0–28.0°W), chlorophyll-*a* and dimethylsulfoniopropionate (DMSP) concentrations and DMSP lyase activity (the DMSP-to-dimethyl sulfide (DMS) conversion efficiency) were measured at 67 stations, and the hourly atmospheric DMS mixing ratios were concurrently measured only in May 2019 at Storhofdi on Heimaey Island, located south of Iceland (63.4°N, 20.3°W). The ocean parameters for biology (i.e., chlorophyll-*a*, DMSP, and DMSP lyase activity) were broadly associated in distribution; however, the statistical significance of the association differed among four ocean domains and also between 2018 and 2019. Specifically, the widespread dominance of *Phaeocystis*, *coccolithophores*, and dinoflagellates (all rich in DMSP and high in DMSP lyase activity) across the study area is a compelling indication

that variations in DMSP-rich phytoplankton were likely a main cause of the variations in statistical significance. For all the ocean domains defined here, we found that the DMS production capacity (calculated using the exposures of air masses to ocean biology prior to their arrivals at Heimaey and the atmospheric DMS mixing ratios of those air masses at Heimaey) was surprisingly consistent with in situ ocean S data (i.e., DMSP and DMSP lyase activity). Our study shows that the proposed computational approach enabled the detection of changes in DMS production and emission in association with changes in ocean primary producers.

keywords:

Dimethyl sulfide (DMS); Dimethylsulfoniopropionate (DMSP); Icelandic waters; DMSP lyase activity (DLA)

1-44 Astronomy & Astrophysics

Observational Evidence of Nonlinear Wave-Wave Interaction Over Antarctic MLT Region

Lee, Jaewook., Kwak, Young-Sil., Eswaraiah, Sunkara., Kam, Hosik., Kim, Yong Ha., **Lee, Changsup.** and **Kim, Jeong-Han.**
Journal of Geophysical Research-Space Physics. 2023. 128(4).
doi: 10.1029/2022ja030738.

Using meteor radar observations over King Sejong Station (62.22°S, 58.78°W) in the Antarctic Peninsula, we investigated the wave-wave interaction in the mesosphere and lower thermosphere (MLT) region. We analyzed hourly horizontal wind measurements at altitudes of 84–96 km from March 2016 through February 2017 and found that the MLT region is dominated by a semidiurnal tide (SDT) and the signature of planetary waves (PWs) with a period of ~8–27 days. The PW activity was substantially intensified during the winter. The day-to-day variability of SDT amplitudes are estimated and the higher-order spectral analysis of SDT amplitudes exhibits intermittent modulation of SDT at PW periods ~8 and 27 days in the zonal winds and periods of 8 and 16 days in the meridional winds. We observed an intense episode of tidal modulation from June through September 2016, during which a set of subsidiary spectral components around the SDT were found as a result of wave-wave interaction. Further, the bi-spectral analysis reveals that quadratic coupling (nonlinear interaction) occurred between SDT and PWs at a band period of 8–27 days, at above 90 km. We compared the spectral powers between the secondary waves created by the nonlinear interaction between the SDT and 16-day PWs. Further, we found that sum-secondary

waves generated by the nonlinear interaction are stronger than the difference-secondary waves during austral winter 2016. We thus conclude that the non-linear interaction between the tides and PWs may play a major role in the short-term tidal variability in the MLT region during austral winter 2016.

keywords:

mesosphere-lower thermosphere; tides; planetary waves; nonlinear interaction; meteor radar

1-45 *Astronomy & Astrophysics; Geochemistry & Geophysics; Meteorology & Atmospheric Sciences*

Observational evidence of thermospheric wind and composition changes and the resulting ionospheric disturbances in the European sector during extreme geomagnetic storms

Kim, Jeongheon., Kwak, Young-Sil., **Lee, Changsup.**, Lee, Jaewook., Kam, Hosik., Yang, Tae-Yong., **Jee, Geonhwa.** and Kim, Yongha.
Journal of Space Weather and Space Climate. 2023. 13.
doi: 10.1051/swsc/2023025.

On November 1st and 2nd, 2021, four Halo coronal mass ejections were ejected from the Sun, releasing billions of tons of high-energy particles into interplanetary space. These were directed towards the Earth and reached our planet on November 3rd and 4th, 2021, generating the first G3-level extreme geomagnetic storm since the beginning of the 25th solar cycle. In this study, we investigate the thermospheric and ionospheric responses in the European sector to a G3-level storm using various observational data from Fabry-Perot interferometer, Ionospheric Connection Explorer/Michelson Interferometer for Global High-resolution Thermospheric Imaging (ICON/MIGHTI), and Thermosphere Ionosphere Mesosphere Energetics and Dynamics/Global Ultraviolet Imager (TIMED/GUVI). The results show positive ionospheric storms in the middle and low latitudes of Europe which may be associated with the equatorward and westward neutral winds induced by heating in the polar region. In contrast, negative storms were detected at high latitudes in association with the increase in thermospheric density (upwelling). These two antithetical responses were confirmed by using European ionosonde and total electron contents (TEC) observation chains distributed over a wide range of latitudes. Finally, we, for the first time, attempt to identify the imaginary boundary line between the two responses.

keywords:

Ionosphere responses; Geomagnetic storm; CMEs; Zonal and meridional winds; TID induced by TAD

1-46 *Astronomy*

Observations for the Ionosphere Using European Incoherent Scatter (EISCAT) in the Dayside Polar Cap/Cusp and Auroral Region

Jee, Geonhwa., Ji, Eun-Young., **Kim, Eunsol.**, Kwak, Youngsil., **Lee, Changsup.**, **Kwon, Hyuck-Jin.**, **Kim, Ji-Eun.**, **Ham, Young-bae.**, **Lee, Ji-Hee.**, **Kim, Jeong Han.** and 2 others.
Journal of Astronomy and Space Sciences. 2023. 40(1): 1-10.
doi: 10.5140/jass.2023.40.1.1.

Korea Polar Research Institute (KOPRI) and Korea Astronomy and Space Institute (KASI) have been participating in the European Incoherent Scatter (EISCAT) Scientific Association as an affiliate institution in order to observe the polar ionosphere since 2015. During the period of December 16–21, 2016 and January 3–9, 2018, the observations for the polar ionospheric parameters such as the electron density profiles, ion drift, and electron/ion temperature are carried out in the polar cap/ cusp region by the EISCAT Svalbard radar (ESR). The purpose of the observations is to investigate the characteristic of the winter ionosphere in the dayside polar cap/cusp region. In this paper, we briefly report the results of the ESR observations for winter daytime ionosphere and also the simultaneous observations for the ionosphere-thermosphere system together with the balloon-borne instrument High-Altitude Interferometer WIND Experiment (HIWIND) performed by the High Altitude Observatory (HAO), National Center for Atmospheric Research (NCAR). We further introduce our research activities using long-term EISCAT observations for the occurrence of ion upflow and the climatology of the polar ionospheric density profiles in comparison with the mid-latitude ionosphere. Finally, our future research plans will briefly be introduced.

keywords:

polar ionosphere; European Incoherent Scatter (EISCAT); High-Altitude Interferometer WIND Experiment (HIWIND)

1-47 *Environmental Sciences***Ocean-atmosphere interactions: Different organic components across Pacific and Southern Oceans**

Jang, Jiyeon., Park, Jongkwan., Yoon, Young Jun., Dall'Osto, Manuel., Park, Ki-Tae., Jang, Eunho., Lee, Ji Yi., Cho, Kyung Hwa. and Lee, Bang Yong.

Science of the Total Environment. 2023. 878.

doi: 10.1016/j.scitotenv.2023.162969.

Sea spray aerosol (SSA) particles strongly influence clouds and climate but the potential impact of ocean microbiota on SSA fluxes is still a matter of active research. Here—by means of in situ ship-borne measurements—we explore simultaneously molecular-level chemical properties of organic matter (OM) in oceans, sea ice, and the ambient PM_{2.5} aerosols along a transect of 15,000 km from the western Pacific Ocean (36°13'N) to the Southern Ocean (75°15'S). By means of orbitrap mass spectrometry and optical characteristics, lignin-like material ($24 \pm 5\%$) and humic material ($57 \pm 8\%$) were found to dominate the pelagic Pacific Ocean surface, while intermediate conditions were observed in the Pacific-Southern Ocean waters. In the marine atmosphere, we found a gradient of features in the aerosol: lignin-like material ($31 \pm 9\%$) dominating coastal areas and the pelagic Pacific Ocean, whereas lipid-like ($23 \pm 16\%$) and protein-like ($11 \pm 10\%$) OM controlled the sympagic Southern Ocean (sea ice-influence). The results of this study showed that the OM composition in the ocean, which changes with latitude, affects the OM in aerosol compositions in the atmosphere. This study highlights the importance of the global-scale OM monitoring of the close interaction between the ocean, sea ice, and the atmosphere. Sympagic primary marine aerosols in polar regions must be treated differently from other pelagic-type oceans.

keywords:

Marine organic aerosol; Shipborne measurement; Latitudinal distribution; Orbitrap mass spectrometry; Ocean-sea ice-atmosphere interaction

Jung, Chang Hoon., Lee, Hyung-Min., Park, Dasom., Yoon, Young Jun., and 5 others.

Journal of Environmental Sciences. 2023. 132: 43-55.

doi: 10.1016/j.jes.2022.07.031.

The below-cloud aerosol scavenging process by precipitation is one of the most important mechanisms to remove aerosols from the atmosphere. Due to its complexity and dependence on both aerosol and raindrop sizes, wet scavenging process has been poorly treated, especially during the removal of fine particles. This makes the numerical simulation of below-cloud scavenging in large-scale aerosol models unrealistic. To consider the slip effects of submicron particles, a simplified expression for the diffusion scavenging was developed by approximating the Cunningham slip correction factor. The derived analytic solution was parameterized as a simple power function of rain intensity under the assumption of the lognormal size distribution of particles. The resultant approximated expression was compared to the observed data and the results of previous studies including a 3D atmospheric chemical transport model simulation. Compared with the default GEOS-Chem coefficient of $0.00106R^{0.61}$ and the observation-based coefficient of $0.0144R^{0.9268}$, the coefficient of a and b in $\Lambda_m = aR^b$ spread in the range of 0.0002 - 0.1959 for a and 0.3261 - 0.525 for b over a size distribution of GSD of 1.3–2.5 and a geometric mean diameter of 0.01–2.5 μm . Overall, this study showed that the scavenging coefficient varies widely by orders of magnitude according to the size distribution of particles and rain intensity. This study also demonstrated that the obtained simplified expression could consider the theoretical approach of aerosol polydispersity. Our proposed analytic approach showed that results can be effectively applied for reduced computational burden in atmospheric modeling.

keywords:

Below-cloud scavenging; Polydisperse aerosol; Parameterization; Cunningham correction factor; Scavenging coefficient

1-48 *Environmental Sciences***Parameterization of below-cloud scavenging for polydisperse fine mode aerosols as a function of rain intensity**

1-49 *Engineering, Chemical; Engineering, Mechanical; Environmental Sciences; Meteorology & Atmospheric Sciences*

Parameterization of polydisperse aerosol optical properties during hygroscopic growth

Jung, Chang H., Han, Kyung Man., Yoon, Young Jun. and 6 others.

Aerosol Science and Technology. 2023. 57(8): 713-726.
doi: 10.1080/02786826.2023.2211121.

Aerosol water uptake and the related influence on its optical properties owing to the hygroscopic growth of polydisperse aerosols have a significant effect on air quality and climate. This study develops an analytical parameterization for a single hygroscopic optical parameter and the scattering enhancement factor for polydisperse aerosol sizes. Polydisperse lognormal size distributions for geometric mean diameters of 0.05–1 μm and geometric standard deviations of 1.3–2.5 are considered with real refractive indices between 1.35 and 1.6. The analytical expression obtained for the optical parameter is compared to Mie theory and reasonable agreements within the size range investigated in this study are observed. Further, our results show that the analytical expression could express polydispersed aerosol optical properties as a function of geometric mean diameter and geometric standard deviation of a lognormal distribution and the refractive index. The obtained analytical expression can be efficiently used for 3D models with a reduced computational burden.

keywords:

Hans Moosmuller

1-50 *Geosciences, Multidisciplinary*

Petrology and quartz grain microtextures of marine shoreline sands from the Punta Arenas area, southernmost Chile and King George Island, Antarctica and implications for their depositional history

Kim, HyeJeong, Lee, A. Chim, Lee, Yong Il and Lee, Min Kyung.
Episodes. 2023. 46(1): 47-62.
doi: 10.18814/epiugs/2022/022013.

Modal composition and quartz microtextures were analyzed to investigate the provenance tectonic setting and transport mechanism in shoreline sediments from the Punta Arenas (PA) area in the southernmost part of Chile and King George Island (KGI), West Antarctica. In the sediments from both areas, volcanic rock fragments were the pre-dominant framework grain, and a significant amount of quartz was also found in the PA area. The provenance tectonic setting of the PA area was a recycled orogen, and that of the KGI area was a magmatic arc. Quartz grains exhibited subangular shape, medium to high relief, and mainly mechanical microtextures,

which were induced by high shear stress (>80%) and high-energy percussion (<20%). The shoreline sands of the two areas did not differ significantly in the distribution of frequency of microtextures of glacial and aqueous origins, so it is interpreted that the sand sediments from both areas had similar glacial and aqueous transport histories. The percussion microstructures, which occurred in less than 20% of the sands in both areas, may be due to the relatively short residence time in the energetic aqueous conditions. The presence of weathered quartz grains fractured by glaciers indicates that they had undergone significant weathering in the preceding warm periods. The presence of high count of pre weathered microtextures suggests that many grains travel into glacial stream carrying the pre-weathering microfeatures, which can be recognized in the sedimentary record.

1-51 *Environmental Sciences; Meteorology & Atmospheric Sciences*

Phytoplankton responses to increasing Arctic river discharge under the present and future climate simulations

Park, Jung Hyun., Kim, Seong-Joong., Lim, Hyung-Gyu., Kug, Jong-Seong., Yang, Eun Jin. and Kim, Baek-Min.
Environmental Research Letters. 2023. 18(6).
doi: 10.1088/1748-9326/acd568.

In recent decades, the unprecedented rate of Arctic warming has accelerated the high-latitude landmass hydrological cycle, leading to increased river discharge into the Arctic Ocean. This study elucidates the role of Arctic river discharge, which was the large model uncertainty in the Coupled Model Intercomparison Project 6, for the phytoplankton responses in present-day and future climate simulations by adding fresh water into the model. In the present-day climate simulation, additional river discharge decreases the spring phytoplankton biomass. Freshening of Arctic seawater facilitates freezing, increasing sea ice concentration in spring and eventually decreasing phytoplankton due to less availability of light. On the other hand, in the summer, phytoplankton increases due to the surplus of surface nitrate and the increase in the vertical mixing induced by the reduced summer sea ice melting water. In the future climate, the plankton response to the additional freshwater input is similar to the present-day climate. Nevertheless, the major phytoplankton responses are shifted from the Eurasian Basin to the Canada Basin and

the East-Siberian Sea, mainly due to the marginal sea ice zone shift from the Barents-Kara Sea to the East Siberian-Chukchi Sea in the future.

keywords:

river discharge; Arctic Ocean; phytoplankton; sea ice concentration

1-52 *Meteorology & Atmospheric Sciences*

Potential Loss of Predictability in the Numerical Weather Prediction from the Reduced Spatial Coverage of the Polar-Orbiting Satellite Observing System

Noh, Young-Chan., Huang, Hung-Lung., Goldberg, Mitchell D. and Choi, Yonghan.

Monthly Weather Review. 2023. 151(5): 1129-1144.

doi: 10.1175/mwr-d-22-0143.1.

To provide global coverage for the hyperspectral infrared (IR) and microwave (MW) sounders, the lowEarth-orbiting (LEO) satellite constellation is in operation in three temporally well-spaced sun-synchronous orbits. However, the satellite program can be altered as a result of aging satellites needing to deorbit and/or termination of the legacy program, resulting in less spatiotemporal coverage. In this study, to stress the contribution of IR and MW sounder observations from the LEO satellite constellation on numerical weather prediction (NWP) system performance, the change of the analysis impact is assessed under two assumptions: 1) the loss of the IR and MW sounder observations in each of three sun-synchronous orbits and 2) the loss of the secondary LEO satellite in two orbits, using a 2017 version of the National Centers for Environmental Prediction Global Forecast System (GFS). In the analysis verification, it is found that the analysis field is degraded due to the loss of the IR and MW sounders in each of the three primary orbits. In particular, the satellites in the afternoon orbit significantly contribute to improving the analysis as compared with the satellites in the other two orbits. In addition, the loss of the secondary satellite results in significant degradation of the analysis, resulting from reduced spatial coverage by the IR and MW sounders. These results suggest that the LEO satellite constellation, consisting of the LEO satellites in three primary sun-synchronous orbits, should be maintained in terms of the contribution to the NWP.

keywords:

Satellite observations; Numerical weather prediction/forecasting; Data assimilation; Forecast verification/skill

1-53 *Chemistry, Physical; Physics, Atomic, Molecular & Chemical*

Production of Molecular Iodine via a Redox Reaction between Iodate and Organic Compounds in Ice

Kim, Kitae., Kim, Bomi., Ahn, Yong-Yoon., and 3 others.

Journal of Physical Chemistry A. 2023. 127(12): 2830-2838.

doi: 10.1021/acs.jpca.3c00482.

The abiotic mechanism of molecular iodine (I_2) production from iodate (IO_3^-) remains largely unknown. Here, we demonstrate the production of I_2 in the presence of IO_3^- and organic compounds in ice. When the solution containing IO_3^- (100 μ M) and furfuryl alcohol (100 μ M) at pH 3.0 was frozen at -20°C , 13.1 μ M of I_2 was produced with complete degradation of furfuryl alcohol after 20 min. However, there was little change in the IO_3^- and furfuryl alcohol concentrations in water at 25°C . The production of I_2 in ice is due to the freeze concentration effect, which induces the accumulation of IO_3^- , furfuryl alcohol, and protons in the ice grain boundaries. This behavior facilitated the production of I_2 via a redox reaction between IO_3^- and organic compounds. The production of I_2 increased with increasing furfuryl alcohol concentration and decreasing pH. However, freezing temperature had a minor effect on the maximum production of I_2 . The production of I_2 is highly dependent on the type of organic compounds. It was higher for organic compounds with higher electron-donating properties. This study suggests a new mechanism for I_2 production, which is helpful for predicting precisely the atmospheric I_2 budget in cold regions.

1-54 *Environmental Sciences; Meteorology & Atmospheric Sciences*

Projections of central Arctic summer sea surface temperatures in CMIP6

Han, Ju-Seok., Park, Hyo-Seok. and Chung, Eui-Seok.

Environmental Research Letters. 2023. 18(12).

doi: 10.1088/1748-9326/ad0c8a.

One of the most dramatic climate responses to future global warming is the near-disappearance of the perennial sea ice cover in the central Arctic Ocean, a phenomenon known as the ice-free summer Arctic. The immediate consequence of an ice-free Arctic would be the surface warming of the central Arctic Ocean, where sea surface temperatures (SSTs) used to be at freezing levels. Through an analysis of climate models participating in the climate model intercomparison project phase-6, this study demonstrates a wide range of responses in the central Arctic SSTs in August–September as a result of the projected ice-free summer Arctic. These responses vary from 0.7 to 8 °C in the shared socioeconomic pathway 2 (SSP2-4.5), referred to as the ‘middle of the road’ scenario, in which socioeconomic and technological trends do not significantly deviate from historical patterns. The extent of the central Arctic sea surface warming in August–September is found to have a loose correlation with the September sea ice extent (SIE), but a stronger connection to the SIE during spring to early summer (May–July), when incoming shortwave radiation is most intense. In certain climate models, the perennial sea ice cover disappears completely in September, causing central Arctic SSTs to rise by 5 °C–8 °C by the end of the 21st century. This leads to a bimodal distribution of annual SSTs. Further analysis reveals a close relationship between mid-summer SSTs in the central Arctic Ocean and preceding winter sea ice thickness (SIT). This underscores the significance of winter SIT in predicting future Arctic surface warming and marine heatwaves.

keywords:

ice-free Arctic; sea surface warming; CMIP6 multi-models

1-55

Recent decline in atmospheric Pb deposition and isotopic constraints on changes in source contributions in snow from northwestern Greenland

Lee, Sanghee., Lee, Khanghyun., Han, Changhee., Han, Yeongcheol., Hong, Sang-Bum., Hur, Soon Do., Lee, Seungmi., Chang, Chaewon., Jung, Hyejin., Moon, Jangil., and 2 others.

Chemosphere, Volume 345, 2023, 140441.

doi: 10.1016/j.chemosphere.2023.140441.

We present lead (Pb) concentrations and isotope ratios

in a continuous series of 38 snow samples from a 1.9-m snow pit, covering the period from winter 2012 to summer 2017, at the East Greenland Ice-core Project (EGRIP) ice core drill site in northwestern Greenland. Pb concentrations were highly variable, ranging from 1.53 to 94.9 pg g⁻¹ (mean value of 10.6 pg g⁻¹), with higher concentrations during winter and spring and lower concentrations during summer and fall. Our results show a substantial reduction in the Pb concentration of ~50% between the 2000s and 2010s, reaching a level close to that observed in the mid-18th century, that is, the time of the Industrial Revolution. Remarkably low radiogenic Pb isotope compositions were observed in our samples compared to previously reported values during the 2000s. The Pb isotope mixing model results indicated a decreasing Chinese contribution from the 2000s onwards, while Europe/Russia emerged as a relatively more important contributor to the anthropogenic Pb input to central Greenland during the corresponding period. Thus, we hypothesized that the reduction in Pb pollution in central Greenland is largely due to a decreasing contribution from Chinese sources in response to the effectiveness of stringent emission control measures in China.

1-56 *Meteorology & Atmospheric Sciences*

Record-high Antarctic Peninsula temperatures and surface melt in February 2022: a compound event with an intense atmospheric river

Gorodetskaya, Irina V., Duran-Alarcon, Claudio., Gonzalez-Herrero, Sergi., Clem, Kyle R., Zou, Xun., Rowe, Penny., Imazio, Paola Rodriguez., Campos, Diego., Leroy-Dos Santos, Christophe., Dutrievoz, Niels., Wille, Jonathan D., Chyhareva, Anastasiia., Favier, Vincent., Blanchet, Juliette., Pohl, Benjamin., Cordero, Raul R., **Park, Sang-Jong.** and 8 others.

Npj Climate and Atmospheric Science. 2023. 6(1).

doi: 10.1038/s41612-023-00529-6.

The Antarctic Peninsula (AP) experienced a new extreme warm event and record-high surface melt in February 2022, rivaling the recent temperature records from 2015 and 2020, and contributing to the alarming series of extreme warm events over this region showing stronger warming compared to the rest of Antarctica. Here, the drivers and impacts of the event are analyzed in detail using a range of observational and modeling data. The northern/northwestern AP was directly impacted by an intense atmospheric river (AR) attaining category 3 on the AR scale,

which brought anomalous heat and rainfall, while the AR-enhanced foehn effect further warmed its northeastern side. The event was triggered by multiple large-scale atmospheric circulation patterns linking the AR formation to tropical convection anomalies and stationary Rossby waves, with an anomalous Amundsen Sea Low and a record-breaking high-pressure system east of the AP. This multivariate and spatial compound event culminated in widespread and intense surface melt across the AP. Circulation analog analysis shows that global warming played a role in the amplification and increased probability of the event. Increasing frequency of such events can undermine the stability of the AP ice shelves, with multiple local to global impacts, including acceleration of the AP ice mass loss and changes in sensitive ecosystems.

1-57 Meteorology & Atmospheric Sciences

Remote Influences of ENSO and IOD on the Interannual Variability of the West Antarctic Sea Ice

Kim, Jihae., Kang, Daehyun., Lee, Myong-In., Jin, Emilia Kyung., Kug, Jong-Seong. and Lee, Won Sang.

Journal of Geophysical Research-Atmospheres. 2023. 128(10).

doi: 10.1029/2022jd038313.

West Antarctica exhibits a pronounced sea ice variability in interannual timescale, and 20%–30% of the total variance can be explained by the El Niño-Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD) during austral spring. The sea ice variation is primarily linked with anomalous atmospheric circulation in the Amundsen-Bellinghousen Sea (ABS) that modulates poleward atmospheric temperature advection and radiative forcing. With a co-varying relationship between ENSO and IOD, isolating their remote impacts on Antarctica has been limited in observations. An idealized experiment using the atmospheric model with a dry dynamical core suggests that the anticyclonic circulation anomaly in the ABS is primarily contributed by the ENSO in the Pacific Ocean, while the contribution of the IOD in the Indian Ocean is only one-third large. This study implies that atmospheric teleconnection through the southern Pacific Ocean is crucial for understanding the West Antarctic sea ice concentration variability.

keywords:

ENSO; IOD; West Antarctic; Sea ice

1-58 Geosciences, Multidisciplinary

Response of Meteor Plasma Trails Observed by Meteor Radar to Geomagnetic Activity

Kam, Hosik., Kwak, Young-Sil., Lee, Changsup., Kim, Jeong-Heon., Hong, Junseok., Kim, Yong Ha. and Kim, Jeong-Han.

Geophysical Research Letters. 2023. 50(6).

doi: 10.1029/2022gl102636.

From meteor radar observations typically measuring neutral winds and temperatures in the upper atmosphere, we showed that under-dense meteor plasma trails respond to geomagnetic activity. Depending on the geomagnetic activity conditions, the parameters of the under-dense trail echoes show substantial anomalies, and their responses are immediate. As geomagnetic activity increases, the decay time decreases up to about 10% at $K_p = 8$, while both the returned signal power and radial velocity error increase. In addition, the types of diffuse evolution vary with geomagnetic activity, resulting in strong geomagnetic activity that immediately affects the trail. The evolution of the trail is affected not only by the ambient mesospheric neutral atmospheric properties but also by electromagnetic effects, such as strong electric fields inside meteor trails. Furthermore, our findings suggest that the geomagnetic effect should be considered when estimating atmospheric parameters from MR during a geomagnetically active period.

keywords:

specular meteor radar; under-dense echo; geomagnetic activity

1-59 Earth Science

Sea Ice Drift from GPS Tracker Deployed in the Arctic Ocean

Park, Jeong-won., Kim, Hyun-Cheol., Jinku, Park., Minji, Seo. and Park, Jieun.

Geo Data. 2023. 5(1): 15-19.

doi: 10.22761/gd.2023.0003.

Sea ice is monitored on a regular basis by satellite observation; however, image-based drift tracking is imprecise as the time interval forming the image-pair is too large to capture the actual trajectory of ice drift. In this study, drift trajectory and speed of an Arctic sea ice floe measured by a GPS tracker for 3 months and the characteristics of the

relating device and data, are introduced.

keywords:

Sea ice; Drift; Trajectory; Speed; GPS tracker

1-60

Sea Ice Drift Tracking from SAR Images and GPS Tracker

Park, Jeong-Won., Kim, Hyun-Cheol., Seo, Minji., Park, Ji-Eun., and Park, Jinku.

Korean Journal of Remote Sensing, 39(3), 257–268.

doi: 10.7780/KJRS.2023.39.3.1.

Sea ice plays an important role in Earth's climate by regulating the amount of solar energy absorbed and controlling the exchange of heat and material across the air-sea interface. Its growth, drift, and melting are monitored on a regular basis by satellite observations. However, low-resolution products with passive microwave radiometer have reduced accuracy during summer to autumn when the ice surface changes rapidly. Synthetic aperture radar (SAR) observations are emerging as a powerful complementary, but previous researches have mainly focused on winter ice. In this study, sea ice drift tracking was evaluated and analyzed using SAR images and tracker with global positioning system (GPS) during late summer-early autumn period when ice surface condition changes a lot. The results showed that observational uncertainty increases compared to winter period, however, the correlation coefficient with GPS measurements was excellent at 0.98, and the performance of the ice tracking algorithm was proportional to the sea ice concentration with a correlation coefficient of 0.59 for ice concentrations above 50%.

Keywords:

Sea Ice; Drift; Synthetic aperture radar, Tracker with global positioning system; Arctic Ocean

1-61 *Earth Science*

Sea Ice Elevation Measurements Using 3-D Laser Scanner

Minji, Seo., Park, Jieun., Park, Jeong-won., Jinku, Park. and Kim,

Hyun-Cheol.

Geo Data. 2023. 5(1): 20-25.

doi: 10.22761/gd.2023.0004.

This study aims to introduce a sea ice elevation dataset estimated by using a 3-D laser scanner during the ice camp of the 2022 Arctic summer field survey. The equipment used is FARO's Laser scanner FOCUS 3D X 130 HDR. The observed sea ice floe is located in the Arctic Ocean (76°13'N, 174°35') and is a multi-year ice with several melt ponds and ice ridges. We scanned eight sections separately, considering the equipment's maximum horizontal scan range and the ice surface's topographic features. The raw data were co-registered based on the positions of reference spheres. The result indicated a significant level of accuracy with a target-based vertical mean error of 4.8 mm. The laser scanner data were merged into point clouds ranging from 160×210 m. As a result, sea ice elevation data were generated in 0 to 2.8 m based on the minimum vertical point in the observation range. Sea ice elevation data is an essential variable in estimating the various properties of sea ice, such as ice thickness and roughness. In addition, using climatic variables such as air temperature and energy budget observed simultaneously can help to understand the physical interaction between the sea ice surface and the atmosphere on a local scale.

keywords:

Sea ice; Sea ice elevation; 3-D laser scanner

1-62 *Geochemistry & Geophysics; Engineering, Electrical & Electronic; Remote Sensing; Imaging Science & Photographic Technology*

Sensitivity of Passive Microwave Satellite Observations to Snow Density and Grain Size Over Arctic Sea Ice

Kwon, Young-Joo., Kim, Hyun-Cheol., Kim, Jong-Min., Park, Jeong-Won. and Kim, Seung Hee.

Ieee Transactions on Geoscience and Remote Sensing. 2023. 61.

doi: 10.1109/tgrs.2023.3322401.

Snow cover on Arctic sea ice is crucial to understanding sea ice evolution and the heat budget in the rapidly changing Arctic Ocean. Despite advancements in remote sensing technology, accurately estimating snow depth (SD), grain size, and density on a large scale remains challenging. This study examines the influence of snow density and

grain size on passive microwave satellite observation data. Data were collected from December 2012 to February 2016 using Advanced Microwave Scanning Radiometer 2 (AMSR2) brightness temperature (BT) data, and snow depth was estimated using ice-tethered ice mass balance (IMB) data from the Cold Regions Research and Engineering Laboratory (CRREL), Hanover, NH, USA. A two-stream approximation radiative transfer model that accounts for the scattering effect of the snow layer over Arctic sea ice was used. This study found that the slope in the linear relationship between the snow density and the BT indices [such as gradient ratio (GR) and brightness temperature ratio (BTR)] is highly sensitive to the density and grain size of the snow layer. Using this dependence, the temporal changes in the physical state of the snow layer were inferred from the observation over the winter season. The radiative transfer model simulations revealed that the grain size of the snow layer decreases during winter as the snow density increases, likely due to the counterbalancing effect of new snow on the temporal variability in grain size increasing caused by snow metamorphism.

keywords:

Arctic sea ice; grain size; passive microwave (PMW); radiative transfer model; snow depth (SD)

1-63 *Earth Science*

Small Unmanned Aerial Vehicle LiDAR-based High Spatial Resolution Topographic Dataset in Russell Glacier, Greenland

Jeong, Yongsik., Sungjae, Lee., Kim, Seung Hee. and Kim, Hyun-Cheol.

Geo Data. 2023. 5(1): 1-7.

doi: 10.22761/gd.2023.0006.

Greenland contains a large continental glacier. The influence of glacier melting has been expanding due to global warming. Although regional monitoring based on satellite data is being conducted, the demand for local/specific variation observation has increased as rising climate temperature patterns in the polar region. In this study, a precise topographic dataset was created for Greenland's Russell glacier using a small unmanned aerial vehicle (sUAV) onboarded LiDAR sensor. A precise digital surface model (DSM) was constructed based on LiDAR data obtained at an altitude of about 100 to 200 m, and DSM resampled to a 2 m sample distance was produced to confirm its applicability by

comparing before-and-after variations. This study provides DSM data applied with a pre/post-processing used for the comparison analysis.

keywords:

Small unmanned aerial vehicle; LiDAR; Russell glacier; Digital surface model; Greenland

1-64 *Geosciences, Multidisciplinary*

Solar Cycle and Long-Term Trends in the Observed Peak of the Meteor Altitude Distributions by Meteor Radars

Dawkins, E. C. M., Stober, G., Janches, D., Carrillo-Sanchez, J. D., Lieberman, R. S., Jacobi, C., Moffat-Griffin, T., Mitchell, N. J., Cobbett, N., Batista, P. P., Andrioli, V. F., Buriti, R. A., Murphy, D. J., Kero, J., Gulbrandsen, N., Tsutsumi, M., Kozlovsky, A., Kim, Jeong-Han., Lee, Changsup. and Lester, M.

Geophysical Research Letters. 2023. 50(2).

doi: 10.1029/2022gl101953.

The mesosphere/lower thermosphere (MLT, 80–100 km) region is an important boundary between Earth's atmosphere below and space above and may act as a sensitive indicator for anthropogenic climate change. Existing observational and modeling studies have shown the middle atmosphere and the MLT is cooling and contracting because of increasing greenhouse gas emissions. However, trend analyses are highly sensitive to the time periods covered, their length, and the measurement type and methodology used. We present for the first time the linear and 11-year solar cycle responses in the meteor ablation altitude distributions observed by 12 meteor radars at different locations. Decreasing altitudes were seen at all latitudes (linear trends varying from -10.97 to -817.95 m dec^{-1}), and a positive correlation with solar activity was seen for most locations. The divergence of responses at high latitudes indicates an important and complex interplay between atmospheric changes and dynamics at varying time scales.

keywords:

meteor; altitude; mesosphere; meteor radar; climate change; mesopause

1-65 Environmental Sciences

Spatiotemporal variability of the PM_{2.5} distribution and weather anomalies during severe pollution events: Observations from 462 air quality monitoring stations across South Korea

Han, Subin, Park, Yongmi, Noh, Namkyu, Kim, Joo-Hong, and 3 others. *Atmospheric Pollution Research*. 2023. 14(3).
doi: 10.1016/j.apr.2023.101676.

We investigated the nationwide spatiotemporal variability of PM_{2.5} during 49 severe PM_{2.5} pollution events based on observations from 462 air quality monitoring stations (AQMSs) across South Korea during 2015–2020. We calculated the coefficient of divergence (COD) and Pearson correlation coefficient (R) for the entire nationwide AQMS network with respect to the time series of average PM_{2.5} in the Seoul area. We identified three distinct spatial COD and R distribution patterns (Cases I–III) among 49 pollution events that can help to determine locations for additional AQMSs. We present the spatial distributions of time lag associated with PM_{2.5} pollution events at each monitoring station relative to the Seoul area, clarifying the inter-district transport of PM_{2.5}. When the time lag was adjusted, the average R values at all AQMSs were greater than 0.74 for all cases (compared to 0.52–0.57 before adjustment), suggesting that characteristic weather patterns over East Asia drive nationwide severe PM_{2.5} pollution. Analyses of composite anomalies of meteorological variables (compared to climatology for 1991–2020) suggest that weakened surface winds accompanied by strong positive temperature anomalies in East Asia play an important role in the onset of severe PM_{2.5} pollution in Korea (for all classified cases). Our findings have elucidated the weather patterns that lead to severe PM_{2.5} pollution, variations of spatiotemporal PM_{2.5} pollution patterns over Korea on the regional scale with weather patterns, and pollution transport across air quality districts (inter-air-quality-district transport patterns).

keywords:

PM_{2.5} pollution; Spatiotemporal distribution; Time-lag; Coefficient of divergence; Weather anomaly pattern

Liu, Anling., Yang, Jing., Bao, Qing., He, Bian., Wu, Xiaofei., Liu, Jiping., Kim, Seong-Joong, and Fan, Yalan. *Atmospheric Research*. 2023. 295.
doi: 10.1016/j.atmosres.2023.107014.

With the opening of Arctic passage for maritime transportation under global warming, accurate prediction of Arctic sea ice (ASI) on subseasonal-to-seasonal (S2S) timescales becomes increasingly crucial for the economy and society but challenging. This study examined the S2S hindcast skills of monthly ASI during 1992–2019 using Flexible Global Ocean-Atmosphere-Land System, Finite-Volume version 2 (FGOALS-f2), a global coupled model that includes an interactive dynamical sea ice component. Firstly, the prediction system can accurately capture the seasonal cycle of Arctic sea ice extent (SIE). Still, it slightly overestimates SIE in March–June and significantly underestimates SIE in August–December. Meanwhile, the declining trend of SIE is underestimated in predictions for all target seasons, particularly for spring. Secondly, relatively high skills with an average ACC of 0.44 are found in predicting monthly SIE anomalies (SIEA) after removing the long-term linear trend at a one-to-six-month lead. However, the one-to-six-month lead prediction skills in April drop significantly by 36% when the interdecadal variation is removed. We find that the variation of April SIEA after removing the linear trend is dominated by the Pacific Decadal Oscillation (PDO), which can be better predicted than interannual variability ahead of subseasonal timescales. Unlike the SIE error-based metrics considered in previous studies, the one-to-three-month lead prediction in FGOALS-f2 shows significantly better performance in predicting the spatial distribution of September ASI for extreme years compared to normal years. Finally, the skill for predicting minimum SIEA in FGOALS-f2 is considerably higher at a three-to-six-month lead than anomaly persistence, indicating the advantage of this dynamical prediction system at a longer lead time.

keywords:

FGOALS-f2; Arctic SIE; S2S prediction; PDO; Extreme sea ice

1-66 Meteorology & Atmospheric Sciences

Subseasonal-to-seasonal prediction of arctic sea ice Using a Fully Coupled dynamical ensemble forecast system

1-67 Environmental Sciences; Meteorology & Atmospheric Sciences

Synoptic meteorological conditions and contributing factors to air quality during the SIJAQ campaign

Kim, Cheol-Hee., Jo, Hyun-Young., Jo, Yu-Jin., Lee, Hyo-Jung., Kim,

Jong-Min., Lee, Na-Mi. and 6 others.
Atmospheric Environment. 2023. 309.
 doi: 10.1016/j.atmosenv.2023.119939.

The Satellite Integrated Joint Monitoring of Air Quality (SIJAQ) field campaign was conducted from October 10 to November 25, 2021, to assess air quality across the Korean Peninsula and validate the results of the Geostationary Environment Monitoring Spectrometer (GEMS) employing remote sensing, modeling, and satellite, aircraft, and ground measurements. To integrate all measurements collected during the campaign, synoptic features across the Korean Peninsula were analyzed. We identified cyclones and anticyclones by tracing weather charts and divided the campaign into five periods (P1 to P5): P1 - Sustained marine stagnation (October 10–28, 2021), P2 - Transitional stagnant high (October 29–November 7, 2021), P3 - Continental migratory low (November 8–14, 2021), P4 - Continental migratory high (November 15–21, 2021), and P5 - Continental migratory low (November 22–25, 2021). The synoptic features, such as the locations of stagnant or migratory cyclones and anticyclones were analyzed during the periods, in association with levels of particulate matter with a diameter of less than 2.5 μm ($\text{PM}_{2.5}$ levels) over the Seoul metropolitan area (SMA). The synoptic characteristics showed that the presence of a high pressure system was well associated with the occurrence of high $\text{PM}_{2.5}$ level over the SMA, and a pattern of near-surface divergence and descending motions originating from the mid-troposphere. In addition, we identified and compared two $\text{PM}_{2.5}$ level peaks caused by local accumulation and transboundary transport process. We also investigated the underlying synoptic meteorological mechanisms of these peaks in terms of large-scale dynamic variables, such as geostrophic wind speed, transient synoptic scale features, vorticity, and vorticity advection at 850 hPa geopotential height, which are responsible for transboundary transport and local accumulation-driven process of $\text{PM}_{2.5}$ in the SMA.

keywords:

SIJAQ campaign; Transboundary transport process; Seoul metropolitan area; Synoptic meteorological conditions

1-68 *Meteorology & Atmospheric Sciences*

The mechanism linking the variability of the Antarctic sea ice extent in the Indian Ocean sector to Indian summer monsoon rainfall

Azhar, Siti Syairah Atiqah., Chenoli, Sheeba Nettukandy., Abu Samah, Azizan., Kim, Seong-Joong. and Murukesh, Nuncio.
Climate Dynamics. 2023. 60(9-10): 2665-2685.
 doi: 10.1007/s00382-022-06466-z.

The study investigates the mechanism of teleconnection between the variability of sea ice extent (SIE) in the Indian Ocean sector of the Southern Ocean and the variability of Indian summer monsoon rainfall. We utilized reanalysis, satellite, in-situ observation data, and model output from the coupled model intercomparison project phase 5 (CMIP5) from 1979 to 2013. The empirical orthogonal function (EOF) and correlation analysis show that the first and third modes of principal component (PC1 and PC3) of SIE in the Indian Ocean sector during April–May–June (AMJ) are significantly correlated with the second mode of principal component (PC2) of Indian summer monsoon rainfall. The reanalysis data revealed that the changes in the SIE in the Indian Ocean sector excite meridional wave train responses along the Indian Ocean for both principal component modes. Positive (negative) SIE anomalies based on first and third EOFs (EOF1 and EOF3), contribute to the strengthening (weakening) of the Polar, Ferrel, and Hadley cells, inducing stronger (weaker) convective activity over the Indian latitudes. The stronger (weaker) convective activity over the Indian region leads to more (less) rainfall over the region during high (low) ice phase years. Furthermore, a stronger (weaker) polar jet during the high (low) ice phase is also noted. The selected CMIP5 models captured certain atmospheric teleconnection features found in the reanalysis. During AMJ, the SIE simulated by the NorESM1-M model was significantly positively correlated with Indian summer monsoon rainfall, whereas the IPSL-CM54-LR model showed a negative correlation.

keywords:

Antarctic sea ice extent (SIE) in the Indian Ocean sector; High ice phase; Low ice phase; Indian summer monsoon rainfall; Convective activity

1-69 *Meteorology & Atmospheric Sciences*

The YOPP Final Summit Assessing Past and Forecasting Future Polar Prediction Research

Wilson, Jeff, Jung, Thomas., Bazile, Eric., Bromwich, David., Casati, Barbara., Day, Jonathan., De Coning, Estelle., Eayrs, Clare. and 14 others.
Bulletin of the American Meteorological Society. 2023. 104(3): E660-E665.
 doi: 10.1175/bams-d-22-0282.1.

The Year of Polar Prediction (YOPP) Final Summit was the final milestone in the World Meteorological Organization's (WMO) World Weather Research Programme's (WWRP) Polar Prediction Project (PPP). The PPP mission was to “promote research enabling improved prediction services for the polar regions,” with PPP running for 10 years from 2013 to 2022 (Jung et al. 2016). YOPP was PPP's flagship activity (Goessling et al. 2016) including a period of intensive observing, modeling, prediction, verification, user engagement and education activities from mid-2017 to mid-2019. This was to be followed by a consolidation period ending in December 2022 to carry out the analysis, synthesize and publish the results. The YOPP Final Summit was attended by 187 participants from 27 countries (123 in person with another 64 online) to discuss the accomplishments and impacts of YOPP and make suggestions for future international polar research programs building on the PPP. Participants included scientists across a wide range of career stages, representatives from operational weather and climate prediction centers, international bodies, key user groups, and other stakeholders. Poster presentations and stands included endorsed projects but also new Arctic flagship projects building in part on the legacy of YOPP. An overview booklet of the Polar Prediction Project and the Year of Polar Prediction—including coordination, resource mobilization, research accomplishments (quantitative and qualitative), and science to services was launched at the YOPP Final Summit (Jung and Wilson 2022). The YOPP Final Summit was preceded by a 1-day workshop at McGill University for early-career polar scientists where more than 20 participants had the opportunity to hear from and interact with YOPP senior scientists on scientific as well as career topics. The summit commenced with background presentations recalling the rationale and drivers for PPP and YOPP and then moved into 3.5 days of plenary and parallel presentation sessions reviewing progress and identifying future challenges for science and services. Brainstorming sessions were held at the end of each day to capture the successes of YOPP, as well as areas where more could be done. Participants also provided ideas and suggestions for future international polar prediction research and services projects. Session themes included Modeling Advancements, Observing System Experiments (OSEs) and Satellites; Polar Processes; Polar Oceans; Processes and the YOPP Supersite Model Intercomparison Project (YOPPsiteMIP);¹ Science to Services; Polar Prediction and Societal Implications; Sea Ice; Southern Hemisphere; Polar Midlatitude Linkages; Observation Campaigns and MOSAiC;² and Observing Systems and Sea Ice.

keywords:

Antarctica; Arctic; Atmosphere-ocean interaction; Forecast verification/skill; Data assimilation; Numerical weather prediction/forecasting

1-70 *Geosciences, Multidisciplinary*

Understanding the delayed Amundsen Sea low response to ENSO

Lee, Hyun-Ju. and Jin, Emilia Kyung.

Frontiers in Earth Science. 2023. 11.

doi: 10.3389/feart.2023.1136025.

Although the El Niño-Southern Oscillation (ENSO) affects West Antarctica *via* teleconnection, it is delayed by a season, because the Amundsen Sea Low (ASL) anomaly in response to the ENSO is the strongest in May. However, the process and mechanism of the delay has not been fully elucidated yet. In this study, we examined the formation of the ENSO-driven teleconnection in each month from January to May by analyzing the kinetic energy conversion and Rossby wave propagation. The flow perturbed by the ENSO gains energy from the basic state by energy conversion, but the perturbation does not reach the high latitudes until April. In May, although the ENSO intensity becomes weak, the development of the subtropical jet induces waves to propagate further south, resulting in the anticyclonic circulation anomaly over the ASL region. Numerical experiments that account for the decay of the ENSO forcing and the monthly varying basic state also indicate that the formation of the teleconnection is the strongest in May. The results reveal that the configuration of the basic state is crucial for the teleconnection in response to the ENSO to reach West Antarctica.

keywords:

ENSO teleconnection; the Amundsen Sea low (ASL); delayed impact of the ENSO; rossby wave propagation; kinetic energy conversion

1-71 *Astronomy & Astrophysics; Geochemistry & Geophysics; Meteorology & Atmospheric Sciences*

Validation of Ionospheric Specifications During Geomagnetic Storms: TEC and foF2 During the 2013 March Storm Event-II

Shim, Ja Soon., Song, In-Sun., Jee, Geonhwa., and 15 others.

Space Weather-the International Journal of Research and Applications. 2023. 21(5).

doi: 10.1029/2022sw003388.

Assessing space weather modeling capability is a key element in improving existing models and developing

new ones. In order to track improvement of the models and investigate impacts of forcing, from the lower atmosphere below and from the magnetosphere above, on the performance of ionosphere-thermosphere models, we expand our previous assessment for 2013 March storm event [Shim et al., 2018]. In this study, we evaluate new simulations from upgraded models (the Coupled Thermosphere Ionosphere Plasmasphere Electrodynamics (CTIPE) model version 4.1 and the Global Ionosphere Thermosphere Model (GITM) version 21.11) and from the NCAR Whole Atmosphere Community Climate Model with thermosphere and ionosphere extension (WACCM-X) version 2.2 including eight simulations in the previous study. A simulation from the NCAR Thermosphere-Ionosphere-Electrodynamics General Circulation Model version 2 (TIE-GCM 2.0) is also included for comparison with WACCM-X. TEC and foF2 changes from quiet-time background are considered to evaluate the model performance on the storm impacts. For evaluation, we employ four skill scores: Correlation coefficient (CC), root-mean square error (RMSE), ratio of the modeled to observed maximum percentage changes (Yield), and timing error (TE). It is found that the models tend to underestimate the storm-time enhancements of foF2 (F2-layer critical frequency) and TEC (Total Electron Content) and to predict foF2 and/or TEC better in North America but worse in the Southern Hemisphere. The ensemble simulation for TEC is comparable to results from a data assimilation model (Utah State University-Global Assimilation of Ionospheric Measurements (USU-GAIM)) with differences in skill score less than 3% and 6% for CC and RMSE, respectively.

an increasing trend only in ERA5, with EBAF indicating a decreasing trend in the Arctic Circle (AC; poleward from 65°N) from 2000 to 2018. The differences in the net radiation trend between product types was due to longwave downward radiation. The extreme season was selected according to the seasonality of net radiation, surface air temperature, and sea ice extent. The surface radiation budget was synthesized for extreme season in the AC. Regardless of the data, net radiation tended to increase in the summer on an annual trend. By contrast, in the winter, trend of surface net radiation was observed in which ERA5 increased and EBAF decreased. The difference in surface radiation is represented in longwave of each data. This comprehensive information can be used to analyze and predict the surface energy budget, transport, and interaction between the atmosphere and surface in the Arctic.

keywords:

Arctic; cryosphere; climate change; surface radiation budget

1-72 *Environmental Sciences; Geosciences, Multidisciplinary; Remote Sensing; Imaging Science & Photographic Technology*

Variability of Surface Radiation Budget over Arctic during Two Recent Decades from Perspective of CERES and ERA5 Data

Seo, Minji, Kim, Hyun-Cheol, and 3 others.

Remote Sensing. 2023. 15(3).

doi: 10.3390/rs15030829.

This study focused on surface radiation budget, one of the essential factors for understanding climate change. Arctic surface radiation budget was summarized and explained using a satellite product, Clouds and the Earth's Radiant Energy System (CERES) Energy Balanced and Filled (EBAF), and reanalysis data, ERA5. Net radiation records indicated

Part 2.

Geo Sciences

2-1 Paleontology

A possibly deep branching artiopodan arthropod from the lower Cambrian Sirius Passet Lagerstätte (North Greenland)

Berks, Harry O., Nielsen, Morten Lunde., Flannery-Sutherland., Joseph, Nielsen., Arne Thorshøj., **Park, Tae-Yoon S.** and Vinther, Jakob.
Papers in Palaeontology. 2023. 9(3).
 doi: 10.1002/spp2.1495.

Artiopoda was a diverse group of Palaeozoic euarthropods that proliferated in the early Palaeozoic, epitomized by the ubiquitous trilobites. Their possible phylogenetic position outside mandibulates and chelicerates offers the potential for understanding the evolution of euarthropods in more detail. However, this opportunity remains unexploited given that identification of deep-splitting artiopodans remains to be fully explored. Here, we describe a new non-trilobite artiopodan from the lower Cambrian Sirius Passet Lagerstätte, North Greenland. *Thulaspis tholops* gen. et sp. nov. is a large species with a broad, domed head shield, followed by a trunk consisting of 15 thoracic tergites and a small pygidium, giving the body an ovoid appearance when viewed dorsally. *Thulaspis* is distinctive with its rounded genae and anterior thoracic pleural tips, as well as short pleural spines posteriorly. A heart-shaped hypostome with an anterior lobe is present. Appendages, partly obscured by the tergal skeleton, have many moderate length gnathobasic spines, and large flap-like exopods with a fringe of small setae. Cladistic analyses recover *Thulaspis* as the sister taxon to *Squamacula*, a genus found in the Chengjiang and Emu Bay Shale biotas, in either a polytomy with a number of artiopodan taxa or as a sister group to all other artiopodans, indicating an important role in understanding the roots of artiopodan anatomy and evolution.

keywords:

Artiopoda; Euarthropoda; Sirius Passet Lagerstätte

2-2 Multidisciplinary Sciences

Abundant presolar grains and primordial organics preserved in carbon-rich exogenous clasts in asteroid Ryugu

Nguyen, Ann N., Mane, Prajcta., Keller, Lindsay P., Piani, Laurette., Abe, Yoshinari., Aleon, Jerome., Alexander, Conel M. O'D., Amari, Sachiko., Amelin, Yuri., Bajo, Ken-ichi., Bizzarro, Martin., Bouvier, Audrey., Carlson, Richard W., Chaussidon, Marc., Choi, Byeon-Gak., Dauphas, Nicolas., Davis, Andrew M., Di Rocco, Tommaso., Fujiya, Wataru., Fukai, Ryota., Gautam, Ikshu., Haba, Makiko K., Hibiya, Yuki., Hidaka, Hiroshi., Homma, Hisashi., Hoppe, Peter., Huss, Gary R., Ichida, Kiyohiro., Iizuka, Tsuyoshi., Ireland, Trevor R., Ishikawa, Akira., Itoh, Shoichi., Kawasaki, Noriyuki., Kita, Noriko T., Kitajima, Kouki., Kleine, Thorsten., Komatani, Shintaro., Krot, Alexander N., Liu, Ming-Chang., Masuda, Yuki., McKeegan, Kevin D., Morita, Mayu., Motomura, Kazuko., Moynier, Frederic., Nakai, Izumi., Nagashima, Kazuhide., Nesvorný, David., Nittler, Larry., Onose, Morihiko., Pack, Andreas., **Park, Changkun.** and 41 others.
Science Advances. 2023. 9(28).
 doi: 10.1126/sciadv.adh1003.

Preliminary analyses of asteroid Ryugu samples show kinship to aqueously altered CI (Ivuna-type) chondrites, suggesting similar origins. We report identification of C-rich, particularly primitive clasts in Ryugu samples that contain preserved presolar silicate grains and exceptional abundances of presolar SiC and isotopically anomalous organic matter. The high presolar silicate abundance (104 ppm) indicates that the clast escaped extensive alteration. The 5 to 10 times higher abundances of presolar SiC (~235 ppm), N-rich organic matter, organics with N isotopic anomalies (1.2%), and organics with C isotopic anomalies (0.2%) in the primitive clasts compared to bulk Ryugu suggest that the clasts formed in a unique part of the protoplanetary disk enriched in presolar materials. These clasts likely represent previously unsampled outer solar system material that accreted onto Ryugu after aqueous alteration ceased, consistent with Ryugu's rubble pile origin.

2-3 Geochemistry & Geophysics

²⁶Al–²⁶Mg chronology of high-temperature condensate hibonite in a fine-grained, Ca-Al-rich inclusion from reduced CV chondrite

Kawasaki, Noriyuki., Yamamoto, Daiki., Wada, Sohei., **Park, Changkun., Kim, Hwayoung.** and 2 others.

Meteoritics & Planetary Science. 2024. 59(4): 630-639.

doi: 10.1111/maps.13989.

Al–Mg mineral isochron studies using secondary ion mass spectrometry (SIMS) have revealed the initial $^{26}\text{Al}/^{27}\text{Al}$ ratios, ($^{26}\text{Al}/^{27}\text{Al}$)₀, for individual Ca–Al-rich inclusions (CAIs) in meteorites. We find that the relative sensitivity factors of $^{27}\text{Al}/^{24}\text{Mg}$ ratio for SIMS analysis of hibonite, one of the major constituent minerals of CAIs, exhibit variations based on their chemical compositions. This underscores the critical need for using appropriate hibonite standards to obtain accurate Al–Mg data. We measured the Al–Mg mineral isochron for hibonite in a fine-grained CAI (FGI) from the Northwest Africa 8613 reduced CV chondrite by SIMS using synthesized hibonite standards with $^{27}\text{Al}/^{24}\text{Mg}$ of ~30, ~100, and ~400. The obtained mineral isochron of hibonite in the FGI yields ($^{26}\text{Al}/^{27}\text{Al}$)₀ of $(4.73 \pm 0.09) \times 10^{-5}$, which is identical to that previously obtained from the mineral isochron of spinel and melilite in the same FGI (Kawasaki et al., 2020). The uncertainties of ($^{26}\text{Al}/^{27}\text{Al}$)₀ indicate that the constituent minerals in the FGI formed within ~0.02 Myr in the earliest solar system. The disequilibrium O-isotope distributions of the minerals in the FGI suggest that the O-isotope compositions of the nebular gas from which they condensed underwent a transitional change from ^{16}O -rich to ^{16}O -poor within ~0.02 Myr in the earliest solar system. Once formed, the FGI may have been removed from the forming region within ~0.02 Myr and transported to the accretion region of the parent body.

2-4

Applications of the Fast Grain Boundary Model to Cosmochemistry

Park, Changkun.

Korean Journal of Mineralogy and Petrology, 36(3): 199-212.

doi: 10.22807/KJMP.2023.36.3.199.

Diffusion is a powerful tool to understand geological processes recorded in terrestrial rocks as well as extraterrestrial materials. Since the diffusive exchange of elements or isotopes may have occurred differently in the solar nebula (high temperature and rapid cooling) and on the parent bodies (fluid-assisted thermal metamorphism at relatively low temperature), it is particularly important to model elemental or isotopic diffusion profiles within the mineral grains to better understand the evolution of the early solar system. A numerical model with the finite difference

method for the fast grain boundary diffusion was established for the exchange of elements or isotopes between constituent minerals in a closed system. The fast grain boundary diffusion numerical model was applied to 1) ^{26}Mg variation in plagioclase of an amoeboid olivine aggregate (AOA) from a CH chondrite and 2) Fe–Mg interdiffusion between chondrules, AOA, and matrix minerals in a CO chondrite. Equilibrium isotopic fractionation and equilibrium partitioning were also included in the numerical model, based on the assumption that equilibrium can be reached at the interfaces of mineral crystals. The numerical model showed that diffusion profiles observed in chondrite samples likely resulted from the diffusive exchange of elements or isotopes between the constituent minerals. This study also showed that the closure temperature is determined not only by the mineral with the slowest diffusivity in the system, but also strongly depends on the constituent mineral abundances.

Keywords:

Fast grain boundary diffusion; Finite difference method; Magnesium isotope self-diffusion; Fe–Mg interdiffusion

2-5 Multidisciplinary Sciences

Cambrian lobopodians shed light on the origin of the tardigrade body plan

Kihm, Ji-Hoon., Smith, Frank W., Kim, Sanghee., Rho, Hyun Soo., Zhang, Xingliang., Liu, Gianni. and Park, Tae-Yoon S.

Proceedings of the National Academy of Sciences of the United States of America. 2023. 120(28).

doi: 10.1073/pnas.2211251120.

Phylum Tardigrada (water bears), well known for their cryptobiosis, includes small invertebrates with four paired limbs and is divided into two classes: Eutardigrada and Heterotardigrada. The evolutionary origin of Tardigrada is known to lie within the lobopodians, which are extinct soft-bodied worms with lobopodous limbs mostly discovered at sites of exceptionally well-preserved fossils. Contrary to their closest relatives, onychophorans and euarthropods, the origin of morphological characters of tardigrades remains unclear, and detailed comparison with the lobopodians has not been well explored. Here, we present detailed morphological comparison between tardigrades and Cambrian lobopodians, with a phylogenetic analysis encompassing most of the lobopodians and three panarthropod phyla. The results indicate that the

ancestral tardigrades likely had a Cambrian lobopodian-like morphology and shared most recent ancestry with the luolishaniids. Internal relationships within Tardigrada indicate that the ancestral tardigrade had a vermiform body shape without segmental plates, but possessed cuticular structures surrounding the mouth opening, and lobopodous legs terminating with claws, but without digits. This finding is in contrast to the long-standing stygarctid-like ancestor hypothesis. The highly compact and miniaturized body plan of tardigrades evolved after the tardigrade lineage diverged from an ancient shared ancestor with the luolishaniids.

keywords:

Cambrian explosion; Panarthropoda; Tardigrada; lobopodian; morphological evolution

2-6 Geosciences, Multidisciplinary

Carbonate record of temporal change in oxygen fugacity and gaseous species in asteroid Ryugu

Fujiya, Wataru., Kawasaki, Noriyuki., Nagashima, Kazuhide., Sakamoto, Naoya., O'D. Alexander, Conel M., Kita, Noriko T., Kitajima, Kouki., Abe, Yoshinari., Aleon, Jerome., Amari, Sachiko., Amelin, Yuri., Bajo, Ken-ichi., Bizzarro, Martin., Bouvier, Audrey., Carlson, Richard W., Chaussidon, Marc., Choi, Byeon-Gak., Dauphas, Nicolas., Davis, Andrew M., Di Rocco, Tommaso., Fukai, Ryota., Gautam, Ikshu., Haba, Makiko K., Hibiya, Yuki., Hidaka, Hiroshi., Homma, Hisashi., Hoppe, Peter., Huss, Gary R., Ichida, Kiyohiro., Iizuka, Tsuyoshi., Ireland, Trevor R., Ishikawa, Akira., Itoh, Shoichi., Kleine, Thorsten., Komatani, Shintaro., Krot, Alexander N., Liu, Ming-Chang., Masuda, Yuki., McKeegan, Kevin D., Morita, Mayu., Motomura, Kazuko., Moynier, Frederic., Nakai, Izumi., Nguyen, Ann., Nittler, Larry., Onose, Morihiko., Pack, Andreas., **Park, Changkun.** and 41 others.

Nature Geoscience. 2023. 16(8): 675-+.

doi: [10.1038/s41561-023-01226-y](https://doi.org/10.1038/s41561-023-01226-y).

The Hayabusa2 spacecraft explored asteroid Ryugu and brought its surface materials to Earth. Ryugu samples resemble Ivuna-type (CI) chondrites—the most chemically primitive meteorites—and contain secondary phyllosilicates and carbonates, which are indicative of aqueous alteration. Understanding the conditions (such as temperature, redox state and fluid composition) during aqueous alteration is crucial to elucidating how Ryugu evolved to its present state, but little is known about the temporal changes in these conditions. Here we show that calcium carbonate (calcite) grains in Ryugu and Ivuna samples have variable

$^{18}\text{O}/^{16}\text{O}$ and $^{13}\text{C}/^{12}\text{C}$ ratios that are, respectively, 24–46‰ and 65–108‰ greater than terrestrial standard values, whereas those of calcium–magnesium carbonate (dolomite) grains are much more homogeneous, ranging within 31–36‰ for oxygen and 67–75‰ for carbon. We infer that the calcite precipitated first over a wide range of temperatures and oxygen partial pressures, and that the proportion of gaseous $\text{CO}_2/\text{CO}/\text{CH}_4$ molecules changed temporally. By contrast, the dolomite formed later in a more oxygen-rich and thus CO_2 -dominated environment when the system was approaching equilibrium. The characteristic isotopic compositions of secondary carbonates in Ryugu and Ivuna are not observed for other hydrous meteorites, suggesting a unique evolutionary pathway for their parent asteroid(s).

2-7 Multidisciplinary Sciences

Climate-controlled submarine landslides on the Antarctic continental margin

Gales, Jenny A., McKay, Robert M., De Santis, Laura., Rebesco, Michele., Laberg, Jan Sverre., Shevenell, Amelia E., Harwood, David., Leckie, R. Mark., Kulhanek, Denise K., King, Maxine., Patterson, Molly., Lucchi, Renata G., Kim, Sookwan., **Kim, Sunghan.** and 4 others.

Nature Communications. 2023. 14(1).

doi: [10.1038/s41467-023-38240-y](https://doi.org/10.1038/s41467-023-38240-y).

Antarctica's continental margins pose an unknown submarine landslide-generated tsunami risk to Southern Hemisphere populations and infrastructure. Understanding the factors driving slope failure is essential to assessing future geohazards. Here, we present a multidisciplinary study of a major submarine landslide complex along the eastern Ross Sea continental slope (Antarctica) that identifies preconditioning factors and failure mechanisms. Weak layers, identified beneath three submarine landslides, consist of distinct packages of interbedded Miocene- to Pliocene-age diatom oozes and glaciomarine diamicts. The observed lithological differences, which arise from glacial to interglacial variations in biological productivity, ice proximity, and ocean circulation, caused changes in sediment deposition that inherently preconditioned slope failure. These recurrent Antarctic submarine landslides were likely triggered by seismicity associated with glacioisostatic readjustment, leading to failure within the preconditioned weak layers. Ongoing climate warming and ice retreat may increase regional glacioisostatic seismicity, triggering Antarctic submarine landslides.

2-8 *Geosciences, Multidisciplinary*

Commentary: Reply to commentary by Noormets and Kirchner on “Glacial history and depositional environments in little Storfjorden and Hambergbukta of Arctic Svalbard since the younger dryas” [Frontiers in Earth Science, (2022), 2211]

Joe, Young Jin., Jang, Kwangchul., Forwick, Matthias., Laberg, Jan Sverre. and Nam, Seung-Il.

Frontiers in Earth Science. 2023. 11.

doi: 10.3389/feart.2023.1196640.

The commentary by Noormets and Kirchner argues that the entire Terminal Moraine Complex (TMC) at the mouth of Hambergbukta would have formed by multiple glacier advances after the Younger Dryas. They pointed out that Joe et al. (2022) has overlooked the complex morphological features, especially the stacked debris flow lobes and flattened crest areas, of TMC to interpret its formation. In this reply, we present an additional subbottom profiling data covering two sets (DFL-3 and DFL-2) of debris flow lobes defined by Noormets and Kirchner and further discuss for the the stacked debris lobes, the age model of the studied core, and iceberg-flattened crests of the TMC. Although a further investigation is necessary to better understand the behavior of the former tidewater glacier (Hambergbreen) in Hambergbukta, our conclusion is that the complex morphology of TMC could have formed during the latest Holocene including the Little Ice Age.

keywords:

Hambergbukta; terminal moraine; shallow seismic stratigraphy; lithofacies; Little Ice Age; iceberg scouring

2-9

Comparative analysis of shipboard three-component magnetometer (STCM) and proton precession magnetometer (PPM) datasets in the Australian-Antarctic Ridge

Choi, Hakkyum., Kim, Seung-sep., and Park Sung-Hyun.

Data in Brief, 2023, Volume 49,.

doi: 10.1016/j.dib.2023.109351.

Two different types of magnetometer, the Proton Precession Magnetometer (PPM) and the Shipboard Three-

Component Magnetometer (STCM), each possess its own strengths and weaknesses in their operation. The PPM can measure the total intensity of the Earth's geomagnetic field without requiring complicated post-processing and correction. However, its operation is often limited by the condition of the sea surface. In contrast, the STCM can measure three components of the Earth's field -X, Y and Z - and is not restricted by the sea condition. However, the STCM is highly sensitive to ship's viscous magnetization, which introduces significant noise into the data quality and can lead to a loss in measured geomagnetic field. The simultaneous measurements were carried out using both types of magnetometers along the same section within the Australian-Antarctic Ridge. This region experiences strong measurements of the geomagnetic field due to its proximity to the geomagnetic South Pole. We then compared the differences between the two datasets. For each dataset, we calculated a unique linear trend and subsequently removed the discrepancy between the trends. The corrected STCM data exhibited excellent agreement with the PPM data, suggesting the potential for complementary utilization of the STCM along the PPM.

Keywords:

Geomagnetic field; Vector magnetic field; Magnetometer; Marine magnetic survey; Magnetized seafloor

2-10 *Astronomy & Astrophysics*

Contribution of Ryugu-like material to Earth's volatile inventory by Cu and Zn isotopic analysis

Paquet, Marine., Moynier, Frederic., Yokoyama, Tetsuya., Dai, Wei., Hu, Yan., Abe, Yoshinari., Aleon, Jerome., O'D. Alexander, Conel M., Amari, Sachiko., Amelin, Yuri., Bajo, Ken-ichi., Bizzarro, Martin., Bouvier, Audrey., Carlson, Richard W., Chaussidon, Marc., Choi, Byeon-Gak., Dauphas, Nicolas., Davis, Andrew M., Di Rocco, Tommaso., Fujiya, Wataru., Fukai, Ryota., Gautam, Ikshu., Haba, Makiko K., Hibiya, Yuki., Hidaka, Hiroshi., Homma, Hisashi., Hoppe, Peter., Huss, Gary R., Ichida, Kiyohiro., Iizuka, Tsuyoshi., Ireland, Trevor R., Ishikawa, Akira., Ito, Motoo., Itoh, Shoichi., Kawasaki, Noriyuki., Kita, Noriko T., Kitajima, Kouki., Kleine, Thorsten., Komatani, Shintaro., Krot, Alexander N., Liu, Ming-Chang., Masuda, Yuki., McKeegan, Kevin D., Morita, Mayu., Motomura, Kazuko., Nakai, Izumi., Nagashima, Kazuhide., Nesvorny, David., Nguyen, Ann N., Nittler, Larry., Onose, Morihiko., Pack, Andreas., Park, Changkun. and 41 others.

Nature Astronomy. 2023. 7(2): 182-189.

doi: 10.1038/s41550-022-01846-1.

Initial analyses showed that asteroid Ryugu's composition is close to CI (Ivuna-like) carbonaceous chondrites (CCs) - the chemically most primitive meteorites, characterized by near-solar abundances for most elements. However, some isotopic signatures (for example, Ti, Cr) overlap with other CC groups, so the details of the link between Ryugu and the CI chondrites are not yet fully clear. Here we show that Ryugu and CI chondrites have the same zinc and copper isotopic composition. As the various chondrite groups have very distinct Zn and Cu isotopic signatures, our results point at a common genetic heritage between Ryugu and CI chondrites, ruling out any affinity with other CC groups. Since Ryugu's pristine samples match the solar elemental composition for many elements, their Zn and Cu isotopic compositions likely represent the best estimates of the solar composition. Earth's mass-independent Zn isotopic composition is intermediate between Ryugu/CC and non-carbonaceous chondrites (NCs), suggesting a contribution of Ryugu-like material to Earth's budgets of Zn and other moderately volatile elements.

2-11 Oceanography

Developmental history of a newly discovered chain of paired mound and depression structures on the southwestern continental shelf of the Ulleung Basin, East Sea, Korea

Kim, Tae Yeon., Kong, Gee Soo., Lee, Mirinae., and 2 others.

Continental Shelf Research. 2023. 269.

doi: 10.1016/j.csr.2023.105102.

A chain of paired mound and depression structures are presented in the southwestern continental shelf of the Ulleung Basin, East Sea, Korea. We integrate multibeam bathymetry to identify topographic features, sub-bottom profile and multi-channel seismic reflection data to confirm geological features, and piston cores to understand the sediments of the mounds and depressions. Paired structures occur with a northwest-southeast orientation at water depths between 130 and 150 m and have similar scales of 10–20 m in height and depth. The mounds consist of cold-water corals and authigenic carbonate with shelly sand, whereas, the surficial lithology of depressions are only composed of siliciclastic deposits. The mounds appeared to have grown from the depression based on the observation for morphological features in the cross-section profiles of the paired mound and depression structures. Seismic profiles show acoustic blanking anomalies and seismic chimneys,

indicating that the topographic relief formed under the influence of gas seepage. The petrological and geochemical signature of carbonate chunks also displayed gas leak effects different from CWC. This study suggests a developmental history model with paired mound and depression structures, in which gas/fluid escape causes depressions and the selective coral growth creates mounds growing on one side of these depressions. The mounds had sufficiently grown, depressions would have been further developed in interaction with the bottom current.

keywords:

Southwestern continental shelf of Ulleung; Basin; East Sea; Seafloor mound; Seafloor depression; Cold-water coral; Gas seepage

2-12 Geosciences, Multidisciplinary

Ediacaran mafic magmatism recorded in Cambrian eclogites of the Ross orogen, Antarctica: Implications for the Neoproterozoic rifting episodes along the Pacific-Gondwana margin

Kim, Taehwan., Kim, Yoonsup., Cheong, Wonseok., Cho, Moon-sup. and Lee, Jong Ik.

Terra Nova. 2023. 35(1): 32-40.

doi: 10.1111/ter.12626.

We report the first finding of Ediacaran mafic magmatism in northern Victoria Land of the Ross orogen, Antarctica, based on ca. 600–590 Ma magmatic zircon cores in Cambrian eclogites. The mafic magmatism could be either linked to ca. 615–590 Ma incipient convergent margin magmatism in central segment of the Ross orogen, or ca. 600–580 Ma continental rift-related volcanism widespread in eastern Australia. The latter is preferred based on the trace-element compositions distinctive from those of arc-related basalts and the depleted mantle-like Hf isotopic compositions of zircon. Our results suggest dual rifting episodes during both the Ediacaran and Cryogenian (ca. 670–650 Ma) in the East Antarctic margin, correlative with those in eastern Australia. A spatial distribution of coeval rifting and subduction along the Ediacaran margin of East Antarctica is readily accounted for by rift inheritance; the upper- and lower-plate geometry resulting from detachment and transform faulting.

2-13 *Geosciences, Multidisciplinary***Elemental and triple oxygen isotope geochemistry of new Northwest Africa (NWA) ordinary chondrites (L5, L6): Implications for onion-shell to rubble-pile OC parent body structure**

Ali, Arshad., Jabeen, Iffat., Nasir, Sobhi J., Kim, Nak Kyu. and Kim, Hwayoung.

Journal of African Earth Sciences. 2023. 202.

doi: 10.1016/j.jafrearsci.2023.104923.

The new L-type ordinary chondrites (OCs) are characterized by fayalite (25.7–26.1 mol%) and ferrosillite (21.5–22.2 mol%) contents in olivine and low-Ca pyroxene, respectively. The Fe/Mg and Fe/Mn ratios in olivine, as well as oxygen isotope compositions in bulk samples, compared to those of other impact-related brecciated OCs (e.g., NWA 869, L3-6, Ghubara, L5) and olivine from Itokawa dust particles. The data demonstrate a correlation between Fe/Mg and Fe/Mn ratios in olivine, and comparability in oxygen isotope compositions between the newly analyzed L-type meteorites and various clasts of NWA 869 used as a proxy for rubble-pile asteroid. Furthermore, these ratios from bulk and olivine of equilibrated ordinary chondrites (EOC) derived from the literature data fall close to the co-variation line (1:1). However, the ratios of different fractions in unequilibrated ordinary chondrites (UOC) such as chondrules, clasts, and matrix, do not fall close to the co-variation line. The coupled anti-correlation trend observed between the bulk and olivine ratios in EOC (i.e., H, L, and LL) is primarily due to variations in the total Fe content caused by redox reactions of silicate to metal in the nebula and metal to silicate in the parent body. The proposed scenario for the formation and evolution of larger asteroids in the early solar system suggests that they accreted and evolved as an onion-shell structure, and over time, they may have undergone internal heating due to radioactive decay. The internal heating may have caused metalsilicate segregation and thermal metamorphism. Eventually, catastrophic impacts may have caused the fragmentation of the asteroid into smaller pieces. Later, gravitational collapse reassembled the parent asteroid's fragments into several daughter asteroids that resembled rubble-piles, with the H-chondrites representing the deepest part and the L- and LL-chondrites representing the outer parts of the larger asteroid(s). Additionally, the oxygen isotope compositions of new L-chondrites are similar to those of the impact-related clasts in brecciated chondrites NWA 869, indicating that they have a shared L-type parent asteroid that was once part of a larger asteroid.

keywords:

Chondrites; Asteroids; Northwest Africa; Oxygen isotopes; Ordovician; Onion-shell; Rubble-pile

2-14 *Engineering, Environmental; Environmental Sciences***Frozen Clay Minerals as a Potential Source of Bioavailable Iron and Magnetite**

Chung, Hyun Young., Jung, Jaewoo., Yang, Kiho., Kim, Jungwon. and Kim, Kitae.

Environmental Science & Technology. 2023. 57(48): 19805-19816.

doi: 10.1021/acs.est.3c06144.

Iron (Fe) is an essential micronutrient that affects biological production. Iron-containing clay minerals are an important source of bioavailable iron. However, the dissolution of iron-containing clay minerals at temperatures below the freezing point has not been investigated. Here, we demonstrate the enhanced reductive dissolution of iron from a clay mineral in ice in the presence of iodide (I^-) as the electron donor. The accelerated production of dissolved iron in the frozen state was irreversible, and the freeze concentration effect was considered the main driving force. Furthermore, the formation of magnetite (Fe_3O_4) after the freezing process was observed using transmission electron microscopy analysis. Our results suggest a new mechanism of accelerated abiotic reduction of Fe(III) in clay minerals, which may release bioavailable iron, Fe(II), and reactive iodine species into the natural environment. We also propose a novel process for magnetite formation in ice. The freezing process can serve as a source of bioavailable iron or act as a sink, leading to the formation of magnetite.

keywords:

ice chemistry; freeze concentration effect; iron source; clay minerals; magnetite formation

2-15 *Geosciences, Multidisciplinary***Geochemical implication of Eu isotopic ratio in anorthosite: new evidence of Eu isotope fractionation during feldspar crystallization**

Lee, Seung-Gu., Tanaka, Tsuyoshi. and Lee, Mi Jung.

Geosciences Journal. 2023. 27(3): 271-284.

doi: 10.1007/s12303-023-0009-6.

Rare earth element geochemistry (REE) can provide critical information on the evolution of the crust-mantle system. Europium (Eu) exists in divalent and trivalent states, and Eu^{2+} can substitute for Ca^{2+} during plagioclase feldspar crystallization in reducing magmas. This leads to positive Eu anomaly in Ca-plagioclase-rich anorthosite derived from the mantle and negative Eu anomalies in fractionated silica-rich crustal rocks. While many studies have addressed Eu anomalies in REE data, especially in igneous rocks, almost none have evaluated ratios of Eu's two stable isotopes (^{151}Eu and ^{153}Eu) alongside Eu anomalies. Here we report systematic variation of the Eu isotopic ratio ($\delta^{153}\text{Eu}$) from igneous rocks including anorthosite. This study detected a correlation between Eu anomalies and Eu isotopic ratios. Rhyolites and highly fractionated granites exhibited large negative Eu anomalies and negative $\delta^{153}\text{Eu}$ values while anorthosites exhibited large positive Eu anomalies and positive $\delta^{153}\text{Eu}$ values. In the case of the highly fractionated igneous rocks with negative Eu anomaly, the Eu isotope fractionation slope varied according to the degree of magmatic differentiation for both volcanic (extrusive) and plutonic (intrusive) rocks. Our finding reveals that Eu isotope fractionation in igneous rocks can provide new information related to magmatic differentiation and plagioclase feldspar crystallization including anorthosite formation.

keywords:

Eu isotope fractionation; Eu anomaly; magmatic differentiation; feldspar crystallization; anorthosite

2-16 Resources Engineering

Geophysical Evidence Indicating the Presence of Gas Hydrates in a Mud Volcano (MV420) in the Canadian Beaufort Sea

Choi, Yeonjin., Kim, Young-Gyun., Kang, Seung-Goo., Jin, Young Keun., Hong, Jong Kuk. and 2 others.

Geophysics and Geophysical Exploration. 2023. 26(1): 18-30.

doi: 10.7582/GGE.2023.26.1.018

Submarine mud volcanos are topographic features that resemble volcanoes, and are formed due to eruptions of fluidized or gasified sediment material. They have gained attention as a source of subsurface heat, sediment, or hydrocarbons supplied to the surface. In the continental slope of the Canadian Beaufort Sea, mud volcano exists at

various water depths. The MV420, is an active mud volcano erupting at a water depth of 420 meters, and it has been the subject of extensive study. The Korea Polar Research Institute(KOPRI) collected high-resolution seismic data and heat flow data around the caldera of the mud volcano. By analyzing the multi-channel seismic data, we confirmed the reverse-polarity reflector assumed by a gas hydrate-related bottom simulating reflector(BSR). To further elucidate the relationship between the BSR and gas hydrates, as well as the thermal structure of the mud volcano, a numerical geothermal model was developed based on the steady-state heat equation. Using this model, we estimated the base of the gas hydrate stability zone and found that the BSR depth estimated by multi-channel seismic data and the bottom of the gas hydrate stability zone were in good agreement. This suggests the presence of gas hydrates, and it was determined that the depth of the gas hydrate was likely up to 50 m, depending on the distance from the mud conduit. Thus, this depth estimate slightly differs from previous studies.

keywords:

Canadian Beaufort Sea; MV420 mud volcano; gas hydrate stability zone; bottom simulating reflector; heat flow measurement; thermal modeling

2-17 Astronomy & Astrophysics

Hydrogen Isotopic Composition of Hydrous Minerals in Asteroid Ryugu

Piani, Laurette., Nagashima, Kazuhide., Kawasaki, Noriyuki., Sakamoto, Naoya., Bajo, Ken-ichi., Abe, Yoshinari., Aleon, Jerome., Alexander, Conel M. O'D., Amari, Sachiko., Amelin, Yuri., Bizzarro, Martin., Bouvier, Audrey., Carlson, Richard W., Chaussidon, Marc., Choi, Byeon-Gak., Dauphas, Nicolas., Davis, Andrew M., Di Rocco, Tommaso., Fujiya, Wataru., Fukai, Ryota., Gautam, Ikshu., Haba, Makiko K., Hibiya, Yuki., Hidaka, Hiroshi., Homma, Hisashi., Hoppe, Peter., Huss, Gary R., Ichida, Kiyohiro., Iizuka, Tsuyoshi., Ireland, Trevor R., Ishikawa, Akira., Itoh, Shoichi., Kita, Noriko T., Kitajima, Kouki., Kleine, Thorsten., Komatani, Shintaro., Krot, Alexander N., Liu, Ming-Chang., Masuda, Yuki., McKeegan, Kevin D., Morita, Mayu., Motomura, Kazuko., Moynier, Frederic., Nakai, Izumi., Nguyen, Ann., Nittler, Larry., Onose, Morihiro., Pack, Andreas., Park, Changkun, and 39 others. *Astrophysical Journal Letters*. 2023. 946(2).

doi: 10.3847/2041-8213/acc393.

Rock fragments of the Cb-type asteroid Ryugu returned to Earth by the JAXA Hayabusa2 mission share mineralogical,

chemical, and isotopic properties with the Ivuna-type (CI) carbonaceous chondrites. Similar to CI chondrites, these fragments underwent extensive aqueous alteration and consist predominantly of hydrous minerals likely formed in the presence of liquid water on the Ryugu parent asteroid. Here we present an in situ analytical survey performed by secondary ion mass spectrometry from which we have estimated the D/H ratio of Ryugu's hydrous minerals, D/H_{Ryugu} , to be $[165 \pm 19] \times 10^{-6}$, which corresponds to $\delta D_{\text{Ryugu}} = +59 \pm 121\text{‰}$ (2σ). The hydrous mineral D/H_{Ryugu}'s values for the two sampling sites on Ryugu are similar; they are also similar to the estimated D/H ratio of hydrous minerals in the CI chondrites Orgueil and Alais. This result reinforces a link between Ryugu and CI chondrites and an inference that Ryugu's samples, which avoided terrestrial contamination, are our best proxy to estimate the composition of water at the origin of hydrous minerals in CI-like material. Based on this data and recent literature studies, the contribution of CI chondrites to the hydrogen of Earth's surficial reservoirs is evaluated to be ~3%. We conclude that the water responsible for the alteration of Ryugu's rocks was derived from water ice precursors inherited from the interstellar medium; the ice partially re-equilibrated its hydrogen with the nebular H₂ before being accreted on the Ryugu's parent asteroid.

2-18 Biochemistry & Molecular Biology; Biology

Interpreting fossilized nervous tissues

Aria, Cedric., Vannier, Jean., Park, Tae-Yoon S. and Gaines, Robert R. R. *Bioessays*. 2023. 45(3).
doi: 10.1002/bies.202200167.

Paleoneuroanatomy is an emerging subfield of paleontological research with great potential for the study of evolution. However, the interpretation of fossilized nervous tissues is a difficult task and presently lacks a rigorous methodology. We critically review here cases of neural tissue preservation reported in Cambrian arthropods, following a set of fundamental paleontological criteria for their recognition. These criteria are based on a variety of taphonomic parameters and account for morphoanatomical complexity. Application of these criteria shows that firm evidence for fossilized nervous tissues is less abundant and detailed than previously reported, and we synthesize here evidence that has stronger support. We argue that the vascular system, and in particular its lacunae, may be central to the understanding of many of the fossilized peri-intestinal features known across Cambrian arthropods. In conclusion,

our results suggest the need for caution in the interpretation of evidence for fossilized neural tissue, which will increase the accuracy of evolutionary scenarios.

keywords:

Arthropoda; Burgess Shale-type; Cambrian; Lagerstätten; morphoanatomy; paleoneuroanatomy; taphonomy

2-19 Geochemistry & Geophysics

Least-squares reverse time migration using the most energetic source wavefields based on excitation amplitude imaging condition

Kim, Sumin. and 2 others.

Geophysical Prospecting. 2023. 71(8): 1438-1454.

doi: 10.1111/1365-2478.13387.

Least-squares reverse time migration, a linearized inversion problem, can provide high-quality migration image by minimizing the misfit function, which is defined by predicted and observed data. According to the theory of data-domain least-squares reverse time migration, a forward source wavefield that is simulated with a fixed background velocity does not change during iterations. However, storing the forward source wavefield directly into computer memory involves substantial memory consumption. Although a source wavefield reconstruction technique can be applied during least-squares reverse time migration iterations, this approach can increase the computational cost because of the need for additional wavefield simulations. To alleviate this computational issue in storing the forward source wavefield, we propose an efficient least-squares reverse time migration scheme based on an excitation amplitude method. Unlike conventional excitation amplitude imaging conditions, the proposed least-squares reverse time migration scheme enables one to reconstruct the forward source wavefield by convolving a source wavelet with the excitation amplitude of Green's function at the excitation time. With this excitation amplitude method, the forward source wavefield can be efficiently stored in the computer memory because the sizes of the excitation amplitude and excitation time maps are equal to the size of one snapshot. To validate the feasibility of our least-squares reverse time migration scheme, we perform dot-product tests and compare forward source wavefields, demigrated data and gradient vectors obtained by conventional least-squares reverse time migration and our proposed least-squares reverse time migration. Using numerical tests on synthetic data, we confirm that our

least-squares reverse time migration can produce high-quality migration results with a significant improvement in computational efficiency with respect to performance time and memory consumption.

keywords:

imaging; inversion; computing aspects

2-20 *Geochemistry & Geophysics; Mineralogy; Mining & Mineral Processing*

Magmatic-Hydrothermal Fluid Processes of the Sn-W Granites in the Maniema Province of the Kibara Belt (KIB), Democratic Republic of Congo

Makutu, Douxoux Kumakele., Seo, Jung Hun., Lee, Insung., Oh, Jihye., **Kang, Pilmo.** and 2 others.

Minerals. 2023. 13(4).

doi: 10.3390/min13040458.

The Kibara belt (KIB) in the Maniema province hosts orebodies bearing cassiterite-wolframite, which are associated with equigranular to pegmatitic late Mesoproterozoic (1094–755 Ma) granites and Sn-W bearing quartz veins that cut through metasedimentary country rocks. Alteration assemblages of muscovite-quartz ($\pm$ topaz-fluorite-tourmaline) occur in the granites, and muscovite-sericite-quartz occurs in Sn-W quartz veins. Petrographic analyses, including cathodoluminescence (SEM-CL) on cassiterite grains, reveal two types of cassiterite: yellow transparent cassiterite (lighter under SEM-CL: type I) and dark translucent cassiterite (darker under SEM-CL: type II). These types are organized in micro-textures as oscillatory (growth) zones and replacement zones (type II replaces type I). Unlike cassiterite, wolframite is texturally homogenous. LA-ICP-MS results reveal that type II cassiterite is relatively enriched in Fe, Al, Ga, In, As, Pb, Zn, and U, whereas type I is enriched in V, Ti, Zr, Ta, Hf, and Nb. Contrasting Ce anomaly values in the cassiterite types suggest a transition of redox potentials during the Sn precipitation. Fluid inclusion assemblages (FIAs) in quartz, fluorite, and cassiterite are dominantly aqueous, liquid- or vapor-rich, and rarely carbonic-bearing aqueous inclusions. These often texturally coexist in a single “boiling” assemblage in granites. Raman spectroscopy on the bubble part of fluid inclusions in quartz and cassiterite shows various gas species, including CO₂, CH₄, N₂, and H₂. Boiling assemblages in the granites suggest that fluid phase separation occurred at about 380–610 bars, which is about 1–2 km (lithostatic) or 3–5 km (hydrostatic) in apparent

paleodepth. FIAs in the granites show ranges of salinities of 4–23 wt.% (NaCl equivalent) and homogenization temperatures (T_h) of 190–550 °C. FIAs hosted in cassiterite displayed distinctively lower and narrower ranges of salinities of 2–10 wt.% and T_h of 220–340 °C compared to the FIAs hosted in quartz in the granites (salinity of 4–23 wt.%, T_h of 190–550 °C) and the quartz veins (salinity of 1–23 wt.%, T_h of 130–350 °C). This suggests a less salinized and cooler fluid during the cassiterite precipitation. We suggest that magmatic-derived Sn-W bearing fluids be mixed with less saline and cooler aqueous fluids, possibly meteoric water, during the major cassiterite and possibly wolframite depositions in the KIB. This is based on (1) temperature and salinities, (2) hydrothermal alterations, (3) cassiterite micro-textures, and (4) trace element distributions.

keywords:

kibara belt; cassiterite; wolframite; ore micro-textures; CL; LA-ICP-MS; trace elements; fluid inclusions

2-21 *Geosciences, Multidisciplinary*

Middle Ordovician (middle Darriwilian) *Dirafinesquina* and *Jigunsania* gen. nov. (*Rafinesquinidae*; *Strophomenoidea*; *Brachiopoda*) from South Korea, with discussion of rafinesquinid evolution

Oh, Yeongju., Lee, Sangmin., **Park, Tae-Yoon S.** and Lee, Dong-Chan.

Geosciences Journal. 2023. 27(3): 253-270.

doi: 10.1007/s12303-022-0034-x.

Three rafinesquinid brachiopod (*Strophomenoidea*) species, *Dirafinesquina chosenensis*, *Jigunsania guraeriensis* gen. et sp. nov., and *Jigunsania hambaeksanensis* gen. et sp. nov. are described from the Middle Ordovician (middle Darriwilian) Jigunsan and Duwibong formations in the Taebaeksan Basin, South Korea of the Sino-Korean platform of North China. *Dirafinesquina chosenensis* is distinguished from the other two *Dirafinesquina* species, *D. globosa* and *D. antiqua* by having postero-lateral ridges parallel to socket ridges in the dorsal valve. *Jigunsania* gen. nov. is distinctive among the rafinesquinids in having strongly developed and posteriorly curved alae at cardinal extremities and characterized by having dorsal geniculation, prominent postero-lateral rugae, and subperipheral rim on the dorsal interior. Compared with the two rafinesquinid subfamilies (*Rafinesquininae* and *Leptaeninae*), *Jigunsania* bears typical rafinesquinine features such as bifid triangular cardinal

process lobes and straight socket ridges and is most similar to *Kjaerina*, whereas it has the subperipheral rim which is diagnostic to the leptenines but generally absent in the rafinesquines, and thus considered to be taxonomically significant in separating the two subfamilies. *Jigunsania* is tentatively assigned to the Rafinesquinae due to its great resemblance to *Kjaerina*. The spatio-temporal distribution of *Kjaerina* suggests that once originated from the middle Darriwilian *Jigunsania* in the low-latitude province in the late Darriwilian, it rapidly diversified into other regions including the high-latitude province during the Sandbian and Katian. The onset of diversification and paleobiogeographic expansion of *Kjaerina* appears to be late among the strophomenoids which first began to diversify during the Darriwilian at species and generic level. The leptenines, a predominantly post-Ordovician rafinesquinid group, is also considered to have been derived from *Jigunsania* and not undergone the Darriwilian diversification onset. In addition, the occurrence of *Diraefinesquina* suggests that the South Korean brachiopod fauna including orthides may be closely linked with the paleobiogeographically important *Saucrothis* Fauna recognized in South China, Alborz (northern Iran), and Sibumasu (Myanmar).

keywords:

Jigunsan Formation; Dirafinesquina; Jigunsania; Kjaerina; Taebaeksan Basin; Sino-Korean platform

2-22 Geochemistry & Geophysics

Mineralogical alteration of a type A CAI from Allende CV3 chondrite: Formation of secondary dmisteinbergite and its phase transition to anorthite

Enokido, Yuma., Nakamura, Tomoki., Matsumoto, Megumi., Miyake, Akira., Shibuya, Takazo., Park, Changkun. and Zolensky, Mike.

Meteoritics & Planetary Science. 2023. 58(3): 405-420.

doi: 10.1111/maps.13961.

Dmisteinbergite, a hexagonal form of $\text{CaAl}_2\text{Si}_2\text{O}_8$, was found in a compact type A Ca-Al-rich inclusion (CAI) in the Allende CV3 chondrite. Scanning and transmission electron microscopic observations show that dmisteinbergite was always in contact with grossular and grossular was in contact with melilite. In addition, there is a crystallographic relationship between dmisteinbergite and anorthite. Based on the textural and crystallographic evidence, the following mineralogical alteration processes are proposed

to have occurred in the CAI. (1) Melilite was replaced by grossular. High densities of vesicles in the grossular indicate that hydrogrossular might have been the primary alteration phase and dehydrated by later metamorphism. (2) Dmisteinbergite formed from (hydro)grossular through a reaction with Si-rich fluid. (3) Nano-sized minerals are formed within dmisteinbergite. (4) Dmisteinbergite was transformed to anorthite. (5) Both anorthite and dmisteinbergite were altered to nepheline. (6) Hydrogrossular was dehydrated to grossular. (Hydro)grossular, dmisteinbergite, anorthite, and nepheline in the CAI seem to have formed in the course of metasomatism that occurred in the Allende parent body. Except for the hydrogrossular dehydration, these reactions could have occurred at moderate temperature (200–250°C) in high pH fluids (pH 13–14) according to past experimental studies. Episodic changes in fluid composition seem to have occurred before reactions (2), (4), and (5), because these reactions were not completed before the next reaction started. Higher temperature is required for reactions (5) and (6) to occur. Our observation of the CAI suggests that it experienced multiple episodes of metasomatism as temperatures were rising in the Allende parent asteroid.

2-23 Multidisciplinary Sciences

Noble gases and nitrogen in samples of asteroid Ryugu record its volatile sources and recent surface evolution

Okazaki, Ryuji., Marty, Bernard., Busemann, Henner., Hashizume, Ko., Gilmour, Jamie D., Meshik, Alex., Yada, Toru., Kitajima, Fumio., Broadley, Michael W., Byrne, David., Fueri, Evelyn., Riebe, My E. I., Krietsch, Daniela., Maden, Colin., Ishida, Akizumi., Clay, Patricia., Crowther, Sarah A., Fawcett, Lydia., Lawton, Thomas., Pravdivtseva, Olga., Miura, Yayoi N., Park, Jisun., Bajo, Ken-ichi., Takano, Yoshinori., Yamada, Keita., Kawagucci, Shinsuke., Matsui, Yohei., Yamamoto, Mizuki., Richter, Kevin., Sakai, Saburo., Iwata, Naoyoshi., Shirai, Naoki., Sekimoto, Shun., Inagaki, Makoto., Ebihara, Mitsuru., Yokochi, Reika., Nishiizumi, Kunihiro., Nagao, Keisuke, Lee, Jong Ik, and 94 others.

Science. 2023. 379(6634): 788-U752.

doi: 10.1126/science.abo0431.

The near-Earth carbonaceous asteroid (162173) Ryugu is expected to contain volatile chemical species that could provide information on the origin of Earth's volatiles. Samples of Ryugu were retrieved by the Hayabusa2 spacecraft. We measured noble gas and nitrogen isotopes in Ryugu samples and found that they are dominated by presolar and primordial components, incorporated during Solar System

formation. Noble gas concentrations are higher than those in Ivuna-type carbonaceous (CI) chondrite meteorites. Several host phases of isotopically distinct nitrogen have different abundances among the samples. Our measurements support a close relationship between Ryugu and CI chondrites. Noble gases produced by galactic cosmic rays, indicating a ~5 million year exposure, and from implanted solar wind record the recent irradiation history of Ryugu after it migrated to its current orbit.

2-24 Geochemistry & Geophysics

Non-destructive elemental analysis of lunar meteorites using a negative muon beam

Chiu, I. Huan., Terada, Kentaro., Osawa, Takahito., **Park, Changkun.** and 3 others.

Meteoritics & Planetary Science. 2023. 58(9): 1333-1344.

doi: 10.1111/maps.14059.

We report the result of a non-destructive elemental analysis of lunar meteorites using a negative muon beam at J-PARC. An experimental system of six Ge semiconductor detectors and a newly designed He analysis chamber (to enable quantitative analysis of Al) was used to provide a high signal-to-noise ratio for the detection of major elements from lunar rocks (Mg, Si, Fe, O, Ca, and Al). We performed a Monte Carlo simulation to determine the chemical compositions at two sides and the center of a sample (at depths of 0.33 and 0.96 mm below the sample surface, respectively) of the lunar meteorite DEW 12007. These results indicate that the three interior regions of DEW 12007 are likely to be 55.8:44.2, 51.4:48.6, and 54.4:45.6 wt% mixtures of anorthositic and basaltic clasts, respectively. This study is the first quantitative analysis of a heterogeneous meteorite interior using a negative muon beam. As elemental analysis using a muon beam is non-destructive and highly sensitive to light elements, including C, N, and O, the protocols established in this study are applicable to initial characterization of returned samples from the South Pole of the Moon.

2-25 Geochemistry & Geophysics

Nucleosynthetic s-Process Depletion in Mo from Ryugu samples returned by Hayabusa2

Nakanishi, N., Yokoyama, T., Ishikawa, A., Walker, R. J., Abe, Y., Aleon, J., Alexander, C. M. O'D., Amari, S., Amelin, Y., Bajo, K. I., Bizzarro, M., Bouvier, A., Carlson, R. W., Chaussidon, M., Choi, B. G., Dauphas, N., Davis, A. M., Di Rocco, T., Fujiya, W., Fukai, R., Gautam, I., Haba, M. K., Hibiya, Y., Hidaka, H., Homma, H., Hoppe, P., Huss, G. R., Ichida, K., Iizuka, T., Ireland, T. R., Itoh, S., Kawasaki, N., Kita, N. T., Kitajima, K., Kleine, T., Komatani, S., Krot, A. N., Liu, M. C., Masuda, Y., Morita, M., Motomura, K., Moynier, F., Nakai, I., Nagashima, K., Nguyen, A., Nittler, L., Onose, M., Pack, A., **Park, Changkun.** and 40 others.

Geochemical Perspectives Letters. 2023. 28: 31-36.

doi: 10.7185/geochemlet.2341.

Initial analyses of samples collected from two locations on the asteroid Ryugu indicated that the mineralogical, chemical, and isotopic characteristics of the Ryugu samples show similarities to carbonaceous chondrites, particularly the Ivuna-type (CI) group. In this study, we analysed a composite sample of four bulk Ryugu samples (A0106, A0106-A0107, C0107, and C0108) collected from both sampling locations that were combined in order to determine its mass independent Mo isotopic composition and reveal contributions from diverse nucleosynthetic sources. The $\epsilon^{94}\text{Mo}$ and $\epsilon^{95}\text{Mo}$ values for the Ryugu sample are characterised by the carbonaceous chondrite (CC)-type, which is consistent with the nucleosynthetic isotope compositions observed for other elements (Cr, Ti, Fe, and Zn). The Ryugu composite sample, however, is characterised by greater s-process depletion of Mo isotopes compared with any known bulk carbonaceous chondrite, even including CI chondrites. The observed Mo isotopic signature in the Ryugu composite was most likely caused by either incomplete digestion of s-process-rich presolar SiC, or biased sampling of materials enriched in aqueously-formed secondary minerals characterised by s-process-poor Mo isotopes, resulting from the physicochemical separation between s-process-rich presolar grains and a complementary s-process-poor aqueous fluid in the Ryugu parent body.

2-26 Geology

Paleoenvironmental reconstruction of glaciomarine sediments in the Drygalski Basin of the western Ross Sea since the Last Glacial Maximum

Ha, Sangbeom., Lee, Jae Il., Bak, Young-Suk., Yoo, Kyu-Cheul. and Khim, Boo-Keun.

Sedimentary Geology. 2023. 456.

doi: 10.1016/j.sedgeo.2023.106495.

The repeated growth and reduction of the ice sheet have controlled the striking variation of the continental shelf environment in the Ross Sea. Particularly, glaciomarine shelf sedimentation is closely related to the ice sheet dynamics and ice shelf development since the Last Glacial Maximum (LGM). Using the four gravity (and box) cores obtained from the northern Drygalski Basin in the western Ross Sea, multi-proxies including sediment properties, geochemical proxies, carbon isotopic values of organic matter, clay mineral compositions of fine-grained sediments, and diatom assemblage were analyzed with AMS ^{14}C dating from bulk organic matters. Based on the core description, X-radiograph observation, and results of grain size distribution, the core sediments were classified into the seven sediment facies: clast-rich muddy diamicton, clast-rich sandy diamicton, massive mud, laminated mud, bioturbated mud, massive sandy mud, and bioturbated sandy mud. The association of these sediment facies defines the four lithologic units in terms of the depositional evolution. Lithologic unit 1 represents diamicton deposited proximal to the grounding line. When the ice sheet and ice shelf retreated since the LGM, the unsorted sediment mass was deposited proximal to the grounding line. Lithologic unit 2 consists of the massive mud deposited under the sub-ice shelf condition. During the ice sheet retreat, the fine-grained particles were transported by the meltwater plume to the subice shelf floor. The biogenic materials were also transported from the seasonal open marine area to the sub-ice shelf by the currents. Lithologic unit 3 was composed of sandy mud and mud with abundant dropstones that might have been deposited at the calving line. As the calving line passed the Drygalski Basin, a large amount of the coarse fractions was deposited due to ice shelf breakup. The terrestrial sediments from the Victoria Land coast were transported from the grounding line of the remained local ice sheet, when the calving line passed the north side of Drygalski Ice Tongue. Lithologic unit 4 comprises the bioturbated mud and sandy mud that were deposited under the seasonal open marine condition. The biological productivity increased significantly during the late Holocene, while the terrestrial sedimentation decreased under seasonal open marine conditions. The diatom assemblage and $\delta^{13}\text{C}$ values of sediment organic matter indicate the mid-Holocene warm climate with more sea ice melting. Since the LGM, the paleoenvironmental change and glaciomarine depositional evolution on the northern Drygalski Basin were closely linked with the ice sheet dynamics and ice shelf activity, in addition to the climate change during the Holocene.

keywords:

Continental shelf sediments; Ice sheet; Ice shelf; Grounding line; Calving line; Drygalski Basin; Ross Sea

Provenance analysis of the Cretaceous Gyeongsang Basin, SE Korea: A synthesis and tectonic implications for active continental margin in East Asia

Lee, Yong Il., Lee, Jae Il. and Choi, Yong Seok.

Earth-Science Reviews. 2023. 238.

doi: 10.1016/j.earscirev.2023.104334.

In the middle to late Mesozoic period, the Korean Peninsula was in an active continental margin with an accretionary complex developed in the direction of trench to the southeast. The Cretaceous Gyeongsang Basin is the largest nonmarine basin distributed in the southeastern part of the Korean Peninsula and is generally considered to be a transtensional or an extensional basin formed by the oblique subduction of the Paleo-Pacific (Izanagi) Plate or Izanagi slab rollback. The pre-volcanic sedimentary succession of the Gyeongsang Basin is subdivided into the Sindong and Hayang groups as the age decreases and this sedimentary succession is unconformably overlain by the Yucheon Group, which consists of intermediate to felsic volcanic rocks with minor volcanoclastic sediments and forms a volcanic arc (the Gyeongsang Arc). Because the Gyeongsang Basin was geographically developed behind the Japanese Arc during the Cretaceous period, and the Gyeongsang Arc was considered an extension of the Japanese Arc, the Gyeongsang Basin was considered a backarc basin, although sedimentation in the basin occurred before the development of the Japanese Arc and Gyeongsang Arc. Here, we reinterpret the tectonic setting and basin formation mechanism in the pre-volcanic stage of the Gyeongsang Basin by synthesizing the results of provenance studies on the Sindong and Hayang groups. The sediments were derived from western and northwestern sources (the Yeongnam Massif), which currently do not contain records of Early Cretaceous arc magmatism. The modal and geochemical compositions of these sediments and detrital zircon U–Pb ages suggest that the sediments were derived from arc-related crystalline basement rocks of the Yeongnam Massif with a record of Early Cretaceous (143–100 Ma) arc magmatism. We propose that the pre-volcanic stage of the Gyeongsang Basin was a forearc basin formed between the Yeongnam Massif (then arc) and the Jurassic accretionary complex on the seaside and that the basin may have been formed by extensional stresses related to the subduction of an oceanic plateau during the Early Cretaceous.

keywords:

The Korean Peninsula; Cretaceous; The Gyeongsang Basin;

Active continental margin; Provenance; Tectonic setting; Izanagi Plate

2-28 *Geosciences, Multidisciplinary*

Reappraisal of the Neoproterozoic to middle Paleozoic fossils of North Korea and its tectonic implication

Oh, Yeongju., Jung, Jikhan., Lee, Mirinae., Jeon, Juwan., Lee, Seung-Bae. and Park, Tae-Yoon S.

Geosciences Journal. 2023. 27(6): 661-687.

doi: 10.1007/s12303-023-0029-2.

The tectonic affinity of the Korean Peninsula in reference to the Permo-Triassic collision of the Sino-Korean Craton (SKC) and the South China Craton (SCC) has been in the center of debates over the last three decades. Since the Imjingang Belt that runs through the middle part of the Korean Peninsula is thought to represent the major tectonic boundary, most part of North Korea, including the "Pyeongnam Basin" in the southern part, has been regarded as part of the SKC. However, differences in stratigraphy and the fossil occurrence have been recognized by local geologists between the southern part of "the Pyeongnam Basin" (SPB) and the northern part of the "Pyeongnam Basin" (NPB), and which have hardly been considered for the paleogeographical affinity of the regions so far. Here we provide a comprehensive review on 1,072 fossil taxa from the Neoproterozoic to middle Paleozoic sedimentary successions of North Korea, and utilize the data for determining tectonic affinity of the regions. Especially, Cambrian trilobite genera from the SPB and NPB have been quantitatively compared with those of North China (the SKC) and the SCC, using similarity indices, the non-metric multidimensional scaling (NMDS), and PerMANOVA test. The results have revealed that the SPB is tied to the SCC, not to North China (the SKC), whereas the NPB is closely related to North China. The SCC affinity of the SPB is corroborated by stratigraphical features, such as the presence of the Precambrian-Cambrian boundary and the middle Paleozoic strata, which are largely absent in the SKC. Our results demonstrate that the SPB region likely originated from the SCC, and thus further suggest that the collisional boundary of supracrustal rocks between the SKC and the SCC in the Korean Peninsula corresponds to the boundary of the NPB and the SPB. Accordingly, the extent of the newly-defined Pyeongnam Basin is restricted to the traditional NPB region. The SPB region is included in the extent of the newly-proposed Hwanghae District,

which is bounded to the east with the Imjingang Belt by the Ryesonggang Fault. The South China Craton-originated rocks of the Hwanghae District and the Imjingang Belt are collectively termed the South China-affinity terrane (SAT).

keywords:

North Korea; Pyeongnam Basin; Cambrian trilobites; Hwanghae District; South China-affinity terrane (SAT)

2-29 *Multidisciplinary Sciences*

Samples returned from the asteroid Ryugu are similar to Ivuna-type carbonaceous meteorites

Yokoyama, Tetsuya., Nagashima, Kazuhide., Nakai, Izumi., Young, Edward D., Abe, Yoshinari., Aleon, Jerome., Alexander, Conel M. O'D., Amari, Sachiko., Amelin, Yuri., Bajo, Ken-ichi., Bizzarro, Martin., Bouvier, Audrey., Carlson, Richard W., Chaussidon, Marc., Choi, Byeon-Gak., Dauphas, Nicolas., Davis, Andrew M., Di Rocco, Tommaso., Fujiya, Wataru., Fukai, Ryota., Gautam, Ikshu., Haba, Makiko K., Hibiya, Yuki., Hidaka, Hiroshi., Homma, Hisashi., Hoppe, Peter., Huss, Gary R., Ichida, Kiyohiro., Iizuka, Tsuyoshi., Ireland, Trevor R., Ishikawa, Akira., Ito, Motoo., Itoh, Shoichi., Kawasaki, Noriyuki., Kita, Noriko T., Kitajima, Kouki., Kleine, Thorsten., Komatani, Shintaro., Krot, Alexander N., Liu, Ming-Chang., Masuda, Yuki., McKeegan, Kevin D., Morita, Mayu., Motomura, Kazuko., Moynier, Frederic., Nguyen, Ann., Nittler, Larry., Onose, Morihiko., Pack, Andreas., Park, Changkun. and 99 others.

Science. 2023. 379(6634): 786-+.

doi: 10.1126/science.abn7850.

Carbonaceous meteorites are thought to be fragments of C-type (carbonaceous) asteroids. Samples of the C-type asteroid (162173) Ryugu were retrieved by the Hayabusa2 spacecraft. We measured the mineralogy and bulk chemical and isotopic compositions of Ryugu samples. The samples are mainly composed of materials similar to those of carbonaceous chondrite meteorites, particularly the CI (Ivuna-type) group. The samples consist predominantly of minerals formed in aqueous fluid on a parent planetesimal. The primary minerals were altered by fluids at a temperature of $37^{\circ} \pm 10^{\circ}\text{C}$, about $5.2^{+0.8}_{-0.7}$ million (statistical) or $5.2^{+1.6}_{-2.1}$ million (systematic) years after the formation of the first solids in the Solar System. After aqueous alteration, the Ryugu samples were likely never heated above $\sim 100^{\circ}\text{C}$. The samples have a chemical composition that more closely resembles that of the Sun's photosphere than other natural samples do.

2-30 *Geology*

Silicification of trilobites and biofilm from the Cambrian Weeks Formation, Utah: Evidence for microbial mediation of silicification: COMMENT

Oh, Yeongju., Choe, Yong-Hoe., Peel, John S., Zhen, Yong Yi., Smith, Patrick. and Park, Tae-Yoon S.

Geology. 2023. 51(9): E566-E566.

doi: 10.1130/g51428c.1.

Melim et al. (2023) presented potential evidence for the microbial mediation of silicification, citing examples such as “carbon-rich threads, ribbons, and strings.” They interpreted the carbon-rich materials covering the trilobite sclerites and the matrix as a silicified biofilm, suggesting this was the first direct evidence of microbial-mediated silicification. While we agree that biofilms could play a significant role in silicification, we recommend reevaluating some of the evidence for the “silicified biofilm” presented by Melim et al.

suggesting that the proportion of manganate phases with a tunnel structure decreases with nodule growth. In addition, the distinct Raman bands at ~ 280 and 403 cm^{-1} indicated that the triclinic birnessite is prevalent in the outer regions of the nodule. Semi-quantitative measurement of the intensity of diagnostic Raman bands for todorokite (I_{733}) allows us to effectively observe the spatial distribution of manganese oxide minerals in the ferromanganese nodule. At the center of the nodule, I_{733} was ~ 0.7 . Despite a few fluctuations, I_{733} clearly decreased from ~ 0.7 to ~ 0.2 with increasing D from 0 to $7500\text{ }\mu\text{m}$, indicating that the relative fraction of todorokite in nodules significantly decreases with nodule growth. This study highlights that a highly resolved spatial distribution of manganate mineral phases in ferromanganese nodules can provide a historical record of the formation process and geochemical conditions.

keywords:

Ferromanganese nodule; Raman spectroscopy; Manganese oxide minerals; Todorokite; Birnessite

2-31 *Geochemistry & Geophysics*

Spatial distribution of manganese oxide minerals in the natural ferromanganese nodule of the Arctic Sea: A view from Raman spectroscopy

Kim, Hyo-Im., Cho, Hyen Goo., Lee, Sangmi., Koo, Hyo Jin., Hong, Jong Kuk. and Jin, Young Keun.

Chemical Geology. 2023. 623.

doi: 10.1016/j.chemgeo.2023.121398.

Knowledge of the spatial distribution of manganese oxide minerals in the natural ferromanganese nodules provides improved prospects for understanding the geochemical processes involved in nodule formation. In this study, we report a series of micro-laser Raman spectra along with a line profile from the center to the rim of a spherical ferromanganese nodule from the East Siberian Sea in the Arctic region. For the Raman spectra obtained at the center of the nodule, the characteristic Raman bands for todorokite at ~ 733 , ~ 508 , and $\sim 240\text{ cm}^{-1}$ were clearly observed, suggesting that the todorokite is predominant in the central part of the nodule. As the data acquisition point moved away from the center to the rim (D), the Raman bands corresponding to the todorokite decreased, while the intensity of the 588 cm^{-1} band corresponding to the layered manganate minerals (i.e., birnessite) increased,

2-32 *Geosciences, Multidisciplinary*

Spreading rate, opening time, and kinematic history of the Ayu Trough

Choi, Hakkyum., Kim, Seung-Sep., Park, Sung-Hyun. and Lee, Sang-Mook.

Geosciences Journal. 2023. 27(5): 553-561.

doi: 10.1007/s12303-023-0021-x.

The Ayu Trough, located in the equatorial western Pacific, is the only divergent boundary surrounding the Philippine Sea Plate. A mid-ocean ridge spreading in the N-S direction near low-latitude regions presents low geomagnetic anomalies, thereby complicating the constraining of the trough's spreading rate based on the geomagnetic signal from the magnetized seafloor. According to previous studies, the Ayu Trough has been open since ~ 25 Ma, with a half-spreading rate of $4.1\text{--}8.1\text{ mm/yr}$. This implies that the trough belongs to the ultraslow-spreading mid-ocean ridge category with a full-spreading rate below 20 mm/yr . However, the geochemical signatures of the rock samples from the Ayu Trough do not exhibit the unique characteristics of ultraslow-spreading ridges, including the enriched mid-ocean ridge basalts (E-MORB) with high rare earth element (REE) concentrations and abundant light rare earth elements (LREE). Rather, the sampled rocks from the entire trough-axis exhibit the typical features of

the normal mid-ocean ridge basalts (N-MORB) with low REE concentrations. The contradictory inferences made from geochemical results suggest that the Ayu Trough did not undergo an ultraslow-spreading but rather a considerably rapid spreading over a short period compared to the estimates made by previous studies. The modified interpretation for the spreading rate of the Ayu Trough can be associated with the global plate reconstruction model, considering the major plate reorganization in East Asia. Around 15 Ma, a series of significant tectonic events occurred in East Asia and the western Pacific. The global models for East Asia imply that the spreading of the Ayu Trough could have been initiated afterwards. Based on our geochemical analysis of the MORB on the Ayu Trough and the global plate model, we argue that the spreading of the Ayu Trough was initiated after ~15 Ma during the major plate reorganization in East Asia, and not in ~25 Ma as reported by previous studies. Therefore, the spreading occurred only for a period of about 10 Myr at a relatively rapid full-spreading rate of >20 mm/yr. The massive sediments with a thickness of approximately 50–70 m on the spreading-axis of the Ayu Trough reinforce the estimated cessation time of the trough. In addition, the V-shaped seafloor of the Ayu Trough and the unclear transform fault may be interpreted as topography formed by a propagation of rift or mantle melting. Therefore, the trough does not have to be simultaneously opened throughout the axis, and its spreading rate could be higher than previously estimated.

keywords:

Ayu Trough; Philippine Sea Plate; spreading rate; sedimentation rate; mid-ocean ridge basalts; rare earth elements; global plate reconstruction

continental intraplate alkaline magmas undergo early sulfide saturation. However, there is a lack of evidence linking erupted magmas to their cumulative counterparts. We examined the petrography and chalcophile and platinum group element (PGE) geochemistry of sodic and potassic differentiation lineage lavas and cumulate autoliths from The Pleiades, an intraplate alkaline volcanic field in northern Victoria Land, Antarctica. The presence of sulfide minerals and depleted PGE contents in mafic lavas show they were saturated in sulfide from the initial stages of magma differentiation. The sodic lineage lavas and their kaersutite gabbro autoliths have abundant sulfides associated with fractionation of titanomagnetite and kaersutite. Their presence is consistent with the chalcophile element geochemistry of the lavas. In the potassic lineage lavas, petrography of autoliths indicates that the sulfides are more abundant in kaersutite diorite than wehrlite, olivine essexite, olivine diorite, and syenite autoliths. Kaersutite is not a phenocryst phase in the potassic lineage but crystallized via in situ replacement of the precursor olivine and augite. During the kaersutite formation, sulfides were precipitated from the interstitial silicate melt. The melt was sulfide oversaturated due to temperature decrease, and compositional variations (mainly SiO_2 , ΣFeO , $\text{Fe}^{3+}/\Sigma\text{Fe}$ ratio). The mantle-like isotope compositions of Cu, Zn, and S in the potassic lineage confirms a magmatic origin of the sulfides. The magmatic sulfides from The Pleiades are characterized by depleted PGE, Au and Cu contents. Fractional crystallization models show that early sulfide saturation led to impoverishment of chalcophile metals in The Pleiades magmatic system. This phenomenon may be common in continental intraplate alkaline magmas ascending through thick crusts.

keywords:

Continental alkaline magmatism; The Pleiades Volcanic Field; Autoliths; Crystal mush; Sulfides; Platinum group elements

2-33 *Geochemistry & Geophysics; Mineralogy*

Sulfide minerals and chalcophile elements in The Pleiades Volcanic Field, Antarctica: implications for the distribution of chalcophile metals in continental intraplate alkaline magma systems

Kim, Jihyuk., **Lee, Mi Jung.**, **Lee, Jong Ik.**, and 4 others.
Contributions to Mineralogy and Petrology. 2023. 178(10).
 doi: 10.1007/s00410-023-02048-2.

Fractionation of sulfides during ascent of mantle-derived magmas distributes sulfur and chalcophile elements into the Earth's lithosphere. It has been suggested that

2-34 *Astronomy & Astrophysics*

The Magnesium Isotope Composition of Samples Returned from Asteroid Ryugu

Bizzarro, Martin., Schiller, Martin., Yokoyama, Tetsuya., Abe, Yoshinari., Aleon, Jerome., Alexander, Conel M., Amari, Sachiko., Amelin, Yuri., Bajo, Ken-ichi., Bouvier, Audrey., Carlson, Richard W., Chaussidon, Marc., Choi, Byeon-Gak., Dauphas, Nicolas., Davis, Andrew M., Di Rocco, Tommaso., Fujiya, Wataru., Fukai, Ryota., Gautam, Ikshu., Haba, Makiko K., Hibiya, Yuki., Hidaka, Hiroshi., Homma, Hisashi., Hoppe, Peter., Huss, Gary R., Ichida, Kiyohiro., Iizuka, Tsuyoshi., Ireland,

Trevor R., Ishikawa, Akira., Itoh, Shoichi., Kawasaki, Noriyuki., Kita, Noriko T., Kitajima, Kouki., Kleine, Thorsten., Komatani, Shintaro., Krot, Alexander N., Liu, Ming-Chang., Masuda, Yuki., Morita, Mayu., Moynier, Frederic., Motomura, Kazuko., Nakai, Izumi., Nagashima, Kazuhide., Nesvorny, David., Nguyen, Ann., Nittler, Larry., Onose, Morigihiko., Pack, Andreas., **Park, Changkun**, and 41 others.

Astrophysical Journal Letters. 2023. 958(2).

doi: 10.3847/2041-8213/ad09d9.

The nucleosynthetic isotope composition of planetary materials provides a record of the heterogeneous distribution of stardust within the early solar system. In 2020 December, the Japan Aerospace Exploration Agency Hayabusa2 spacecraft returned to Earth the first samples of a primitive asteroid, namely, the Cb-type asteroid Ryugu. This provides a unique opportunity to explore the kinship between primitive asteroids and carbonaceous chondrites. We report high-precision $\mu^{26}\text{Mg}^*$ and $\mu^{25}\text{Mg}$ values of Ryugu samples together with those of CI, CM, CV, and ungrouped carbonaceous chondrites. The stable Mg isotope composition of Ryugu aliquots defines $\mu^{25}\text{Mg}$ values ranging from -160 ± 20 ppm to -272 ± 30 ppm, which extends to lighter compositions relative to Ivuna-type (CI) and other carbonaceous chondrite groups. We interpret the $\mu^{25}\text{Mg}$ variability as reflecting heterogeneous sampling of a carbonate phase hosting isotopically light Mg ($\mu^{25}\text{Mg} \sim -1400$ ppm) formed by low temperature equilibrium processes. After correcting for this effect, Ryugu samples return homogeneous $\mu^{26}\text{Mg}^*$ values corresponding to a weighted mean of 7.1 ± 0.8 ppm. Thus, Ryugu defines a $\mu^{26}\text{Mg}^*$ excess relative to the CI and CR chondrite reservoirs corresponding to 3.8 ± 1.1 and 11.9 ± 0.8 ppm, respectively. These variations cannot be accounted for by in situ decay of ^{26}Al given their respective $^{27}\text{Al}/^{24}\text{Mg}$ ratios. Instead, it requires that Ryugu and the CI and CR parent bodies formed from material with a different initial $^{26}\text{Al}/^{27}\text{Al}$ ratio or that they are sourced from material with distinct Mg isotope compositions. Thus, our new Mg isotope data challenge the notion that Ryugu and CI chondrites share a common nucleosynthetic heritage.

Understanding subduction processes is critical in assessing the long-term evolution of the upper mantle and continental crust. We present new geochemical data on glassy submarine lavas from the Bransfield Strait, the Phoenix and West Scotia ridges, and previously unpublished data of marine sediments from atop the Phoenix Plate. We combined new and published geochemical data from across the northern sector of the Antarctic Peninsula to unravel both large-scale mantle composition and flow across the region. The geochemistry of Phoenix and West Scotia Ridge basalts supports the hypothesis that both ridges are underlain by Pacific MORB mantle, brought into the region through the eastward expansion of the Scotia Plate. Comparisons among lavas from the Phoenix/West Scotia ridges, the South Shetland Islands volcanic arc, and the Bransfield Strait/Prince Gustav Rift back-arc region reveal that the Pacific upper mantle flowed into the mantle wedge and was subsequently modified by subduction processes. The compositions of Bransfield Strait lavas range from strongly subduction-influenced near the strait's center to akin to Phoenix Ridge MORB toward the strait's edges. This suggests that the Phoenix MORB mantle has flowed around the slab edges into the mantle wedge, diluting the subduction signal and focusing the subduction-modified mantle towards the center of the strait. Monte Carlo simulations indicate that mixing of Phoenix MORB mantle with 0 to 3% subduction component having a fluid/sediment ratio of ~ 1 can explain the compositional range in the Bransfield Strait. Furthermore, our modeling suggests the presence of a more depleted Phoenix MORB mantle beneath the South Shetland Islands modified by the addition of $\sim 3\%$ subduction component with a fluid/sediment ratio ranging from ~ 0.18 to 4. The increase in fluid/sediment ratios in the South Shetland Island lavas corresponds to a spatiotemporal progression of volcanism from the southwest (40–140 Ma) to the northeast (30–60 Ma). Finally, we have identified a set of lavas with unique trace element and isotope compositions typical of alkaline volcanism found across other parts of the Antarctic Peninsula. Surprisingly, we find occurrences of these lavas on both sides of the South Shetland Trench, suggesting the presence of a distinct enriched source in the upper mantle throughout the region.

2-35 Geochemistry & Geophysics

Tracing mantle components and the effect of subduction processes beneath the northern Antarctic Peninsula

Anderson, D. W., Saal, A. E., **Lee, Jae Il.** and 4 others.
Geochimica Et Cosmochimica Acta. 2023. 343: 234-249.
doi: 10.1016/j.gca.2022.11.018.

keywords:

Bransfield Strait; Phoenix Ridge; Subduction; Back-arc basin; Geochemistry

2-36 Entomology

Trilobite hypostome as a fusion of anterior sclerite and labrum

Park, Tae-Yoon S.

Arthropod Structure & Development. 2023. 77.

doi: 10.1016/j.asd.2023.101308.

The trilobite hypostome is a biomineralized ventral plate that covers the mouth, but its evolutionary origin remains controversial. The labrum is a lobe-like structure that can take on variety of shapes in front of the mouth in arthropods, while the anterior sclerite refers to a cuticular plate articulated to the anterior margin of the head in some Cambrian arthropods. Here I present a perspective that views the trilobite hypostome as a fusion of the anterior sclerite and the labrum based on anatomical, topological, and developmental evidence. According to this perspective, the anterior lobe of the hypostome originated from the anterior sclerite, while the posterior lobe reflects a remnant of the sclerotized cover of the labrum. The convex anterior lobe housed the root of the eye stalks, represented by the palpebral ridges and the hypostomal wing, and the posterior lobe occasionally developed a pair of posterolateral extensions, as do the labra. The position of the antennal insertion was located in front of the posterior lobe, displaying a similar topology to the Cambrian arthropods with the labrum. The hypostome was present in many arthropods except for the *Concilliterga*, in which the anterior sclerite was separate from the labrum.

keywords:

Trilobites; Hypostome; Anterior sclerite; Labrum

zircon crystallized from metamorphic fluid under high-pressure (P) conditions rather than captured as xenocrysts from the host eclogites, on the basis of: (1) weak oscillatory- and fine tree-zoned cathodoluminescence textures and extremely low Th/U ratios of zircon, (2) highly steep patterns of heavy rare earth elements and weak negative to positive Eu anomaly of zircons, suggesting their growth not in equilibrium with garnet and plagioclase, respectively; and (3) the high celadonite contents of phengite megacrysts (up to 3.33 a.p.f.u. Si for O = 11). Zircon U-Pb ages dated the high-P quartz vein formation at 501 ± 7 Ma (2 σ), which overlaps with time of peak metamorphism of the eclogites at c. 500–498 Ma. The zircon crystallization age and marginal breakdown of phengite megacrysts into biotite–oligoclase symplectites suggest that the high-P quartz vein formation was at near-peak to early-exhumation stages of the eclogite facies metamorphism. The similarity in depths of the vein formation and major dehydration of subducting metamafic rocks further suggests that this fluid activity would be one of possible agents responsible for arc-related magmatism in northern Victoria Land of the Ross orogen.

keywords:

megacrystic phengite; quartz vein; U-Pb zircon age; REE composition; Ross orogen

2-37 Geochemistry & Geophysics

U-Pb ages and REE compositions of zircon in megacrystic phengite-bearing quartz vein from the Lanterman Range, northern Victoria Land, Antarctica

Kim, Taehwan. and Lee, Mi Jung.

Geochemical Journal. 2023. 57(1): 1-12.

doi: 10.2343/geochemj.GJ23001.

Megacrystic phengite-bearing quartz veins associated with retrogressed eclogites occur along terrane boundary zone in the northern Ross orogen, Antarctica. The vein

2-38 Multidisciplinary Sciences

Water circulation in Ryugu asteroid affected the distribution of nucleosynthetic isotope anomalies in returned sample

Yokoyama, Tetsuya., Wadhwa, Meenakshi., Iizuka, Tsuyoshi., Rai, Vinai., Gautam, Ikshu., Hibiya, Yuki., Masuda, Yuki., Haba, Makiko K., Fukai, Ryota., Hines, Rebekah., Phelan, Nicole., Abe, Yoshinari., Aleon, Jerome., Alexander, Conel M. O'D., Amari, Sachiko., Amelin, Yuri., Bajo, Ken-ichi., Bizzarro, Martin., Bouvier, Audrey., Carlson, Richard W., Chaussidon, Marc., Choi, Byeon-Gak., Dauphas, Nicolas., Davis, Andrew M., Di Rocco, Tommaso., Fujiya, Wataru., Hidaka, Hiroshi., Homma, Hisashi., Hoppe, Peter., Huss, Gary R., Ichida, Kiyohiro., Ireland, Trevor., Ishikawa, Akira., Itoh, Shoichi., Kawasaki, Noriyuki., Kita, Noriko T., Kitajima, Koki., Kleine, Thorsten., Komatani, Shintaro., Krot, Alexander N., Liu, Ming-Chang., McKeegan, Kevin D., Morita, Mayu., Motomura, Kazuko., Moynier, Frederic., Nakai, Izumi., Nagashima, Kazuhide., Nguyen, Ann., Nittler, Larry., Onose, Morihiko., Pack, Andreas., Park, Changkun, and 40 others.

Science Advances. 2023. 9(45).

doi: 10.1126/sciadv.adi7048.

Studies of material returned from Cb asteroid Ryugu have revealed considerable mineralogical and chemical heterogeneity, stemming primarily from brecciation and aqueous alteration. Isotopic anomalies could have also been affected by delivery of exogenous clasts and aqueous mobilization of soluble elements. Here, we show that isotopic anomalies for mildly soluble Cr are highly variable in Ryugu and CI chondrites, whereas those of Ti are relatively uniform. This variation in Cr isotope ratios is most likely due to physicochemical fractionation between ^{54}Cr -rich presolar nanoparticles and Cr-bearing secondary minerals at the millimeter-scale in the bulk samples, likely due to extensive aqueous alteration in their parent bodies that occurred $5.2^{+1.8}_{-1.4}$ Ma after Solar System birth. In contrast, Ti isotopes were marginally affected by this process. Our results show that isotopic heterogeneities in asteroids are not all nebular or accretionary in nature but can also reflect element redistribution by water.

Part 3.

Marine Sciences

3-1 *Engineering, Aerospace; Engineering, Electrical & Electronic; Telecommunications*

A Monostatic Forward-Looking Staring Spotlight SAR Raw Data Generation and Hybrid-Domain Image Formation Modifications Based on Extended Azimuth Nonlinear Chirp Scaling Autofocusing

Shahrezaei, Iman Heidarpour. and Kim, Hyun-Cheol.
Ieee Transactions on Aerospace and Electronic Systems. 2023. 59(3):
 2329-2358.
 doi: 10.1109/taes.2022.3212993.

Forward-looking staring spotlight synthetic aperture radar (FSS-SAR) offers operational advantages over conventional squinted SAR counterparts. However, due to its complex observation configuration, pixel anomalies occur when processing raw data. For instance, in the forward-looking geometry, symmetrically distributed point scatterers along the flight path have the same Doppler history, resulting in azimuth ambiguities, whereas staring observation narrows and skews the two-dimensional received spectrum, reducing signal orthogonality and causing spectral folding. As a result, not only is the Doppler frequency gradient too small to be precisely measured in the FSS-SAR mode, limiting the ability to achieve high azimuth angular resolution, but it also suffers from azimuth ambiguities when forming an image. To overcome such azimuth-variant characteristics known as inherent resolution anomalies, a hybrid-domain image formation algorithm (IFA) based on azimuth scaling is modified here. As an approach, radiometric bias correction techniques in conjunction with an extended azimuth nonlinear chirp scaling (ANCS) algorithm capable of equalizing range space variance in the azimuth direction, which benefits from an embedded autofocusing step, have been designed for raw data processing. Given the fact that the platform experiences trajectory deviations under a real-flight condition compared to an ideal trajectory, a preprocessing motion compensation step based on Kalman

filtering is included within the IFA. The entire proposed IFA solution tackled the inherent resolution anomalies of FSS-SAR and succeeded in reconstructing the focused image without azimuthal anomalies. To further assess the IFA, a modified Cartesian back-projection algorithm was developed along with other objective evaluation scenarios, all of which confirm that the proposed hybrid-domain extended ANCS algorithm is valid for the FSS-SAR application.

keywords:

Azimuth; Geometry; Trajectory; Synthetic aperture radar; Doppler effect; Image reconstruction; Spatial resolution

3-2 *Environmental Sciences; Public, Environmental & Occupational Health*

A regional-scale approach for modeling primary production and biogenic silica export in the Southern Ocean

Kwon, Young Shin., La, Hyoung Sul., Kang, Hyoun-Woo. and Park, Jisoo.
Environmental Research. 2023. 217.
 doi: 10.1016/j.envres.2022.114811.

Persistent uncertainties in the representations of net primary production (NPP) and silicate in the Southern Ocean have been noted in recent assessments of the ocean biogeochemical components of Earth system models (ESMs). Consequently, more mechanistic studies at the regional scale are required. To reduce these uncertainties, we applied a one-dimensional (1D) marine ecosystem model to different bioregions in the Southern Ocean: the Polar Frontal Zone in the Pacific sector, the seasonal sea ice zone in the northwestern Ross Sea, and the inner shelf of Terra Nova Bay. To make the existing ecosystem model applicable to the Southern Ocean, we modified the phytoplankton physiology (stoichiometry depending on species) and the silicate cycle (dissolution rate of biogenic silica (BSi) depending on latitude) in the model. We quantified and compared seasonal variations in several limitation factors of NPP, namely, iron, irradiance, silicate and temperature, in the three regions. The simulation results showed that dissolved iron plays the most significant role in determining the magnitude of NPP and the phytoplankton community structure during summer. Additionally, the modified model successfully reproduced the vertical flux of BSi and particulate organic carbon (POC). The POC export efficiency was high in the inner shelf zone, which had high levels of iron concentration, NPP, and *Phaeocystis*

biomass. In contrast, BSi export occurred most efficiently in the Polar Frontal Zone, where diatoms are dominant, the BSi dissolution rate is low, and NPP is extremely low. Our results from the integrated mechanistic framework at the regional scale demonstrate which specific processes should be urgently included in ESMs for better representation of the biogeochemical dynamics in the Southern Ocean.

keywords:

Marine ecosystem model; Southern ocean; Polar front; Polynya; Ross sea; Primary production; Vertical export

3-3 *Environmental Sciences; Marine & Freshwater Biology*

Acidity in rainwater and airborne suspended particles in the southwestern coast of the East Sea (Sea of Japan): Their potential impact on seawater total alkalinity

Park, Geun-Ha., Park, Seunghee., Seok, Min-Woo., Lee, Seon-Eun., Kim, Young-Il., **Mo, Ahra**, and 3 others.

Marine Pollution Bulletin. 2023. 197.

doi: 10.1016/j.marpolbul.2023.115742.

Our understanding of the impact of atmospheric acid deposition on marine carbonate system remains limited, largely due to a lack of data regarding acidity present in atmospheric particles and precipitation. Previous research has relied on the electroneutrality-based ion balance method for indirect estimation of atmospheric acidity. In this study, atmospheric samples collected at a coastal site of South Korea were mixed with seawater to measure the change in seawater total alkalinity (ΔTA_{APL}) associated with atmospheric proton loading. For the precipitation samples, the measured ΔTA_{APL} and electroneutrality-based estimates showed a significant correlation. However, we did not observe similar results for the atmospheric particle samples. Furthermore, the decrease in oceanic TA due to ΔTA_{APL} was substantially smaller than that in dissolved inorganic carbon from concurrent nitrogen fertilization. Consequently, the adverse impact of acid deposition on ocean acidification or air-sea exchange of CO_2 appears to be insignificant on a short-term scale.

keywords:

Atmospheric acid deposition; Atmospheric proton loading; East Asian marginal sea; Total alkalinity; Total suspended particle; Acid rain

3-4 *Multidisciplinary Sciences*

Arctic Ocean sediments as important current and future sinks for marine microplastics missing in the global microplastic budget

Kim, Seung-Kyu., Kim, Ji-Su., Kim, So-Young., Song, Nan-Seon., **La, Hyoung Sul**, and **Yang, Eun Jin**.

Science Advances. 2023. 9(27).

doi: 10.1126/sciadv.add2348.

To better understand unexpectedly low plastic loads at the ocean's surface compared with inputs, unidentified sinks must be located. Here, we present the microplastic (MP) budget for multi-compartments in the western Arctic Ocean (WAO) and demonstrate that Arctic sediments serve as important current and future sinks for MPs missing from the global budget. We identified an increase of 3% year⁻¹ in MP deposition from sediment core observations. Relatively elevated MP abundances were found in seawater and surface sediments around the summer sea ice retreat region, implying enhanced MP accumulation and deposition facilitated by the ice barrier. We estimate $15.7 \pm 2.30 \times 10^{16}$ N and 0.21 ± 0.14 MT as total MP loads in the WAO with 90% (by mass) buried in the post-1930 sediments, which exceeds the global average of the current marine MP load. The slower increase in plastic burial versus production implies a lag in plastic delivery to the Arctic, indicating more pollution in the future.

3-5 *Environmental Sciences; Marine & Freshwater Biology*

Assessment of austral autumn air-sea CO_2 exchange in the Pacific sector of the Southern Ocean and dominant controlling factors

Mo, Ahra, **Park, Keyhong**, **Park, Jisoo**., Hahm, Doshik., **Kim, Kitae**., Ko, Young Ho., Iriarte, Jose Luis., **Choi, Jung-Ok** and Kim, Tae-Wook.

Frontiers in Marine Science. 2023. 10.

doi: 10.3389/fmars.2023.1192959.

The factors that control the partial pressure of carbon dioxide (pCO_2) in the Pacific sector of the Southern Ocean were investigated in April 2018, onboard the icebreaker, ARAON. The mean ($\pm 1\sigma$) of the sea surface pCO_2 was estimated to be 431 ± 6 μ atm in the north of the Ross Sea (NRS), 403 ± 18 μ atm in the Amundsen-Bellinghousen Sea (ABS), and 426 ± 16 μ atm in the western Antarctic Peninsula and Weddell Sea (WAP/WS). The controlling

factors for $p\text{CO}_2$ in the NRS appeared to be meridionally different based on the southern boundary of the Antarctic Circumpolar Current (SB; $\sim 62.5^\circ\text{S}$ in the Ross Sea). The sea surface $p\text{CO}_2$ exhibited a strong correlation with salinity and the difference between the O_2/Ar ($\Delta\text{O}_2/\text{Ar}$) values of the sample and air-saturated water in the north and south of the SB, respectively. The $p\text{CO}_2$ in the ABS and western WAP/WS displayed a strong correlation with salinity. Furthermore, $\Delta\text{O}_2/\text{Ar}$ and sea ice formation appear to be the dominant factors that control $p\text{CO}_2$ in the Confluence Zone (CZ) and northern parts of WAP/WS. The estimated air–sea CO_2 fluxes (positive and negative values indicate the source and sink for atmospheric CO_2 , respectively) range from 3.1 to 18.8 $\text{mmol m}^{-2} \text{d}^{-1}$ in the NRS, -12.7 to $17.3 \text{ mmol m}^{-2} \text{d}^{-1}$ in the ABS, and -59.4 to $140.8 \text{ mmol m}^{-2} \text{d}^{-1}$ in the WAP/WS. In addition, biology-driven large variations in the air–sea CO_2 flux were observed in the CZ. Our results are the most recent observation data acquired in austral autumn in the Southern Ocean.

keywords:

Southern Ocean; surface CO_2 partial pressure ($p\text{CO}_{2\text{(a)}}$); carbon cycle; air–sea CO_2 flux; western Antarctic Peninsula

3-6 Multidisciplinary Sciences

Atlantic-origin water extension into the Pacific Arctic induced an anomalous biogeochemical event

Nishino, Shigeto., Jung, Jinyoung., Cho, Kyoung-Ho., Williams, William J., Fujiwara, Amane., Murata, Akihiko., Itoh, Motoyo., Watanabe, Eiji., Aoyama, Michio., Yamamoto-Kawai, Michiyo., Kikuchi, Takashi., Yang, Eun Jin. and Kang, Sung-Ho.

Nature Communications. 2023. 14(1).

doi: 10.1038/s41467-023-41960-w.

The Arctic Ocean is facing dramatic environmental and ecosystem changes. In this context, an international multiship survey project was undertaken in 2020 to obtain current baseline data. During the survey, unusually low dissolved oxygen and acidified water were found in a high-seas fishable area of the western (Pacific-side) Arctic Ocean. Herein, we show that the Beaufort Gyre shrinks to the east of an ocean ridge and forms a front between the water within the gyre and the water from the eastern (Atlantic-side) Arctic. That phenomenon triggers a frontal northward flow along the ocean ridge. This flow likely transports the low oxygen and acidified water toward the high-seas fishable

area; similar biogeochemical properties had previously been observed only on the shelf-slope north of the East Siberian Sea. The authors show that the appearance of anomalously low oxygen and acidified water on the Chukchi Plateau, a high-seas fishable area of the western Arctic Ocean, is associated with a change in basin-scale ocean circulation related to the recent sea ice loss.

3-7 Geochemistry & Geophysics

Biogeochemistry of iron in coastal Antarctica: isotopic insights for external sources and biological uptake in the Amundsen Sea polynyas

Tian, Hung-An., van Manen, Mathijs., Bunnell, Zach B., Jung, Jinyoung., Lee, Sang Hoon., Kim, Tae-Wan. and 3 others.

Geochimica Et Cosmochimica Acta. 2023. 363: 51-67.

doi: 10.1016/j.gca.2023.10.029.

Seasonal phytoplankton blooms in the Antarctic Amundsen Sea Polynyas are thought to be supported by an external supply of iron (Fe) from circumpolar deep waters, benthic sediments, and/or ice shelf meltwaters. However, largely due to the limited amount of Fe data reported for the Amundsen Sea Polynyas, understanding of the sources and processes that affect the biogeochemistry of Fe in this region (notably within the ice shelf system) remains limited. Here, we present the first investigation of dissolved Fe isotope distributions ($\delta^{56}\text{Fe}$) along the conveyor belt of waters into and through the Amundsen Sea, via the Dotson Ice Shelf, from samples collected during austral summer (2017–2018). Our dataset allows us to characterize and compare the dissolved $\delta^{56}\text{Fe}$ signatures of incoming modified Circumpolar Deep Water (mCDW) and of sedimentary sources on the continental shelf. The range in dissolved $\delta^{56}\text{Fe}$ (-1 to $+0.1 \text{ ‰}$) observed in the Amundsen Sea close to the seafloor, coupled with elevated dissolved Fe concentrations (up to 1.6 nmol/L), suggests that Fe is released from shelf sediments via a combination of reductive and non-reductive processes, with non-reductive dissolution input being relatively more important (20–56 %) than reductive dissolution (4–12 %). Near the Dotson Ice Shelf, the $\delta^{56}\text{Fe}$ in the mCDW inflow (-0.70 ‰) was lower than the mCDW outflow (-0.23 ‰), whereas any change in dissolved Fe concentrations was negligible. We speculate that this shift in dissolved $\delta^{56}\text{Fe}$ underneath the ice shelf is driven by a combination of enhanced preservation (and addition) of lithogenic colloidal Fe(III) and/or complexation with Fe-binding ligands, together

with a differential loss of Fe^{2+} . We also found distinct $\delta^{56}\text{Fe}$ signatures in surface waters of the polynya, with apparent preferential uptake of isotopically light Fe in a bloom dominated by diatoms leading to a relatively heavy remnant dissolved $\delta^{56}\text{Fe}$ signature of +1.06 ‰, compared to a bloom dominated by haptophytes where more modest and variable isotope fractionation was observed. The different isotopic composition between the two regions could be related to the dominance of different species, but this remains speculative. Despite prominent biological uptake, we suggest that other factors such as rapid recycling (e.g., adsorption and regeneration), bacterial regeneration, and complexation with organic ligands, together with the supply of lithogenic particles also play important roles in setting surface dissolved $\delta^{56}\text{Fe}$ in the Amundsen Sea Polynyas. Overall, this study provides a further understanding of the external Fe sources and the biogeochemical processes in the Amundsen Sea and thus a baseline on how changing conditions in Antarctica can affect Fe cycling in the Southern Ocean and beyond.

keywords:

GEOTRACES; Trace metals; Isotopic compositions; Biogeochemistry

3-8 *Geosciences, Multidisciplinary; Marine & Freshwater Biology; Oceanography*

Bio-optical properties of algal communities in Antarctic pack ice during spring

Dalman, Laura A., Schallenberg, Christina., Fraser, Alexander D., Bestley, Sophie., **Yang, Eun Jin.** And 2 others.
Journal of Marine Systems. 2023. 240.
 doi: 10.1016/j.jmarsys.2023.103890.

Microalgae use Antarctic sea ice as habitat and accumulate in spring, leading to significant early-season production in Southern Ocean ecosystems. As key contributors to the marine food web and carbon fixation within the Antarctic pack-ice zone, ice algae depend on the light environment and their adaptability to irradiance extremes. This study examines spectral ice algal and non-algal particulate absorption coefficients, pigments, and community composition in pack-ice cores sampled off East Antarctica and in the Weddell Sea during the winterspring transitions in 2012 and 2013, respectively. Our results show that ice algae dominated particulate absorption in pack ice in both regions. From high- to low-light exposure in both

East Antarctica and Weddell Sea, biomass-specific absorption decreased, suggesting strong pigment packaging with depth towards the ice-water interface. Ice algae also showed increased production of photoprotective pigments in the surface in comparison to the bottom of the sea ice, with flagellates being more dominant in the surface ice sections. Our results indicate species-specific light-acclimation and photoprotection through the ice profiles, and highlight the role of light conditions in influencing pigment production and shifts in community composition.

keywords:

Ice algae; Pigments; Photoprotection; Light absorption; Sea ice; Community composition

3-9 *Environmental Sciences; Marine & Freshwater Biology*

Bridging the gap for ice-ocean-ecosystem processes: integrated observing system for the Ross Sea-far East Antarctic Region

Heil, Petra, Stevens, Craig, **Lee, Won Sang,** Eayrs, Clare, **Shin, Hyoung Chul.** and 2 others.
Frontiers in Marine Science. 2023. 10.
 doi: 10.3389/fmars.2023.1206119.

Our understanding of cross-disciplinary connections for Antarctica's role in the Earth system remains incomplete, especially around its coastal margins. The focus here is on sea-ice, oceanic, and atmospheric drivers in the joint Ross Sea-far East Antarctic Region (RSfEAR)—one which spans a large longitudinal range and connects a number of ice shelves and polynyas promoting sea-ice growth and underpinning a diverse and rich ecosystem. Here, we present a minireview of recent case studies and how these inform the design for a future integrated ocean-sea ice-atmosphere observing system. The review is built around five themes: i) regional setting, ii) recent studies in the region and current strategies, iii) gap analysis, iv) future observing system design, and v) wider implications for stakeholders.

keywords:

Antarctic Earth-system science; Ross Sea-far East Antarctic Region; cross-disciplinary observing system; sea ice; hydrography; biogeochemistry; atmosphere; coastal processes

3-10 Environmental Sciences; Marine & Freshwater Biology

Characterization and source of fluorescent dissolved organic matter in the Western Arctic Ocean: new insights from the 2019 summer study

Jeon, Mi Hae., Jung, Jinyoung., Park, Mi Ok., Cho, Kyoung-Ho., Lee, Youngju., Yang, Eun Jin. and Kang, Sung-Ho.

Frontiers in Marine Science. 2023. 10.

doi: 10.3389/fmars.2023.1199893.

Increase in river discharge and seasonal primary production and decline in sea ice coverage in the Arctic Ocean in summer can significantly affect the distribution and composition of dissolved organic matter (DOM). This study aimed to enhance the current available knowledge about the impacts of environmental changes on the characteristics of DOM in the rapidly changing Arctic Ocean. Seawater samples were collected from the western Arctic Ocean during the summer of 2019 and analyzed for fluorescent DOM (FDOM), dissolved organic carbon (DOC), and stable oxygen isotope ($\delta^{18}\text{O}$) content in conjunction with biophysical properties. We identified two humic-like (C1 and C2) and one protein-like (C3) components using fluorescence excitation-emission matrix coupled with parallel factor (EEM-PARAFAC) analysis. Remarkably high intensities of humic-like FDOM were found in the upper halocline layer ($32 < \text{salinity} < 33.5$ psu, at depths between 50–200 m) with high inorganic nutrient concentrations and low N^* values, indicating that the humic-like FDOM was supplied from the shelf sediment. Furthermore, shoaling of the upper halocline layer brought high levels of humic-like FDOM to the euphotic zone, resulting in an increased probability of photodegradation of humic-like FDOM due to exposure to solar radiation in the surface layer. Tryptophan-like FDOM was positively correlated with river water fraction (f_{river}) and riverine DOC but not with chlorophyll-*a* (Chl-*a*) and heterotrophic bacterial abundance, indicating river discharge as a potential additional source of tryptophan-like FDOM. The correlation coefficients between tryptophan-like FDOM and river water parameters (f_{river} and riverine DOC) differed across the Chukchi Sea, Chukchi Borderland, and East Siberian Sea, implying that the influence of river discharge on tryptophan-like FDOM is region-dependent. An increase in river discharge in future might lead to a greater supply of tryptophan-like FDOM, impacting the dynamics of DOM cycling in the western Arctic Ocean.

keywords:

fluorescent dissolved organic matter; shelf sediment shoaling; river discharge; Western Arctic Ocean

3-11 Environmental Sciences; Marine & Freshwater Biology

Distinct vertical behavior of key Arctic copepods following the midnight sun period in the East Siberian continental margin region, Arctic Ocean

Son, Wuju., Kim, Jee-Hoon., Yang, Eun Jin. and La, Hyoung Sul.

Frontiers in Marine Science. 2023. 10.

doi: 10.3389/fmars.2023.1137045.

Diel vertical migration (DVM) of zooplankton plays a vital role in biological carbon pump and food web interactions. However, there is considerable debate about the DVM of zooplankton in response to environmental changes in the Arctic Ocean. We investigated DVM behavior in the key Arctic copepods *Calanus glacialis*, *Calanus hyperboreus*, and *Metridia longa* following the midnight sun period in the East Siberian continental margin region. The two *Calanus* species showed non-DVM behaviors, whereas *M. longa* showed a typical DVM pattern consistent with the solar radiation cycle. Additionally, these species showed different vertical distributions. *Calanus glacialis* was distributed at depths above 20 m in the warm fresh water, where the highest density gradient was observed. *Calanus hyperboreus* was distributed at depths between 30 and 55 m in the cold salty water, where a high contribution of micro phytoplankton and the subsurface chlorophyll maximum (SCM) layer were observed. *M. longa* was found across a broader range of temperature and salinity than both *Calanus* species, and it was distributed in the upper water column, where the SCM layer was observed at night and at depths between 100 and 135 m in the daytime. These results imply that *M. longa* can be well adapted to the changing Arctic Ocean environment, where sea ice loss and ocean warming are ongoing, whereas *C. hyperboreus* can be the most vulnerable to these changes. These findings provide important information for understanding variations in the vertical distributions of key copepod species in the rapidly changing Arctic marine environment.

keywords:

copepod; diel vertical migration; East Siberian Sea; Arctic Ocean; midnight sun

3-12 *Environmental Sciences; Marine & Freshwater Biology***Distributions and potential sources of polychlorinated biphenyls and polycyclic aromatic hydrocarbons in the glacimarine sediments of Arctic Svalbard**

Lee, Juhee., Kim, Youngnam., Cha, Jihyun., **Kim, Dahae., Jang, Kwangchul.,** Kim, Jung-Hyun., **Nam, Seung-II.** and Hong, Seongjin.
Marine Pollution Bulletin. 2023. 189.
 doi: 10.1016/j.marpolbul.2023.114740.

Distribution and sources of polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) in the glacimarine sediments (35 sites) of Svalbard were investigated. PCBs (32 congeners), traditional PAHs (15 homologs), emerging PAHs (11 homologs), and alkylated PAHs (16 homologs) were widely distributed in the Svalbard sediments (ranges: below method detection limit to 20, 21 to 3600, 1.0 to 1400, and 31 to 15,000 ng g⁻¹ dry weight, respectively). Compositional analysis indicated that PCBs mainly originated from combustion sources, with PAHs being strongly influenced by local sources. Positive matrix factorization analysis showed that PAHs were associated with vehicle and petroleum combustion, coal, and coal combustion. Coal-derived PAHs contributed significantly to the sediments of Van Mijenfjorden. Remnants of coal mining activity trapped in the permafrost appear to enter the coastal environments as ground ice melts. Consequently, PAHs are currently emerging as the most significant contributors to potential risks in the Svalbard ecosystems.

keywords:

Persistent toxic substances; Arctic Svalbard.; Mining activity; Alkyl-PAHs; Sediment

3-13 *Engineering, Marine; Engineering, Civil; Engineering, Ocean; Oceanography***Dominant factors responsible for wave modulation in the macro-tidal Gyeonggi Bay of the Yellow Sea**

Kim, Ki-Hwan., **Kim, Myung-Seok.,** Lee, Hye Min., Kim, Myung Hwan. and Woo, Seung-Buhm.
Ocean Engineering. 2023. 287.
 doi: 10.1016/j.oceaneng.2023.114875.

Surface gravity waves, crucial for sediment transport

in coastal regions, undergo wave modulation owing to local hydrodynamic conditions. However, the cause of the spatial and temporal distribution of the dominant factors in wave modulation remains vague. This study was aimed at identifying the causes of tidal modulation of waves in Gyeonggi Bay, which exhibits shallow water and macro-tidal environment, and estimating site-specific dominant factors using numerical modeling. The results indicated that tides significantly impact wave dynamics at semi-diurnal tidal frequencies, with spatiotemporal variability. The most dominant factor in wave modulation in the nearshore region is the depth change caused by tides, and the most notable impact was found in tidal flats. Depth dependence is mainly evident in surf zones, with a clear distinction at locations where the wave height to water depth ratio reaches 0.2. While idealized studies highlight the significant role of wind in governing incoming waves, it is not the primary cause of modulation. Nevertheless, stronger tidal strength can lead to more pronounced modulation, which is further amplified when accompanied by strong wind conditions. This finding indicates that the spatiotemporal distribution of wave modulation in macro-tidal regions may have a significant impact on various estuarine dynamics including sediment transport.

keywords:

Macro-tidal environment; Tidal modulation; Wave dissipation; Dominant factor; Numerical modeling; Tidal flat

3-14 *Chemistry, Analytical; Engineering, Electrical & Electronic; Instruments & Instrumentation***Frequency-Domain Reverse-Time Migration with Analytic Green's Function for the Seismic Imaging of Shallow Water Column Structures in the Arctic Ocean**

Kang, Seung-Goo. and Jang, U. Geun.
Sensors. 2023. 23(14).
 doi: 10.3390/s23146622.

Seismic oceanography can provide a two- or three-dimensional view of the water column thermocline structure at a vertical and horizontal resolution from the multi-channel seismic dataset. Several seismic imaging methods and techniques for seismic oceanography have been presented in previous research. In this study, we suggest a new formulation of the frequency-domain reverse-time migration method for seismic oceanography based on the

analytic Green's function. For imaging thermocline structures in the water column from the seismic data, our proposed seismic reverse-time migration method uses the analytic Green's function for numerically calculating the forward- and backward-modeled wavefield rather than the wave propagation modeling in the conventional algorithm. The frequency-domain reverse-time migration with analytic Green's function does not require significant computational memory, resources, or a multifrontal direct solver to calculate the migration seismic images as like conventional reverse-time migration. The analytic Green's function in our reverse-time method makes it possible to provide a high-resolution seismic water column image with a meter-scale grid size, consisting of full-band frequency components for a modest cost and in a low-memory environment for computation. Our method was applied to multi-channel seismic data acquired in the Arctic Ocean and successfully constructed water column seismic images containing the oceanographic reflections caused by thermocline structures of the water mass. From the numerical test, we note that the oceanographic reflections of the migrated seismic images reflected the distribution of Arctic waters in a shallow depth and showed good correspondence with the anomalies of measured temperatures and calculated reflection coefficients from each XCDT profile. Our proposed method has been verified for field data application and accuracy of imaging performance.

keywords:

analytical Green's function; frequency-domain reverse-time migration; full-band frequency seismic imaging; seismic oceanographic imaging; thermocline structures in the shallow water column in the Arctic Ocean

3-15 *Environmental Sciences; Meteorology & Atmospheric Sciences*

FTIR autecological analysis of bottom-ice diatom taxa across a tidal strait in the Canadian Arctic

Pogorzelec, Nicole M., Gough, Kathleen M., Ha, Sun-Yong. and 5 others.

Elementa-Science of the Anthropocene. 2022. 10(1).

doi: 10.1525/elementa.2021.00094.

A recent study demonstrated that an Arctic tidal strait, where a shoaled and constricted waterway increases tidally driven sub-ice currents and turbulence, represents

a "hotspot" for ice algal production due to a hypothesized enhanced ocean-ice nutrient supply. Based on these findings, we sampled the bottom-ice algal community across the same tidal strait between the Finlayson Islands within Dease Strait, Nunavut, Canada, in spring 2017. Our objective was to examine cellular responses of sea-ice diatoms to two expected nutrient supply gradients in their natural environment: (1) a horizontal gradient across the tidal strait and (2) a vertical gradient in the bottom-ice matrix. Two diatom taxa, *Nitzschia frigida* and *Attheya* spp. in bottom-ice sections (0–2, 2–5, and 5–10 cm) under thin snow cover (<5 cm), were selected for Fourier Transform Infrared (FTIR) spectrochemical analysis for lipid and protein content. Results from the FTIR technique strongly supported the existence of a horizontal nutrient gradient across the tidal strait of the Finlayson Islands, while estimates of particulate organic carbon and chlorophyll *a* concentrations were difficult to interpret. The larger *N. frigida* cells appeared to be more sensitive to the suspected horizontal nutrient gradient, significantly increasing in lipid content relative to protein beyond the tidal strait. In contrast, the epiphytic diatoms, *Attheya* spp., were more sensitive to the vertical gradient: above 2 cm in the bottom-ice matrix, the non-motile cells appeared to be trapped with a depleted nutrient inventory and evidence of a post-bloom state. Application of the FTIR technique to estimate biomolecular composition of algal cells provided new insights on the response of the bottom-ice algal community to the examined spatial gradients that could not be obtained from conventional bulk measurements alone. Future studies of sea ice and associated environments are thus encouraged to employ this technique.

keywords:

FTIR spectroscopy; Biomolecular composition; Ice algae; Nutrient concentrations; Diatom; Arctic

3-16 *Environmental Sciences; Marine & Freshwater Biology*

Glacial-interglacial changes in oceanic conditions and depositional process in the continental rise in response to ice sheet (shelf) variation in Bellingshausen Sea, Antarctica

Kim, Sunghan., Bak, Young-Suk., Prebble, Joseph G., Kang, Myung-II., Kim, Sookwan., Park, Jinku., Lee, Min Kyung., Lee, Jae II., Yoo, Kyu-Cheul and Moon, Heung Soo.

Frontiers in Marine Science. 2023. 10.

doi: 10.3389/fmars.2023.1183516.

Antarctic continental margin sediments are eroded from the shelf and transported to the slope/rise in association with changing ice sheet configuration. Understanding the dynamics of this transport pathway is important for utilizing distal deep-sea sedimentary archives to determine past changes in the Antarctic ice sheet. However, these connections are poorly understood. Here we present multi-proxy records of two sediment cores (BS17-GC01 and BS17-GC02) from the Bellingshausen Sea continental rise, to explore relationships between depositional regime and ice sheet dynamics. Two cores show depositional/sedimentological variations on glacial-interglacial scales. Biogenic sediments were deposited during MIS 1, 5, and 7 under open ocean conditions. Glacial to deglacial sediments were laminated as a result of varying intensity of bottom currents. Terrestrially derived sediments are inferred to be transported from shelf both as grounded ice advanced during glacial expansion, and as ice retreated during deglacial periods. Sediment color shifted to brown after deglacial periods with high Mn/Ti and occurrence of bioturbation, indicating increasing bottom water oxygenation in the study area. Since surface water production started to increase from deglacial periods, we infer increased bottom water oxygenation in this setting is due to ventilation (i.e., Antarctic Bottom Water (AABW) formation), implying that AABW formation was increased during interglacial periods from deglacial period whereas was decreased during glacial periods. Thus, sedimentary/depositional changes in BS17-GC01 and BS17-GC02 are closely linked to ice sheet dynamics during the late Quaternary.

keywords:

Bellingshausen Sea; surface diatom production; contourite; lamination; ice sheet variation

3-17 *Geography, Physical; Geosciences, Multidisciplinary; Paleontology*

Glacial-interglacial environmental changes in the Drake Passage over the past 600 kyrs

Kim, Sunghan., Lee, Jae Il., Yoo, Kyu-Cheul., Lee, Min Kyung., Bak, Young-Suk, Kang, Myung-II, Kim, Sookwan and Park, Jinku. *Palaeogeography Palaeoclimatology Palaeoecology*. 2023. 631. doi: 10.1016/j.palaeo.2023.111835.

Oceanographic conditions in the Southern Ocean are closely related to the oceanic frontal system. Glacial-interglacial changes in cryosphere influence variations in

oceanic fronts in the Southern Ocean and vice versa, causing changes in surface water productivity, nutrient utilization, bottom water chemistry, and/or bottom current intensity. Here, we documented geochemical, nitrogen isotope, and grain size records over the last 600 kyrs from the Drake Passage with previously published data to compare between glacial and interglacial oceanic conditions from surface to bottom. Biogenic opal (diatom) and export productions were high during interglacial periods and low during glacial periods. Surface water production was dominated by open ocean species during both glacial and interglacial periods without a clear glacial-interglacial change in sea ice species. After Marine Isotope Stage (MIS) 9, interglacial biogenic opal and diatom abundance increased distinctively with decreased terrestrial influence. Nutrient utilization increased (decreased) during interglacial (glacial) periods with increased (decreased) surface water production, particularly after MIS 9. This indicates that surface water production was regulated by light availability in association with sea ice duration/extent. According to good correlation between sortable silt mean grain size (SS MGS) and %sortable silt, SS MGS can be used for bottom current intensity indicator in this study; increased (decreased) bottom current during glacial (interglacial) periods. Increased glacial bottom current is likely related to southwestward flowing bottom current. Interglacial bottom current intensity became also significantly weakened after MIS 9. However, outstanding interglacial warmth in the Drake Passage occurred from MIS 9, not following the global trend to occur after MIS 11. This implies that more studies from the Southern Ocean in response to the Mid-Brunhes Event are required in the future.

keywords:

Drake Passage; Surface water production; Nutrient utilization; Bottom current; Marine Isotope Stage 9; Warmer interglacial

3-18 *Oceanography*

Holocene Palaeoenvironmental and Palaeoproductivity Changes in the Western Amundsen Sea Embayment of Antarctica

Kim, Minkyung., Lee, Jae Il., Bak, Young-Suk., Hillenbrand, Claus-Dieter., Yang, Eun Jin., and 4 others. *Journal of Geophysical Research-Oceans*. 2023. 128(6). doi: 10.1029/2023jc019797.

The Amundsen Polynya (AP) on the inner and middle continental shelf of the western Amundsen Sea Embayment

is the fourth largest coastal polynya around Antarctica. The AP is highly productive when it opens in austral summer, with ~20 times greater organic carbon accumulation rates over the last few thousand years compared to those at nearby shelf sites with more persistent seasonal sea-ice cover. We examined sedimentary records at a site from the AP and another site from the outer shelf to investigate temporal variations in the depositional environment with a special focus on the timing of the AP opening since the deglaciation following the Last Glacial Maximum (LGM; ca. 23–19 cal. ka BP). In the AP region, sedimentological and biogeochemical proxy data reveal a transition from a sub-glacial to a sub-ice shelf and then seasonally open marine conditions comparable to those at present. Total organic carbon contents and diatom valve abundances during the seasonally open marine period imply that the polynya environments was reached at ca. 9.2 cal. ka BP. Since the post-LGM deglaciation, diatom productivity and assemblages in the AP region appear to have varied in association with the variation in the physical environment. Compared to the AP site, only small amounts of organic carbon accumulated on the outer shelf. Differences in the depositional environments and productivity modes between the inner and outer shelf sites have persisted since ca. 10.5 cal. ka BP.

3-19 *Geosciences, Multidisciplinary*

Ice Shelf Water Structure Beneath the Larsen C Ice Shelf in Antarctica

Na, Ji Sung., Davis, Peter E. D., Kim, Byeong-Hoon., Jin, Emilia Kyung. and Lee, Won Sang.

Geophysical Research Letters. 2023. 50(19).

doi: 10.1029/2023gl104088.

Understanding ice shelf water (ISW) structure is crucial for studying the basal melting of ice shelves. In this study, we performed large-eddy simulation experiments to assess ISW structure and basal melt patterns under different current velocity scenarios observed in the Larsen C ice shelf, Antarctica. The LES results revealed that the thickness of ISW is primarily determined by the meridional velocity (perpendicular to the grounding line), while the zonal velocity influences the potential temperature and salinity of ISW. We found that a key parameter determining the basal melt rate was northward meltwater advection which originates from variances in meltwater generation. This advection, in turn, leads to the tilted isopycnals and the potential for thermohaline interleaving in a diffusive

convection regime. The different slopes of isopycnals induce distinct heat fluxes, resulting in different basal melt rates far from and near the grounding line (~0.44 and 1.59 m yr⁻¹, respectively).

keywords:

ice shelf water; meltwater; melt rate; interleaving layer; large eddy simulation; turbulence

3-20 *Environmental Sciences; Marine & Freshwater Biology*

Importance of nanophytoplankton biomass during summer 2019 in a retreating marine-terminating glacier-fjord system, Marian Cove, West Antarctica (62°S)

Jeon, Misa., Iriarte, Jose Luis., Yang, Eun Jin., Park, Jisoo., Alves-de-Souza, Catharina and Park, Sang Jong.

Frontiers in Marine Science. 2023. 10.

doi: 10.3389/fmars.2023.1174722.

The biogeochemical dynamics of fjords around Antarctica are strongly influenced by cryospheric, climatic, and oceanographic processes that occur on a seasonal scale. Furthermore, as global climate change continues, there is a growing awareness of the impact of ocean warming on glacier melting, which is expected to affect the composition of phytoplankton community structure in West Antarctica's nearshore marine areas. In this study, we describe the role of hydrographic forcing on the short-term summer variability of the phytoplankton community in Marian Cove, an Antarctic glacial fjord (62°S). Phytoplankton and hydrographic variables were measured at five stations along the Marian Cove during summer 2019 (January–February). The highest concentrations of microphytoplankton biomass were found in the outer area of the fjord, whereas nanophytoplankton biomass displayed continued dominance during most of the summer period in Marian Cove. Hydrographic assessment showed that freshwater inputs from the glacier influenced the surface layer of the fjord, modulating phytoplankton biomass, which was dominated by nanodiatoms (*Minidiscus* sp., *Thalassiosira* spp.) and nanophytoflagellates (*Cryptomonas* spp., *Phaeocystis* sp.). Concurrent measurement of phytoplankton biomass and environmental conditions during December 2018–January 2019 indicated that a period of weak southeastern winds generated vertical stability, which led to the development of a major peak of microphytoplankton biomass in the outer cove, driven by warm, allochthonous, oceanic, nutrient-rich

waters. High carbon biomass dominated by nanodiatoms and nanophytoflagellates was observed in cold, fresh, and low-light subsurface waters of the cove. Our results highlight the effects of a warming ocean, which may favor the summer resurgence of nanodiatom and nanophytoflagellate communities in Antarctic fjords due to increased glacial meltwater inputs.

keywords:

glacial freshwater; cell carbon biomass; Antarctic shallow fjords; diatoms; nanophytoflagellates; phytoplankton size fractions

3-21

Imputation of Ocean-color Product in Polynya Region of Antarctica for Primary Productivity Estimates

Jinku, Park., Sungjae, Lee., Kim, Jeong-Hoon. and Kim, Hyun-Cheol.

Geo Data. 2023. 5(1): 8-14.

doi: 10.22761/gd.2023.0002.

This study, focusing on the Antarctic polynyas, performed the imputation of chlorophyll-a concentration (Chl-a) dataset, which is one of the ocean color products mainly used for estimating primary productivity, using the Data Interpolating Empirical Orthogonal Function method and constructed accurate time-series data that excludes as much uncertainty as possible in long-term variability studies due to missing data. The polynya regions were classified into a total of 23 zones through quantitative criteria, and the statistical accuracy of imputation performance was 0.89 for R^2 and 0.42, 0.24, and 0.15 for root mean square error, mean squared error, mean absolute error, respectively, on average, showing the ability to perform generally accurate reconstruction. Finally, the reconstructed Chl-a data showed a relatively stable fluctuation compared with standard satellite Chl-a data, and tended to be underestimated due to the expansion of the observable regions. We expect that securing these relatively stable and accurate estimates will be significantly different from the time-series data composed of standard Chl-a estimates, enabling more accurate variability and trend analysis.

keywords:

Antarctic polynyas; Ocean color; Chlorophyll-a concentration; Imputation; Data interpolating empirical orthogonal function

3-22 Microbiology

Influence of sedimentary deposition on the microbial assembly process in Arctic Holocene marine sediments

Han, Dukki., Richter-Heitmann, Tim., Kim, Ji-Hoon., Friedrich, Michael W., Yin, Xiuran., Elvert, Marcus., Ryu, Jong-Sik., Jang, Kwangchul. and Nam, Seung-Il.

Frontiers in Microbiology. 2023. 14.

doi: 10.3389/fmicb.2023.1231839.

The sea-level rise during the Holocene (11–0 ky BP) and its resulting sedimentation and biogeochemical processes may control microbial life in Arctic sediments. To gain further insight into this interaction, we investigated a sediment core (up to 10.7 m below the seafloor) from the Chuckchi Shelf of the western Arctic Ocean using metabarcoding-based sequencing and qPCR to characterize archaeal and bacterial 16S rRNA gene composition and abundance, respectively. We found that Arctic Holocene sediments harbor local microbial communities, reflecting geochemical and paleoclimate separations. The composition of bacterial communities was more diverse than that of archaeal communities, and specifically distinct at the boundary layer of the sulfate–methane transition zone. Enriched cyanobacterial sequences in the Arctic middle Holocene (8–7 ky BP) methanogenic sediments remarkably suggest past cyanobacterial blooms. Bacterial communities were phylogenetically influenced by interactions between dispersal limitation and environmental selection governing community assembly under past oceanographic changes. The relative influence of stochastic and deterministic processes on the bacterial assemblage was primarily determined by dispersal limitation. We have summarized our findings in a conceptual model that revealed how changes in paleoclimate phases cause shifts in ecological succession and the assembly process. In this ecological model, dispersal limitation is an important driving force for progressive succession for bacterial community assembly processes on a geological timescale in the western Arctic Ocean. This enabled a better understanding of the ecological processes that drive the assembly of communities in Holocene sedimentary habitats affected by sea-level rise, such as in the shallow western Arctic shelves.

keywords:

sedimentary deposition; microbial assembly; Arctic Holocene; marine sediments; eDNA; metabarcoding

3-23 Multidisciplinary Sciences

Large contributions of petrogenic and aged soil-derived organic carbon to Arctic fjord sediments in Svalbard

Kim, Dahae., Kim, Jung-Hyun., Ahn, Youngkyu., Jang, Kwangchul., Jung, Ji Young., Bae, Minji. and Nam, Seung-Il.

Scientific Reports. 2023. 13(1).

doi: 10.1038/s41598-023-45141-z.

Svalbard fjords are recognized as hotspots for organic carbon (OC) burial and storage due to their high sedimentation rates, which effectively trap terrestrial sediments and inhibit extensive OC remineralization. In this study, we investigated surface sediments ($n=48$) from eight Svalbard fjords, along with bedrock ($n=17$), soil ($n=28$), and plant ($n=12$) samples, to identify the sources of sedimentary OC in these fjords using geochemical parameters. All examined surface sediments from the fjords showed a depletion in $^{14}\text{C}_{\text{org}}$ ($-666.9 \pm 240.3\text{‰}$), indicating that recently fixed terrestrial and marine biomass alone cannot account for the entire sedimentary OC pool. Conventional bulk indicators such as $\text{N}_{\text{org}}/\text{TOC}$ ratio and $\delta^{13}\text{C}_{\text{org}}$ were insufficient for fully determining the sources of sedimentary OC. Therefore, we employed a four-end-member approach, using $\Delta^{14}\text{C}_{\text{org}}$, $\delta^{13}\text{C}_{\text{org}}$, and lignin phenols to assess the relative contributions of petrogenic, soil-derived, plant-derived, and marine OC to the sedimentary OC pool. The analyzed fjord sediments consisted, on average, of $59.0 \pm 28.1\%$ petrogenic OC, $16.8 \pm 12.1\%$ soil-derived OC, $2.5 \pm 2.2\%$ plant-derived OC, and $21.8 \pm 18.5\%$ marine OC. This approach highlights the substantial contributions of petrogenic and aged soil-derived OC to present-day sedimentary OC in Svalbard fjords. Considering predicted global warming, accelerated inputs of petrogenic and soil-derived OC into fjords due to rapid glacier retreat may significantly impact the active carbon cycle and potentially contribute to CO_2 emissions to the atmosphere, depending on burial efficiency.

3-24 Environmental Sciences; Meteorology & Atmospheric Sciences

Low contributions of dimethyl sulfide (DMS) chemistry to atmospheric aerosols over the high Arctic Ocean

Zhang, Miming, Yan, Jinpei, Lin, Qi, Park, Keyhong, and 3 others. *Atmospheric Environment*. 2023. 313.

doi: 10.1016/j.atmosenv.2023.120073.

The Arctic Ocean is continuously warming, resulting in sea ice retreat, which significantly impacts the marine biogenic sulfur cycle. The formation of aerosols from DMS oxidation and their climatic effects in polar regions are of great concern. However, the impact of DMS chemistry on atmospheric aerosols in the high Arctic Ocean (AO) is still unclear due to the limitation of field observations and datasets. Gaseous methanesulfonic acid (MSA) and aerosol chemical species (MSA, SO_4^{2-} and DMA, etc.) were determined simultaneously with a high time resolution (1 h) in the AO and Pacific Ocean (PO) to reveal the DMS chemistry in these regions. The particulate MSA concentration indicated significant spatial variation with a decreasing tendency from the low latitude oceans to high AO. Extremely low particulate MSA concentrations were observed in the high AO, with an average of only $7.42 \pm 6.6 \text{ ng}\cdot\text{m}^{-3}$. In contrast, highest particulate MSA concentrations, with an average of $168.6 \pm 167.6 \text{ ng}\cdot\text{m}^{-3}$ were observed in the mid-latitude regions ($45^\circ\text{--}60^\circ\text{N}$) in July. Sea salt aerosols were the most dominant source in the high Arctic Ocean, accounting for 88.78% of the total suspended particle mass, which was much larger than the values in the other regions. Low DMS chemistry was determined based on the low DMS emissions in the high latitude (HL, $75^\circ\text{--}85^\circ\text{N}$) region. These results highlight the contribution of DMS chemistry to atmospheric aerosols and extend the knowledge of how biogenic aerosols impact the regional atmosphere in the high AO.

keywords:

Arctic Ocean; MSA; DMS; Aerosols

3-25 Environmental Sciences; Meteorology & Atmospheric Sciences

Measurement report: Summertime fluorescence characteristics of atmospheric water-soluble organic carbon in the marine boundary layer of the western Arctic Ocean

Jung, Jinyoung., Miyazaki, Yuzo., Hur, Jin., Lee, Yun Kyung., Jeon, Mi Hae., Lee, Youngju., Cho, Kyoung-Ho., Chung, Hyun Young., Kim, Kitae., Choi, Jung-Ok., Lalande, Catherine., Kim, Joo-Hong., Choi, Taejin., Yoon, Young Jun., Yang, Eun Jin. and Kang, Sung-Ho. *Atmospheric Chemistry and Physics*. 2023. 23(8): 4663-4684.

doi: 10.5194/acp-23-4663-2023.

Accelerated warming and a decline in sea ice coverage

in the summertime Arctic Ocean can significantly affect the emissions of marine organic aerosols and biogenic volatile organic compounds. However, how these changes affect the characteristics of atmospheric water-soluble organic carbon (WSOC), which plays an important role in the climate system, remains unclear. Thus, to improve our understanding of WSOC characteristics in the rapidly changing Arctic Ocean, including its summertime fluorescence characteristics, we simultaneously measured atmospheric concentrations of ionic species and WSOC, a fluorescence excitation–emission matrix coupled with parallel factor (EEM-PARAFAC) analysis of WSOC, and marine biological parameters in surface seawaters of the western Arctic Ocean during the summer of 2016. WSOC was predominantly present as fine-mode aerosols (diameter $<2.5\ \mu\text{m}$, median = 92%), with the mean concentration being higher in the coastal water areas ($462 \pm 130\ \text{ngC m}^{-3}$) than in the sea-ice-covered areas ($242 \pm 88.4\ \text{ngC m}^{-3}$). Moreover, the WSOC in the fine-mode aerosols was positively correlated with the methanesulfonic acid in the fine-mode aerosol samples collected over the sea-ice-covered areas ($r=0.88$, $p<0.01$, $n=10$), suggesting high rates of sea–air gas exchange and emissions of aerosol precursor gases due to sea ice retreat and increasingly available solar radiation during the Arctic summer. Two fluorescent components, humic-like C1 and protein-like C2, were identified by the PARAFAC modeling of fine-mode atmospheric WSOC. The two components varied regionally between coastal and sea-ice-covered areas, with low and high fluorescence intensities observed over the coastal areas and the sea-ice-covered areas, respectively. Further, the humification index of WSOC was correlated with the fluorescence intensity ratio of the humic-like C1 / protein-like C2 ($r=0.89$, $p<0.01$) and the WSOC concentration in the fine-mode aerosols ($r=0.66$, $p<0.05$), with the highest values observed in the coastal areas. Additionally, the WSOC concentration in the fine-mode aerosols was positively correlated with the fluorescence intensity ratio of the humic-like C1 / protein-like C2 ($r = 0.77$, $p<0.01$) but was negatively correlated with the biological index ($r = -0.69$, $p<0.01$). Overall, these results suggested that the WSOC in the fine-mode aerosols in the coastal areas showed a higher degree of polycondensation and higher aromaticity compared to that in the sea-ice-covered areas, where WSOC in the fine-mode aerosols was associated with relatively new, less oxygenated, and biologically derived secondary organic components. These findings can improve our understanding of the chemical and biological linkages of WSOC at the ocean–sea-ice–atmosphere interface.

3-26 *Geography, Physical; Geosciences, Multidisciplinary*

Millennial-scale oscillations and an environmental regime shift around the Middle to Late Holocene transition in the North Atlantic region based on a multiproxy record from Isfjorden, West Spitsbergen

Brice, Camille., de Vernal, Anne., Francus, Pierre., Forwick, Matthias. and Nam, Seung-Il.

Boreas. 2023. 52(1): 42–59.

doi: 10.1111/bor.12602.

Palynological and sedimentological analyses were performed on the sediment core HH16-1205-GC retrieved from the central Isfjorden, West Spitsbergen. The sequence, which spans the last 7000 years, revealed an overall cooling trend with an important climate shift between 4.4 and 3.8 cal. ka BP, in addition to millennial-scale oscillations. Sea-surface reconstruction from dinocyst assemblages indicates a decrease in summer sea-surface temperature, from 2.5 to 1.5°C, and primary productivity, from 750 to 650 $\text{gC m}^{-2}\ \text{a}^{-1}$ over the last 7000 years. From around 6.8 to 5.8 cal. ka BP, the sedimentological and palynological data suggest a predominant sediment supply from the inner part of the fjord, ice rafting, dense sea ice cover, strongly stratified water masses and high primary productivity. The interval from 4.4 to 3.8 cal. ka BP is marked by a layer of coarser material and a significant decrease in the grain-size mode. Our geochemical data show large-amplitude fluctuations after 2.0 cal. ka BP, while an increase in the dinocysts *Impagidinium pallidum* and *Spiniferites elongatus* from 2.0 to 1.2 cal. ka BP suggests enhanced Atlantic Water inflow. The dinocyst-based reconstructions also reveal large-amplitude millennial fluctuations in sea ice cover, summer sea-surface temperature and salinity. Wavelet analysis and cross-wavelet analysis on K/Ti ratio coupled with sea-ice estimates confirm a strong signal with a periodicity of 1200–1500 years.

3-27 *Environmental Sciences; Marine & Freshwater Biology*

Multi-year variability of summer phytoplankton biomass and size structure in the northern Chukchi and East Siberian Seas, Arctic Ocean: role of light and nutrient availability

Lee, Youngju., Cho, Kyoung-Ho., Jung, Jinyoung., Moon, Jong Kuk., Yang, Eun Jin. and Kang, Sung-Ho.

Frontiers in Marine Science. 2023. 10.

doi: 10.3389/fmars.2023.1237150.

In the Arctic Ocean, the northern Chukchi and East Siberian Seas (NCESS) are vulnerable to climate change due to warming, sea ice melting, and surface freshening. To investigate how local physical forcing affects phytoplankton biomass and communities in this area, the multi-year (2015–2020) distributions of summer (August) chlorophyll-a concentrations and size structures using data collected by the Korea-Arctic Ocean Observing System (K-AOOS) program were investigated. The environmental characteristics and phytoplankton communities in the study area showed east-west regional differences. It is characterized by warm fresh waters and strong stratification to the east and cold saline waters and relatively high nutrient and sea ice concentrations to the west. Despite the differences between the east and west regions, patterns of the inter-annual variation in phytoplankton biomass and communities were similar across the entire study area, implying environmental controllers regulating phytoplankton in the NCESS. Inter-annually, higher sea surface salinity and weaker water column stratification were observed in 2017–2019 than in 2015 and 2020, implying the possibility of a potential modulation by the Arctic Oscillation. The shallower nitracline depth and higher surface nutrient concentrations since 2017 compared to the period from 2015–2016, indicate improved nutrient availability due to Atlantic water intrusion. However, average insolation has been relatively low since 2017, with the exception of August 2018. August mean phytoplankton biomass was highest in 2018 in the study area (average 83.7 mgm^{-2}) and was dominated by large-sized phytoplankton. The low phytoplankton biomass in 2017 (23.9 mgm^{-2}) and 2019 (62.4 mgm^{-2}), despite similar characteristics of nutrient concentration to 2018, is likely due to lower average daily insolation in both years ($206 \mu\text{Em}^{-2}\text{d}^{-1}$ and $184 \mu\text{Em}^{-2}\text{d}^{-1}$ in 2017 and 2019, respectively) compared to the 2018 average ($271 \mu\text{Em}^{-2}\text{d}^{-1}$). These results suggest that increased intrusion through upwelling of Atlantic water, along with nutrient loading, could be a pivotal driving factor contributing to this enhanced production in the NCESS, particularly under conditions where light levels are sufficient for phytoplankton growth and bloom development.

keywords:

phytoplankton biomass; phytoplankton size structure; Chukchi Sea; East Siberian Sea; Arctic Ocean

3-28 *Environmental Sciences; Marine & Freshwater Biology***New diagnostic sea surface current fields to trace floating algae in the Yellow Sea**

Choi, Jang-Geun., Kim, Deoksu., Shin, Jisun., Jang, Seon-Woong., Lippmann, Thomas C., Jo, Young-Heon., **Park, Jinku.** and Cho, Sung-Won.

Marine Pollution Bulletin. 2023. 195.

doi: 10.1016/j.marpolbul.2023.115494.

The new velocity fields based on the Generalized Ekman (GE) theory to trace floating algae were derived and verified by drifter observations and compared to reanalysis datasets in the Yellow Sea (YS). Two velocity fields using diagnostic approaches and two velocity fields from reanalysis datasets were examined. The results revealed that the diagnostic velocity fields had comparable accuracy to the reanalysis datasets, even locally better. Then, we applied each velocity field to trace green algae, *Ulva prolifera*, in July 2011 and brown algae, *Sargassum horneri*, in May 2017 using particle tracking experiments. In addition, drifter trajectories were simulated, and error accumulation speed was estimated for each velocity field. Simulation results using the diagnostic velocity fields consistently showed better agreement with satellite images and in situ observations than those using reanalysis datasets, demonstrating that the diagnostic velocity could be a superior tool for simulating surface-floating substances and organisms. The approach to derive diagnostic velocity fields can be easily applied instead of relying on heavy computing numerical models.

keywords:

Ulva prolifera; *Sargassum horneri*; Ocean current; Floating algae; Generalized Ekman theory; Particle Tracking Experiment

3-29 *Environmental Sciences; Marine & Freshwater Biology***Observing Antarctic Bottom Water in the Southern Ocean**

Silvano, Alessandro., Purkey, Sarah., Gordon, Arnold L., Castagno, Pasquale., Stewart, Andrew L., Rintoul, Stephen R., Foppert, Annie., Gunn, Kathryn L., Herraiz-Borreguero, Laura., Aoki, Shigeru., Nakayama, Yoshihiro., Naveira Garabato, Alberto C., Spingys, Carl., Akhondas, Camille Hayatte., Sallee, Jean-Baptiste., de Lavergne, Casimir., Abrahamsen, E. Povl., Meijers, Andrew J. S., Meredith, Michael P., Zhou, Shenjie., Tamura, Takeshi., Yamazaki, Kaihe.,

Ohshima, Kay I., Falco, Pierpaolo., Budillon, Giorgio., Hattermann, Tore., Janout, Markus A., Llanillo, Pedro., Bowen, Melissa M., Darelus, Elin., Osterhus, Svein., Nicholls, Keith W., Stevens, Craig., Fernandez, Denise., Cimoli, Laura., Jacobs, Stanley S., Morrison, Adele K., Hogg, Andrew McC., Haumann, F. Alexander., Mashayek, Ali., Wang, Zhaomin., Kerr, Rodrigo., Williams, Guy D. and **Lee, Won Sang.**
Frontiers in Marine Science. 2023. 10.
 doi: 10.3389/fmars.2023.1221701.

Dense, cold waters formed on Antarctic continental shelves descend along the Antarctic continental margin, where they mix with other Southern Ocean waters to form Antarctic Bottom Water (AABW). AABW then spreads into the deepest parts of all major ocean basins, isolating heat and carbon from the atmosphere for centuries. Despite AABW's key role in regulating Earth's climate on long time scales and in recording Southern Ocean conditions, AABW remains poorly observed. This lack of observational data is mostly due to two factors. First, AABW originates on the Antarctic continental shelf and slope where *in situ* measurements are limited and ocean observations by satellites are hampered by persistent sea ice cover and long periods of darkness in winter. Second, north of the Antarctic continental slope, AABW is found below approximately 2 km depth, where *in situ* observations are also scarce and satellites cannot provide direct measurements. Here, we review progress made during the past decades in observing AABW. We describe 1) long-term monitoring obtained by moorings, by ship-based surveys, and beneath ice shelves through bore holes; 2) the recent development of autonomous observing tools in coastal Antarctic and deep ocean systems; and 3) alternative approaches including data assimilation models and satellite-derived proxies. The variety of approaches is beginning to transform our understanding of AABW, including its formation processes, temporal variability, and contribution to the lower limb of the global ocean meridional overturning circulation. In particular, these observations highlight the key role played by winds, sea ice, and the Antarctic Ice Sheet in AABW-related processes. We conclude by discussing future avenues for observing and understanding AABW, impressing the need for a sustained and coordinated observing system.

keywords:

Antarctic Bottom Water (AABW); Southern Ocean; ice shelves; ocean warming; ocean freshening; Antarctic sea ice; observations

3-30 Microbiology

On Papulifères, putative ciliate cysts of diverse morphologies, with new observations from the plankton of the Chukchi Sea (Arctic Ocean)

Dolan, John R., **Yang, Eun Jin,** and **On, Jong-Kuk M.**
Acta Protozoologica. 2023. 62: 1-14.
 doi: 10.4467/16890027ap.23.001.17690.

In the early 20th century, Alphonse Meunier described "Papulifères" as a group of enigmatic forms of unknown taxonomic affinity characterized by possessing a hyaline pimple, a "papula". In the early 1980's Papulifères were equated with cysts of tintinnid ciliates. The most conspicuous forms, the large Fusopsis, have been widely found, and are now known to resemble the cyst of a certain species of oligotrich ciliate (i.e., *Cyrtostrombidium boreale*). Thus today, Papulifère forms are often assumed to be cysts of oligotrich ciliates. Here we report on 26 Papulifère forms, of more or less distinct morphologies, found in the plankton of the Chukchi Sea. We found forms resembling some of those described by Meunier, and recorded here for the first time since Meunier's reports, and others that do not resemble any of Meunier's Papulifères. Here, we first review the literature on Papulifères, then we present the surprising variety of forms we found in Chukchi Sea, and for some, we provide for the first time data on morphological variability. With this report we have expanded the catalogue of observed Papulifère forms and documented variability in the dimensions of some morphotypes. However, we urge caution in assigning a ciliate species name to any given Papulifère form in the absence of corroborating data. There is a need for observational and/or sequence-based data to elucidate the identity of Papulifère forms.

keywords:

Fusopsis; Piropsis; Sphaeropsis; microzooplankton; tintinnids; oligotrichs

3-31 Engineering, Marine; Engineering, Ocean; Oceanography

Photophysiological Characterization of Phytoplankton by Measuring Pigment Production Rates: A Description of Detail Method and a Case Study

Kang, Jae-Joong, **Min, Jun-Oh.,** Joo, Huitae., Youn, Seok-Hyun. and Lee, Sang-Heon.

Journal of Marine Science and Engineering. 2023. 11(10).
doi: 10.3390/jmse11101859.

Each phytoplankton species has intrinsic pigments, which result in different photophysiological characteristics in response to natural light conditions. Therefore, phytoplankton pigments provide important information on the photosynthetic activity that produces the basic food source for marine ecosystems. This study addresses the challenge of accurately measuring pigment production rates in phytoplankton communities. Two strategies are proposed for improving measurement sensitivity. Firstly, increasing the injection of ^{13}C substrate into incubation bottles up to 15% of the total dissolved inorganic carbon is recommended, with minimal impact on pigment production rate determinations. Secondly, optimizing sample injection volume for high-performance liquid chromatography balances analysis time and dilution effects. The in situ field experiments conducted in this study for pigment production measurements revealed diminished activity of photoprotective mechanisms involving zeaxanthin and diatoxanthin during the study period. Furthermore, the results showed that the notable production rates of chl-*b* ($0.069\text{--}0.105\text{ ng C L}^{-1}\text{ h}^{-1}$, 74–89% of total accessory pigment production rates), an accessory pigment mainly attributed to prasinophytes, potentially due to restricted light availability. Prioritization of chl-*b* production over primary production (negative correlation between primary and chl-*b* production; $R^2 = 0.6662$) highlights the potential impact of compensatory pigment-related activities on overall phytoplankton productivity. In conclusion, this study underscores the significance of directly quantifying pigment production rates to enhance our comprehension of phytoplankton photophysiology and the production mechanisms specific to various pigments.

keywords:

pigment production; phytoplankton; HPLC; carbon stable isotope (C-13)

Marine Geology. 2022. 443.
doi: 10.1016/j.margeo.2021.106674.

The repeated proximity of West Antarctic Ice Sheet (WAIS) ice to the eastern Ross Sea continental shelf break during past ice age cycles has been inferred to directly influence sedimentary processes occurring on the continental slope, such as turbidity current and debris flow activity; thus, the records of these processes can be used to study the past history of the WAIS. Ross Sea slope sediments may additionally provide an archive on the history and interplay of density-driven or geostrophic oceanic bottom currents with ice-sheet-driven depositional mechanisms. We investigate the upper 121 m of Hole U1525A, collected during International Ocean Discovery Program (IODP) Expedition 374 in 2018. Hole U1525A is located on the southwestern external levee of the Hillary Canyon (Ross Sea, Antarctica) and the depositional lobe of the nearby trough-mouth fan. Using core descriptions, grain size analysis, and physical properties datasets, we develop a lithofacies scheme that allows construction of a detailed depositional model and environmental history of past ice sheet-ocean interactions at the eastern Ross Sea continental shelf break/slope since ~2.4 Ma. The earliest Pleistocene interval (~2.4–~1.4 Ma) represents a hemipelagic environment dominated by ice-rafting and reworking/deposition by relatively persistent bottom current activity. Finely interlaminated silty muds with ice-rafted debris (IRD) layers are interpreted as contourites. Between ~1.4 and ~0.8 Ma, geostrophic bottom current activity was weaker and turbiditic processes more common, likely related to the increased proximity of grounded ice at the shelf edge. Silty, normally-graded laminations with sharp bases may be the result of flow-stripped turbidity currents overbanking the canyon levee during periods when ice was grounded at or proximal to the shelf edge. A sandy, IRD- and foraminifera-bearing interval dated to ~1.18 Ma potentially reflects warmer oceanographic conditions and a period of stronger Antarctic Slope Current flow. This may have enhanced upwelling of warm Circumpolar Deep Water onto the shelf, leading to large-scale glacial retreat at that time. The thickest interval of turbidite interlamination was deposited after ~1 Ma, following the onset of the Mid-Pleistocene Transition, interpreted as a time when most ice sheets grew and glacial periods were longer and more extreme. Sedimentation after ~0.8 Ma was dominated by glacial debris flow deposition, as the trough mouth fan that dominates the eastern Ross Sea continental slope prograded and expanded over the site. These findings will help to improve estimations of WAIS ice extent in future Ross Sea shelf-based modelling studies, and provide a basis for more detailed analysis of the inception and growth of the WAIS under distinct oceanographic conditions.

3-32 *Geosciences, Multidisciplinary; Oceanography*

Pleistocene depositional environments and links to cryosphere-ocean interactions on the eastern Ross Sea continental slope, Antarctica (IODP Hole U1525A)

King, Maxine V., Gales, Jenny A., Laberg, Jan Sverre., McKay, Robert M., De Santis, Laura., Kulhanek, Denise K., Hosegood, Phil J., Morris, Antony., **Kim, Sunghan.**, and Scientists, Iodp Expedition 374.

keywords:

Eastern Ross Sea; Sedimentary process; Trough-mouth fan; Turbidites; Pleistocene

3-33 *Environmental Sciences; Marine & Freshwater Biology*

Potential impact of the sea-ice ecosystem to the polar seas biogeochemistry

Kwon, Young Shin., Rhee, Tae Siek. and Bolding, Karsten.

Frontiers in Marine Science. 2023. 10.

doi: 10.3389/fmars.2023.1181650.

We used a one-dimensional vertical transport model, the sympagic-pelagic-benthic vertical transport model (SPBM) to explore the impact of sea-ice presence on phytoplankton phenology and biogeochemical dynamics. In the model, we introduced new parameter values for sympagic diatoms using ERSEM (European Regional Seas Ecosystem Model) in addition to the existing phytoplankton groups in the sea-ice model. We found that different groups of primary producers exhibit distinct spatial and temporal variabilities in both the sea-ice and water column depending on their physiological and biogeochemical properties. In particular, we discovered that the biomass of pelagic diatoms during the bloom season is strongly influenced by the release of sympagic algal cells during the early spring. This suggests the potential significance of sympagic algae seeding for the occurrence of pelagic diatom blooms in the Amundsen Sea. Notably, our model also indicates a potential connection between the earlier peak in particulate organic carbon flux and the release of sympagic-algae-associated particles from the sea ice, followed by their rapid sinking. Previous studies relying solely on observational data did not fully account for this mechanism. Our findings emphasize the importance of understanding the role of sympagic algae in the polar ecosystem and carbon cycle, and shed light on the complex biogeochemical dynamics associated with the sea-ice ecosystem in the polar seas.

keywords:

sympagic diatoms; sympagic ecosystem model; polar marine ecosystem; POC flux; ERSEM; SPBM

3-34 *Environmental Sciences; Meteorology & Atmospheric Sciences*

Potential Implications of the Sesquiterpene Presence over the Remote Marine Boundary Layer in the Arctic Region

Park, Keyhong, and 7 others.

Atmosphere. 2023. 14(5).

doi: 10.3390/atmos14050823.

We present reactive VOC observations over the North Pacific and the Arctic Ocean from airborne and shipborne measurements, investigating, in particular, distributions of biogenic volatile organic compounds that may be emitted from phytoplankton. In contrast to terrestrial observations, isoprene (C_5H_8), the most dominant BVOC emission from the terrestrial ecosystem, was mostly present under the lower detection limit along with monoterpenes ($C_{10}H_{16}$), the second largest emission from the terrestrial ecosystem. However, we consistently detected sesquiterpenes ($C_{15}H_{24}$) over the Arctic Ocean for the two Arctic cruises. The results of the analysis of sorbent cartridge samplings conducted over the Arctic Ocean on Korean icebreaker R/V Araon in 2016 and 2017 illustrate that few tens ppt levels of sesquiterpenes were present over the Arctic Ocean. Moreover, the concentration variation was positively correlated with the quantitative indicators of ocean biological activities, such as chlorophyll-a, dissolved DMS, and the ratio of dissolved O_2 and Ar. This suggests that further investigations on sesquiterpene's emission and atmospheric transformation processes over the marine boundary layer are required.

keywords:

arctic ocean; BVOC; sesquiterpenes; Araon; DMS

3-35 *Oceanography*

Properties and Mechanisms of Seawater Exchange in Marian Cove, King George Island, West Antarctic Peninsula

Kim, Yeonggi., Kim, Tae-Wan., Park, Sang-Jong., Ha, Sun-Yong., Park, Jisoo., Yoo, Jaeill. and Cho, Yang-Ki.

Journal of Geophysical Research-Oceans. 2023. 128(12).

doi: 10.1029/2023jc020111.

The Antarctic Peninsula is one region that has recently experienced warming substantially more rapidly than the

global mean over the past 50 years. Marian Cove is located in the South Shetland Islands connected to the Bransfield Strait via Maxwell Bay between King George Island and Nelson Island. In this study, we identified properties and mechanisms of seawater exchange in Marian Cove from multiple hydrographic surveys and a single bottom-mounted mooring installed at the entrance to Marian Cove. Regardless of the season, the mean current velocity profiles at the entrance to Marian Cove were constant because of the influence of tidal forcing. Wind was the primary force that determined the variation in surface current; in response, a countercurrent occurred near the bottom area. We estimated salt transport to understand what effects Maxwell Bay's saline water intrusion has on the Marian Cove environment. When the daily easterly wind was at its maximum of 18.5 m s^{-1} , the salinity could increase to $7.20 \times 10^{-4} \text{ g kg}^{-1}$ in 1 day. In addition, the average freshwater residence time in Marian Cove for the quantitative evaluation of seawater exchange was approximately 9 days. However, the freshwater residence time was reduced to less than 2 days when there were extreme easterly winds.

keywords:

Antarctic Peninsula; fjord winds; freshwater residence time; Marian Cove; seawater exchange; tidal forcing

in the other locations only the water depth was measured. Then, the digital models of the lake bottom topography were created. As an additional indicator of the relative sea-level (RSL) position, we used data on the altitude of the coastal terraces. Evidences of two transgressions in the White Sea (late glacial and Middle Holocene) are revealed. The transgressions were interrupted by two regressions (Early and Late Holocene). Our studies do not allow us to make a clear conclusion about the time and maximum level of the late glacial transgression. However, we may suggest that its level was above 11 m a.s.l. The regression of the Early Holocene started before 10.6–10.2 ka cal BP when the water level in the study area dropped below the altitude of 11 m. At 9.4–9.1 ka cal BP the RSL was at an altitude of ca 7 m. The Middle Holocene transgression (Tapes) started after 8.4 ka cal BP. The maximum level was reached before 7.4 ka cal BP and did not exceed an altitude of 9.5 m. The RSL stabilized at an altitude about 8.5–8 m during 7.4–6.0 ka cal BP. During 6.0–3.9 ka cal BP RSL very slowly decreased or fluctuated by the level of 8–7 m. RSL began to fall from the 7 m altitude about 4.0–3.9 ka cal BP and by 2.7–2.3 ka cal BP the sea-level reached 4.5 m. After that RSL dropped to its modern position. During the last 4.0 ka cal BP the rate of RSL fall was approximately 0.17–0.18 cm/year..

keywords:

Lake sediments stratigraphy; Geochemistry; Diatoms; Relative sea-level; White sea; Isolation basins

3-36 *Geography, Physical; Geosciences, Multidisciplinary*

Reconstruction of relative sea-level changes based on a multiproxy study of isolated basins on the Onega Peninsula (the White Sea, northwestern Russia)

Kublitskiy, Yuriy., Repkina, Tatiana., Leontiev, Piotr., Shilova, Olga., Zaretskaya, Nataliya., Gurinov, Artem., Lugovoy, Nikolay., Subetto, Dmitriy., Yakovleva, Alena., **Nam, Seung Il.**, Kim, Jung-Hyun., **Son, Yeong-Ju.** and Peretrukhina, Anastasiya.

Quaternary International. 2023. 644: 79-95.

doi: 10.1016/j.quaint.2022.04.016.

This study presents the results of lithological, diatom, geochemical analyses and radiocarbon chronology of the bottom lake sediments and peat bogs in the central part of the Onega Peninsula (the southern coast of the White Sea): Lake Maloye Murakanskoye (11.0 m a.s.l.), Lake Zhirovskoye (9.5 m a.s.l.), Lake Murakanskoye (7 m a.s.l.), and the Gorbovaty Mokh bog (6.5 m a.s.l.). The bottom topography and sediments of Lake Murakanskoye were examined using sonar and ground penetration radar (GPR) survey, whereas

3-37 *Geochemistry & Geophysics*

Revealing the Extent of Submarine Permafrost and Gas Hydrates in the Canadian Arctic Beaufort Sea Using Seismic Reflection Indicators

Grob, Henrik., Riedel, Marko., Duchesne, Mathieu J., Krastel, Sebastian., Bustamante, Jefferson., Fabien-Ouellet, Gabriel., Jin, Young Keun. and Hong, Jong Kuk.

Geochemistry Geophysics Geosystems. 2023. 24(5).

doi: 10.1029/2023gc010884.

The Canadian Arctic Southern Beaufort Sea is characterized by prominent relict submarine permafrost and gas hydrate occurrences formed by subaerial exposure during extensive glaciations in Pliocene and Pleistocene. Submarine permafrost is still responding to the thermal change as a consequence of the marine transgression that followed the last glaciation. Submarine permafrost is still

underexplored and is currently the focus of several research projects as its degradation releases greenhouse gases that contribute to climate change. In this study, seismic reflection indicators are used to investigate the presence of submarine permafrost and gas hydrates on the outer continental shelf where the base of permafrost is expected to cross-cut geological layers. To address the challenges of marine seismic data collected in shallow water environments, we utilize a representative synthetic model to assess the data processing and the detection of submarine permafrost and gas hydrate by seismic data. The synthetic model allows us to minimize the misinterpretation of acquisition and processing artifacts. In the field data, we identify features along with characteristics arising from the top and base of submarine permafrost and the base of the gas hydrate stability zone. This work shows the distribution of the present submarine permafrost along the southern Canadian Beaufort Sea region and confirms its extension to the outer continental shelf. It supports the general shape suggested by previous works and previously published numerical models.

keywords:

submarine permafrost; gas hydrate; marine seismic; Canadian Beaufort Sea; seismic reflection

3-38 *Environmental Sciences*

RNA outperforms DNA-based metabarcoding in assessing the diversity and response of microeukaryotes to environmental variables in the Arctic Ocean

Kong, Hejun., Yang, Eun-Jin., Jiao, Nianzhi., Lee, Youngju., Jung, Jinyoung., Cho, Kyoung-Ho., Moon, Jong-Kuk., Kim, Jee-Hoon. and Xu, Dapeng.

Science of the Total Environment. 2023. 876.

doi: 10.1016/j.scitotenv.2023.162608.

The Arctic Ocean (AO) has a harsh environment characterized by low temperatures, extensive ice coverage, and periodic freezing and melting of sea ice, which has provided diverse habitats for microorganisms. Prior studies primarily focused on microeukaryote communities in the upper water or sea ice based on environmental DNA, leaving the composition of active microeukaryotes in the diverse AO environments largely unknown. This study provided a vertical assessment of microeukaryote communities in the AO from snow and ice to sea water at a depth of 1670 m using high-throughput sequencing of co-extracted DNA and RNA. RNA

extracts depicted microeukaryote community structure and intergroup correlations more accurately and responded more sensitively to environmental conditions than those derived from DNA. Using RNA:DNA ratios as a proxy for relative activity of major taxonomic groups, the metabolic activities of major microeukaryote groups were determined along depth. Analysis of co-occurrence networks showed that parasitism between Syndiniales and dinoflagellates/ciliates in the deep ocean may be significant. This study increased our knowledge of the diversity of active microeukaryote communities and highlighted the importance of using RNA-based sequencing over DNA-based sequencing to examine the relationship between microeukaryote assemblages and the responses of microeukaryotes to environmental variables in the AO.

keywords:

Protist; Microbial eukaryotes; SSU rRNA; Metabolic activity; Co-occurrence network

3-39 *Chemistry, Multidisciplinary; Oceanography*

Seasonal dynamics of sinking organic matter in the Pacific Arctic Ocean revealed by nitrogen isotope ratios of amino acids

Choi, Hyuntae., Yang, Eun Jin., Kang, Sung-Ho. and 2 others.

Marine Chemistry. 2023. 253.

doi: 10.1016/j.marchem.2023.104252.

The Pacific Arctic Ocean has experienced a rapidly changing climate, sea-ice retreat, and enhanced primary production over the past few decades. The export production generated by photoautotrophs and heterotrophs has been characterized in the Arctic Ocean, but their seasonal variations in relative proportion are largely unknown due to the limited access in the ice-covered season. We measured the concentration and nitrogen isotope ratio of individual amino acids from sinking particles in the northern east Siberian Sea (KAMS1), northern Chukchi Sea (KAMS2), and Northwind Ridge (KAMS4) from August 2017 to July 2019. The average trophic position, based on differences in the nitrogen isotope ratios of glutamic acid and phenylalanine, can indicate the relative proportions of biogenic organic matters derived from photoautotrophs and heterotrophs in sinking particles. Decreasing values (close to 1.0) in summer at KAMS2 in 2018 suggest that primary producers are responsible for most of the downward flux of sinking particles. However, the average trophic position at KAMS1

in 2017 increased to >1.5 in autumn and was maintained at approximately 1.7 during ice-covered winter periods, likely due to greater contributions from heterotrophic organisms. Exceptionally high average trophic positions (close to 2.0) of sinking particles in summer at KAMS1 in 2017 and KAMS4 in 2018 were likely due to small export of photoautotrophs due to the surface seawater stratification and limited pelagic production. The average trophic position in sinking particles should reflect the spatiotemporal variation in export particle composition in the Pacific Arctic Ocean.

keywords:

Sinking particle; Nitrogen isotope; Amino acids; Pacific Arctic Ocean

3-40 *Environmental Sciences; Marine & Freshwater Biology*

Seasonal variation of inorganic carbon parameters and air-sea exchange of CO₂ in Marian Cove, King George Island, Western Antarctic Peninsula

Mo, Ahra., Park, Keyhong., Yang, Eun Jin., Park, Jisoo. and Kim, Tae-Wook.

Marine Pollution Bulletin. 2023. 193.

doi: 10.1016/j.marpolbul.2023.115185.

Inorganic carbon parameters were observed in Marian Cove, King George Island, Western Antarctic Peninsula, to assess the impact of the Antarctic coastal regions on air-sea CO₂ exchange. The variations in total alkalinity (TA) and dissolved inorganic carbon (DIC) were caused by ice melting, formation, and biological activities. The net annual air-sea CO₂ flux ($5.6 \pm 11.8 \text{ mmol m}^{-2} \text{ d}^{-1}$) indicated that Marian Cove was a CO₂ source in the atmosphere, suggesting the opposite role of the Antarctic coastal regions to the Southern Ocean in CO₂ flux estimates. Finally, this study identified the controlling factors of the annual variation of TA and DIC for the first time through direct field observations in King George Island. This study indicated that Antarctic coastal regions can act as a CO₂ source to the atmosphere. Thus, further investigations and continuous monitoring are required in the coastal areas to improve our understanding of global carbon cycles.

keywords:

King George Island; Partial pressure of CO₂(pCO₂); Air-sea CO₂ exchange; Maxwell Bay; Marian Cove

3-41 *Environmental Sciences; Marine & Freshwater Biology*

Seismic airgun sound propagation in shallow water of the East Siberian shelf and its prediction with the measured source signature

Han, Dong-Gyun., Kim, Sookwan., Landro, Martin., Son, Wuju., Lee, Dae Hyeok., Yoon, Young Geul., Choi, Jee Woong., Yang, Eun Jin., Choi, Yeonjin., Jin, Young Keun., Hong, Jong Kuk., Kang, Sung-Ho., Rhee, Tae Siek., Shin, Hyoung Chul. and La, Hyoung Sul.

Frontiers in Marine Science. 2023. 10.

doi: 10.3389/fmars.2023.956323.

Seismic airgun sound was measured with an autonomous passive acoustic recorder as a function of distance from 18.6 to 164.2 km in shallow water (<70 m) at the continental shelf of the East Siberian Sea in September 2019. The least-square regression curves were derived in the zero-to-peak sound pressure level, sound exposure level, and band level in a frequency range between 10 and 300 Hz using the initial amplitude scaled from the near-field hydrophone data. In addition, propagation modeling based on the parabolic equation with the measured source spectrum was performed for range-dependent bathymetry, and the results were compared with the band level of the measurements. The sediment structure of the measurement area was a thin layer of iceberg-scoured postglacial mud overlying a fast bottom with high density based on grounding events of past ice masses. The observed precursor arrivals, modal dispersion, and rapid decrease in spectrum level at low frequencies can be explained by the condition of the high-velocity sediment. Our results can be applied to studies on the inversion of ocean boundary conditions and measurement geometry and basic data for noise impact assessment.

keywords:

seismic airgun sound; underwater ambient noise; sound propagation; transmission loss; source signature; acoustic modeling; acoustic characteristics; East Siberian shelf

3-42 *Marine & Freshwater Biology; Oceanography*

Sources and melt flux of methylmercury in sea ice on the Chukchi Plateau, Arctic Ocean

Kim, Jihee., Moon, Jong-Kuk., Yang, Eun Jin., and 2 others.

Estuarine Coastal and Shelf Science. 2023. 294.

doi: 10.1016/j.ecss.2023.108536.

To identify the major source and melt flux of Hg in sea ice, we measured total Hg (THg) and methylmercury (MeHg) concentrations from sea ice cores collected from the Chukchi Plateau, Arctic Ocean. The THg maxima were found in the surface section (0–40 cm) of the cold cores ($-2.3 \pm 0.19^\circ\text{C}$) and middle section (30–75 cm) of the warm cores ($-1.9 \pm 0.38^\circ\text{C}$), whereas MeHg concentrations were nearly constant by core depth in the cold and warm cores. Using the enrichment factor mixing model, we estimated seawater to be the dominant source of THg over atmospheric deposition, both in the cold (89.1–99.6 %) and warm cores (98.4–99.7 %). The preliminary input estimation for MeHg showed that in situ methylation, instead of seawater input, was the potential source of MeHg in sea ice. The sea ice melt flux of MeHg in the Arctic Ocean was estimated to be $231 \pm 77 \text{ kg yr}^{-1}$ in the period of 2010–2020, which is insignificant compared with other external sources, such as atmospheric deposition, river discharge, and coastal erosion. Based on the results of the present study, the ongoing decline of sea ice extent related to polar amplification is likely to enhance MeHg production in sea ice in late spring and summer as a result of the improved light availability and consequent promotion of algal and microbial activities.

keywords:

Arctic ocean; Sea ice; Snow; Melt pond; Methylmercury; Melt flux

3-43 *Environmental Sciences; Marine & Freshwater Biology*

Spatiotemporal variability in ocean-driven basal melting of cold-water cavity ice shelf in Terra Nova Bay, East Antarctica: roles of tide and cavity geometry

Kim, Taekyun, Hong, Ji-Seok, Jin, Emilia Kyung, Moon, Jae-Hong, Song, Sang-Keun and Lee, Won Sang.

Frontiers in Marine Science. 2023. 10.

doi: 10.3389/fmars.2023.1249562.

Mass loss from ice shelves occurs through ocean-driven melting regulated by dynamic and thermodynamic processes in sub-ice shelf cavities. However, the understanding of these oceanic processes is quite limited because of the scant observations under ice shelves. Here, a regional coupled sea-ice/ocean model that includes physical interactions between the ocean and the ice shelf is used as an alternative tool for exploring ocean-driven melting beneath the Nansen Ice Shelf (NIS) which is a cold-water cavity ice shelf located beside

Terra Nova Bay (TNB) in East Antarctica. For the first time, this study identifies the spatiotemporal variability signatures for different modes of ocean-driven melting at the base of NIS. In February (austral summer), basal melting substantially increases where the ice shelf draft is relatively small in the vicinity of the ice shelf front, contributing 78% of the total NIS melting rate. As the dominant source of NIS mass loss, this melting is driven by tide-induced turbulent mixing along the sloping ice shelf base and summer warm surface water intruding beneath and reaching the shallow parts of the ice shelf. In contrast, the NIS has relatively high basal melting rates near the grounding line in September (austral winter) primarily because of the intrusion of high-salinity shelf water produced by polynya activity in TNB that flows into the cavity beneath NIS toward the deep grounding line. Of the total melting rate of NIS in winter, 36% comes from regions near the grounding line. In addition, the contributions of tides and realistic cavity geometry to NIS basal melting are identified by conducting sensitivity experiments. Tidal effects increase the melting of NIS throughout the year, particularly contributing as much as 30% to the areas of ice draft shallower than 200 m in summer. Sensitivity results for uncertainty in cavity geometry show that spurious vertical mixing can be locally induced and enhanced by interaction between tides and the unrealistic topography, resulting in excessive basal melting near the NIS frontal band. The sensitivity experiments have shown that tides and realistic cavity geometry bring a significant improvement in the estimation of basal melt rates through a numerical model.

keywords:

ocean-ice shelf interaction; ocean-driven basal melt; cold-water cavity ice shelf; tracer experiments; numerical simulation; Antarctica

3-44 *Environmental Sciences*

Spatio-temporal variations in organic carbon composition driven by two different major phytoplankton communities in the Ross Sea, Antarctica

Kim, Jaehong., La, Hyoung Sul., Kim, Jeong-Hoon., Jo, Naeun., Lee, Junbeom., Kim, Bo Kyung., Son, Wuju., Kim, Kwanwoo., Jang, Hyo-Keun., Park, Sanghoon., Yoo, Hyeju., Kim, Jaesoon., Park, Jisoo., and 2 others.

Science of the Total Environment. 2023. 891.

doi: 10.1016/j.scitotenv.2023.164666.

The compositions of organic carbon could be important in determining biological carbon pump efficiency. However, little information on them in relation to each algal assemblage is currently available in the Ross Sea. Here, we investigated the seasonal variations in organic carbon composition and the relative abundance of each organic carbon, including particulate organic carbon (POC), dissolved organic carbon (DOC), and transparent exopolymer particles (TEPs), characterized by different algal groups in the Ross Sea. The average POC and DOC contributions to the total organic carbon (TOC = POC + DOC) were $13.8 \pm 3.7\%$ and $86.2 \pm 3.7\%$ in mid-January 2019 and $20.9 \pm 4.1\%$ and $79.1 \pm 4.1\%$ in February–March 2018, respectively. The carbon content of TEP (TEP-C) contributed $19.6 \pm 11.7\%$ and $4.6 \pm 7.0\%$ of POC and TOC in mid-January and $36.2 \pm 14.8\%$ and $9.0 \pm 6.7\%$ in February–March, respectively. We found that the organic carbon compositions were affected by seasonal variations in the phytoplankton bloom phase, physical characteristics, and phytoplankton community structure. DOC concentrations and contributions to the TOC increased as phytoplankton cells became senescent in mid-January and decreased in February–March when phytoplankton were relatively active. From February–March, the deepened mixed layer depth encouraged TEP formation, subsequently increasing the TEP contributions. Regardless of the sampling season, all organic carbon concentrations per unit Chl-*a* were significantly higher in *P. antarctica*–abundant groups. The DOC contributions to the TOC were correspondingly higher at the *P. antarctica*–abundant stations in mid-January, which indicates that *P. antarctica* could be also important in the DOC contributions in the Ross Sea. The rapid alteration in environmental characteristics and phytoplankton community structures in the Ross Sea due to climate change could affect the organic carbon pool at the euphotic layer which consequently could determine the efficiency of the biological pump.

keywords:

Particulate organic carbon; Dissolved organic carbon; Transparent exopolymer particle; Phytoplankton; Ross Sea; Antarctica

Kyoung-Ho., Jung, Jinyoung., Lee, Youngju., La, Hyoung Sul., Ha, Sun Yong., Kim, Seung-Kyu., Kang, Sung Ho., Yang, Eun Jin., Nam, Seung-Il. and Hong, Jong Kuk.

Progress in Oceanography. 2023. 211.

doi: 10.1016/j.pocean.2023.102970.

The Pacific sector of the Arctic Ocean, a region with the fastest sea-ice loss in recent decades, is experiencing unprecedented biological regime shifts in its marine ecosystems today. However, a shelf-wide characterization of marine plankton communities over this region and environmental processes behind it remain largely unresolved, despite phytoplankton phenology is now considered to be an important factor for assessing how Arctic Ocean interacts with global climate change. Here, we present the first detailed description of recent dinoflagellate cyst assemblages in 32 surface sediment samples from the Chukchi-East Siberian Sea shelves, the Pacific Arctic Ocean, to examine their biogeographic patterns and associated environmental forcing factors. We find a strong regionalization in the species composition and distribution along the shallow-shelf cyst accumulation zone; in the Chukchi Sea sector, northward flow of warm-Pacific water along with extreme seasonality, sufficient nutrient supplies and higher light availability leads to a large occupation of cosmopolitan, opportunistic-nature taxa, whilst the East Siberian Sea sector with more extensive sea-ice cover and lower temperatures is primarily dominated by “round brown spiny cyst” taxa that have a strong affinity for cold, polar conditions. Specifically, an exclusive dominance of heterotrophic taxa at the East Siberian Sea region is inferred to be closely tied to Atlantic-origin water intrusions that lift nutrient-rich, cold bottom water up to oligotrophic surface layer to grow diatoms and other prey organisms. The observed contrast in this geographical “hot spot”, where the Pacific-and Atlantic-origin waters face each other, clearly manifests a growing expansion of southern waters into an increasingly ice-free Arctic Ocean that reshapes Arctic Ocean biogeography from the base of marine food chains. Our study highlights considerable potential of dinoflagellate cysts as a valuable environmental proxy to indicate complex interactions between ocean physics and marine biology under the rapidly changing Arctic climate system.

3-45 Oceanography

Strong regionalism in dinoflagellate cysts in recent sediments from the Chukchi-East Siberian Seas, Arctic Ocean

Kim, So Young., Park, Taewook., Marret, Fabienne., Potvin, Eric., Cho,

3-46 Chemistry, Multidisciplinary; Oceanography

The biogeochemistry of zinc and cadmium in the Amundsen Sea, coastal Antarctica

Tian, Hung-An., van Manen, Mathijs., Wille, Flora., **Jung, Jinyoung.**, Lee, Sang Hoon., **Kim, Tae-Wan.**, and 6 others.

Marine Chemistry. 2023. 249.

doi: 10.1016/j.marchem.2023.104223.

The trace metals zinc (Zn) and cadmium (Cd) are both involved in the metabolic processes of marine phytoplankton, and as such, both metals play important roles in ocean biogeochemical cycles. In Antarctica, the Amundsen Sea (AS) experiences rapid ice shelf melting, and the Amundsen Sea polynya (ASP) hosts seasonal phytoplankton blooms in austral summer, with important implications for atmospheric carbon dioxide draw-down. However, the effects of ice melting and phytoplankton blooms on the biogeochemistry and distributions of Zn and Cd in the ASP remain poorly studied. Here, we present the first combined dataset of dissolved and particulate Zn and Cd in the AS (including the inflow and outflow to and from the Dotson and Getz ice shelves) collected as part of the GEOTRACES process study GPpr12. We use this dataset to assess the sources of both elements to the AS region and characterize the particle composition in the ASP. We find that the main source of both dissolved Zn and Cd in the AS is Circumpolar Deep Water (CDW), with an additional small flux of both metals from shelf sediments. By contrast, aerosol deposition, ice shelf melt, and sea ice melt are all deemed insignificant sources for either Zn or Cd in the AS. Labile particulate Zn and Cd dominate the total particulate pool in the surface layer, indicating that biological uptake is a predominant process for the cycling of both metals in the ASP, whereas sediment resuspension and ice shelf melt do not supply a significant amount of either particulate Zn or Cd. Additionally, we use two commonly used approaches to estimate biogenic and lithogenic particulate concentrations. We find high biogenic particulate concentrations at the surface, decreasing with depth, indicating remineralization plays an important role in the cycling of particulate metals. In contrast, lithogenic particulate metal concentrations remain low throughout the water column. We also show that the estimated uptake ratios of Zn and Cd relative to phosphate in the surface layer are lower than reported for the open Southern Ocean, likely related to the spatial and temporal variability of Fe in the AS. Overall, these new observations provide insight into the biogeochemistry of both Zn and Cd in the AS, a region that is subject to the influence of rapid climate change, which may have implications for the larger-scale cycling of trace metals in the Southern Ocean. Specifically, the amount of Zn and Cd supplied to the surface ASP will increase, given that the volume of CDW that flows towards the Dotson Ice Shelf is predicted to increase.

keywords:

GEOTRACES; Trace metals; Amundsen Sea Polynya; Biogeochemistry

3-47 *Oceanography*

The Pacific water flow branches in the eastern Chukchi Sea

Pickart, Robert S., Lin, Peigen., Bahr, Frank., McRaven, Leah T., Huang, Jie., Pacini, Astrid., Arrigo, Kevin R., Ashjian, Carin J., Berchok, Catherine., Baumgartner, Mark F., **Cho, Kyoung-Ho.** and 23 others.

Progress in Oceanography. 2023. 219.

doi: 10.1016/j.pocean.2023.103169.

The flow of Pacific-origin water across the Chukchi Sea shelf impacts the regional ecosystem in profound ways, yet the two current branches on the eastern shelf that carry the water from Bering Strait to Barrow Canyon – the Alaskan Coastal Current (ACC) and Central Channel (CC) Branch – have not been clearly distinguished or quantified. In this study we use an extensive collection of repeat hydrographic sections occupied at three locations on the Chukchi shelf, together with data from a climatology of shipboard velocity data, to accomplish this. The data were collected predominantly between 2010 and 2020 during the warm months of the year as part of the Distributed Biological Observatory and Arctic Observing Network. The mean sections show that mass is balanced for both currents at the three locations: Bering Strait, Point Hope, and Barrow Canyon. The overall mean ACC transport is 0.34 ± 0.04 Sv, and that of the CC Branch is 0.86 ± 0.11 Sv. The dominant hydrographic variability at Bering Strait is seasonal, but this becomes less evident to the north. At Barrow Canyon, the dominant hydrographic signal is associated with year-to-year variations in sea-ice melt. Farther south there is pronounced mesoscale variability: an empirical orthogonal function analysis at Bering Strait and Point Hope reveals a distinct ACC mode and CC Branch mode in hydrography and baroclinic transport, where the former is wind-driven. Finally, the northward evolution in properties of the two currents is investigated. The poleward increase in salinity of the ACC can be explained by lateral mixing alone, but solar heating together with wind mixing play a large role in the temperature evolution. This same atmospheric forcing also impacts the northward evolution of the CC Branch.

keywords:

Boundary currents; Arctic Ocean; Chukchi Sea circulation; Water masses; Alaskan Coastal Current; Bering Strait; Barrow Canyon

3-48 *Marine & Freshwater Biology; Oceanography*
**Trace-Metal-Clean Sampling System:
Application to Ice-Breaking Research Vessel
Araon**

Kim, Jiwoo., Sim, Hunsub., Lim, Ijin., Kim, Taejin., **Jung, Jinyoung., Cho, Kyoung-Ho., Kim, Tae-Wan., Park, Jisoo., Yang, Eun Jin.** and 2 others.

Ocean Science Journal. 2023. 58(3).

doi: 10.1007/s12601-023-00118-x.

Trace metals generally exist at very low concentrations (pM–nM) in seawater, and could function as nutrients, contaminants, and tracers of various oceanographic processes. However, collection of seawater samples for a trace metal analysis without contamination is difficult because they exist ubiquitously. We present a detailed trace-metal-clean seawater sampling system that has been constructed on the ice-breaking research vessel (IBR/V) *Araon*. This sampling system consists of commercially available components without custom fabrication to minimize costs. The system consists of a polyurethane-coated aluminum rosette frame, 12-L Teflon-coated Niskin-X samplers, nonmetallic rope, and autofiring module that enables an automatic bottle firing. Using this system, seawater samples were collected in the Ulleung Basin, East Sea (Japan Sea), and the concentrations of dissolved trace metals (Mn, Fe, Cu, Zn, Cd, and Pb) were analyzed. Comparisons of trace metal concentrations to those obtained from the normal sampling system and previous data showed that our clean seawater sampling system could be utilized without metal contamination.

keywords:

Trace-metal-clean seawater sampling; Autofiring module; Ulleung Basin

Antarctic polynyas have the highest Southern Ocean summer primary productivity, and due to anthropogenic climate change, these areas have formed faster recently. Ammonia-oxidizing archaea (AOA) are among the most ubiquitous and abundant microorganisms in the ocean and play a primary role in the global nitrogen cycle. We utilized metagenomics and metatranscriptomics to gain insights into the physiology and metabolism of AOA in polar oceans, which are associated with ecosystem functioning. A polar-specific ecotype of AOA, from the “*Candidatus Nitrosomarinus*”-like group, was observed to be dominant in the Amundsen Sea Polynya (ASP), West Antarctica, during a succession of summer phytoplankton blooms. AOA had the highest transcriptional activity among prokaryotes during the bloom decline phase (DC). Metatranscriptomic analysis of key genes involved in ammonia oxidation, carbon fixation, transport, and cell division indicated that this polar AOA ecotype was actively involved in nitrification in the bloom DC in the ASP. This study revealed the physiological and metabolic traits of this key polar-type AOA in response to phytoplankton blooms in the ASP and provided insights into AOA functions in polar oceans.

keywords:

Ammonia-oxidizing archaea; Metatranscriptomics; Polynya; Phytoplankton bloom

3-50 *Environmental Sciences; Marine & Freshwater Biology*
**Upwelling processes driven by contributions
from wind and current in the Southwest East Sea
(Japan Sea)**

Kim, Deoksu., Choi, Jang-Geun., **Park, Jinku.,** and 3 others.

Frontiers in Marine Science. 2023. 10.

doi: 10.3389/fmars.2023.1165366.

The occurrence of coastal upwelling is influenced by the intensity and duration of sea surface wind stress and geophysical components such as vertical stratification, bottom topography, and the entrainment of water masses. In addition, strong alongshore currents can drive upwelling. Accordingly, this study analyzes how wind stress and ocean currents contribute to changing coastal upwelling along the southwest coast of the East Sea (Japan Sea), which has not yet been reported quantitatively. This study aims to estimate each geophysical factor affecting upwelling processes using the Upwelling Age index. The index assesses the major

3-49 *Microbiology*
**Transcriptomic Insights into Archaeal
Nitrification in the Amundsen Sea Polynya,
Antarctica**

Gwak, Joo-Han., Awala, Samuel Imisi., Kim, So-Jeong., Lee, Sang-Hoon., **Yang, Eun-Jin., Park, Jisoo., Jung, Jinyoung.** and Rhee, Sung-Keun.

Journal of Microbiology. 2023. 61(11): 967-980.

doi: 10.1007/s12275-023-00090-0.

contributors to the upwelling process using the relationship between physical forcing and upwelling water fraction estimated from shipboard hydrographic data from January 1993 to October 2018. These findings reveal that wind-driven upwelling was dominant off the northern coast. In contrast, current-driven upwelling prevailed off the southern coast. These results suggest that persistent alongshore currents through the Korea Strait make the southern region a prolific upwelling area. Accordingly, it can shed light on the mechanisms of coastal upwelling in the study area, which is crucial for understanding the influence of physical forces on ocean ecosystems.

keywords:

coastal upwelling; upwelling age (UA); Burger number; wind driven upwelling; current driven upwelling

3-51 *Fishery Science*

UV Effects on Production and Photoreactivity of Chromophoric Dissolved Organic Matter in Media of Polar Marine Phytoplanktons

Park, Mi Ok. and Ha, Sun-Yong.

Journal of the Korean Society of Marine Environment & Safety. 2022. 28(5): 712-720.

doi: 10.7837/kosomes.2022.28.5.712.

In this study, we evaluated the production and photoreactivity of CDOM of two polar phytoplanktons - *Phaeocystis antarctica* and *Phaeocystis pouchetii*, in order to find out UV effects on phytoplanktons. In visible region, CDOM in media of both phytoplanktons under UV-R decreased during 48hrs incubation period. However, in UV region CDOM decreased 30% in the media of *P. antarctica*, but increased 10% in media of *P. pouchetii*, compared to CDOM concentrations of control after 48 hr incubation. This result indicates that biota in polar environment would not well protected from UV-R harmful effect when *P. antarctica* is dominant because of loss of CDOM, but when *P. pouchetii* is dominant species, production of UV absorbing organic matter could play more efficiently for UV screening for marine biota. Also we confirmed that FDOM of humic substance (C-peak) produced by these phtoplanktons under UV-R stress were well matched with fluorescence characteristics of the UV-protecting compound, MAAs. This finding shows that *Phaeocystis pouchetti* with low photoreactivity would contribute to DOM pool of polar

marine environment under stratification by global warming.

keywords:

Chromophoric dissolved organic matter (CDOM); Polar marine phytoplankton; UV-incubation experiment; Photoreactivity; *Phaeocystis antarctica*; *Phaeocystis pouchetii*

3-52 *Environmental Sciences; Marine & Freshwater Biology*

Vertical distributions of organic matter components in sea ice near Cambridge Bay, Dease Strait, Canadian Archipelago

Kim, Kwanwoo., Ha, Sun-Yong., Shin, Kyung-Hoon., Kim, Jee-Hoon., and 8 others.

Frontiers in Marine Science. 2023. 10.

doi: 10.3389/fmars.2023.1231083.

Ice algae thriving within sea ice play a crucial role in transferring energy to higher trophic levels and influencing biogeochemical processes in polar oceans; however, the distribution of organic matter within the ice interior is not well understood. This study aimed to investigate the vertical distribution of organic matter, including chlorophyll a (Chl-a), particulate organic carbon and nitrogen (POC and PON), carbohydrates (CHO), proteins (PRT), lipids (LIP), and food material (FM), within the sea ice. Samples were collected from the bottom, middle, and top sections of the sea ice column near Cambridge Bay during the spring of 2018. Based on the $\delta^{13}\text{C}$ signature, biochemical composition, and POC contribution of biopolymeric carbon (BPC), the organic substances within the sea ice were predominantly attributed to marine autotrophs. While the highest concentrations of each parameter were observed at the sea ice bottom, notable concentrations were also found in the upper sections. The average sea ice column-integrated Chl-a concentration was $5.05 \pm 2.26 \text{ mg m}^{-2}$, with the bottom ice section contributing 59% (S.D. = $\pm 10\%$) to the total integration. The column-integrated concentrations of FM, BPC, POC, and PON were 2.05 ± 0.39 , 1.10 ± 0.20 , 1.47 ± 0.25 , and $0.09 \pm 0.03 \text{ g m}^{-2}$, respectively. Contributions of the bottom ice section to these column-integrated concentrations varied for each parameter, with values of 20 ± 6 , 21 ± 7 , 19 ± 5 , and $28 \pm 7\%$, respectively. While the bottom ice section exhibited a substantial Chl-a contribution in line with previous studies, significantly higher contributions of the other parameters were observed in the upper sea ice sections. This suggests that the particulate matter within the interior of the sea

ice could potentially serve as an additional food source for higher trophic grazers or act as a seeding material for a phytoplankton bloom during the ice melting season. Our findings highlight the importance of comprehensive field measurements encompassing the entire sea ice section to better understand the distribution of organic carbon pools within the sea ice in the Arctic Ocean.

keywords:

sea ice; organic matters; Chl-a (chlorophyll a); biopolymeric carbon (BPC); Cambridge Bay

3-53 *Biochemistry & Molecular Biology; Microbiology*

Vertical segregation and phylogenetic characterization of archaea and archaeal ammonia monooxygenase gene in the water column of the western Arctic Ocean

Vipindas, Puthiya Veettil., Jabir, Thajudeen., Venkatachalam, Siddarthan., **Yang, Eun Jin.** and 2 others. *Extremophiles*. 2023. 27(3).
doi: 10.1007/s00792-023-01310-6.

Archaea constitute a substantial fraction of marine microbial biomass and play critical roles in the biogeochemistry of oceans. However, studies on their distribution and ecology in the Arctic Ocean are relatively scarce. Here, we studied the distributions of archaea and archaeal ammonia monooxygenase (*amoA*) gene in the western Arctic Ocean, using the amplicon sequencing approach from the sea surface to deep waters up to 3040 m depth. A total of five archaeal phyla, *Nitrososphaerota*, “*Euryarchaeota*”, “*Halobacteriota*”, “*Nanoarchaeota*”, and *Candidatus Thermoplasmatota*, were detected. We observed a clear, depth-dependent vertical segregation among archaeal communities. *Ca. Thermoplasmatota* (66.8%) was the most dominant phylum in the surface waters. At the same time, *Nitrososphaerota* (55.9%) was dominant in the deep waters. Most of the *amoA* gene OTUs (99%) belonged to the Nitrosopumilales and were further clustered into five subclades (“*NP-Alpha*”, “*NP-Delta*”, “*NP-Epsilon*”, “*NP-Gamma*”, and “*NP-Theta*”). “*NP-Epsilon*” was the most dominant clade throughout the water column and “*NP_Alpha*” showed higher abundance only in the deeper water. Salinity and inorganic nutrient concentrations were the major factors that determined the vertical segregation of archaea. We anticipate that the observed differences in the vertical distribution of archaea might contribute

to the compartmentalization of dark carbon fixation and nitrification in deeper water and organic matter degradation in surface waters of the Arctic Ocean.

keywords:

Arctic Ocean; Archaeal distribution; Ammonia oxidizing archaea; *amoA* gene; Deep Ocean

3-54 *Ecology; Marine & Freshwater Biology; Microbiology*

Water Mass Controlled Vertical Stratification of Bacterial and Archaeal Communities in the Western Arctic Ocean During Summer Sea-Ice Melting

Vipindas, Puthiya Veettil., Venkatachalam, Siddarthan., Jabir, Thajudeen., **Yang, Eun Jin.**, **Cho, Kyoung-Ho.**, **Jung, Jinyoung.**, **Lee, Youngju.** and Krishnan, Kottekkatu Padinchati. *Microbial Ecology*. 2023. 85(4): 1150-1163.
doi: 10.1007/s00248-022-01992-z.

The environmental variations and their interactions with the biosphere are vital in the Arctic Ocean during the summer sea-ice melting period in the current scenario of climate change. Hence, we analysed the vertical distribution of bacterial and archaeal communities in the western Arctic Ocean from sea surface melt-ponds to deep water up to a 3040 m depth. The distribution of microbial communities showed a clear stratification with significant differences among different water depths, and the water masses in the Arctic Ocean – surface mixed layer, Atlantic water mass and deep Arctic water – appeared as a major factor explaining their distribution in the water column. A total of 34 bacterial phyla were detected in the seawater and 10 bacterial phyla in melt-ponds. Proteobacteria was the dominant phyla in the seawater irrespective of depth, whereas Bacteroidota was the dominant phyla in the melt-ponds. A fast expectation-maximization microbial source tracking analysis revealed that only limited dispersion of the bacterial community was possible across the stratified water column. The surface water mass contributed 21% of the microbial community to the deep chlorophyll maximum (DCM), while the DCM waters contributed only 3% of the microbial communities to the deeper water masses. Atlantic water mass contributed 37% to the microbial community of the deep Arctic water. Oligotrophic heterotrophic bacteria were dominant in the melt-ponds and surface waters, whereas chemoautotrophic and mixotrophic bacterial and archaeal communities were abundant in deeper waters. Chlorophyll and ammonium

were the major environmental factors that determined the surface microbial communities, whereas inorganic nutrient concentrations controlled the deep-water communities.

keywords:

Water mass; Arctic Ocean; Melt-ponds; Marginal ice zone;
Microbial distribution

Part 4.

Life Sciences

4-1 Multidisciplinary Sciences

A chromosome-level reference genome of the Antarctic blackfin icefish *Chaenocephalus aceratus*

Lee, Seung Jae., Kim, Jinmu., Choi, Eun Kyung., Jo, Euna., Cho, Minjoo., Kim, Jeong-Hoon. and Park, Hyun.

Scientific Data. 2023. 10(1).

doi: 10.1038/s41597-023-02861-1

The blackfin Icefish (*Chaenocephalus aceratus*) belongs to the family Channichthyidae and the suborder Notothenioidei which lives in the Antarctic. We corrected the mis-scaffolds in the previous linkage map results by Hi-C analysis to obtain improved results for chromosome-level genome assembly. The final assembly analysis resulted in a total of 3,135 scaffolds, a genome size of 1,065.72 Mb, and an N50 of 33.46 Mb. 820.24 Mb, representing 88.88% of the total genome, is anchored to 24 chromosomes. The final gene set of 38,024 genes, including AFGPs, was annotated using RNA evidence, proteins, and ab-initio predictions. The complete percentage of BUSCO analysis is 92.7%. In this study, we aim to contribute to the study of polar fishes by improving the genome sequences of the blackfin icefish with the AFGP genes belonging to the Notothenioidei.

4-2 Microbiology

A novel bacteriobiont of the Arctic lichen *Flavocetraria nivalis*, *Lichenifustis flavocetrariae* gen. nov, sp. nov. demonstrating hydrolytic properties and containing a full set of the Calvin–Benson–Bassham cycle genes

Pankratov, Timofei A. A., Samylna, Olga S. S., Tikhonova, Ekaterina N. N., Ianutsevich, Elena A. A., Avtukh, Alexander N. N. and Lee, Yung Mi.

Archives of Microbiology. 2023. 205(6).

doi: 10.1007/s00203-023-03577-x.

A Gram-negative, strictly aerobic, chemoorganotrophic, bacteriochlorophyll a-containing, slow-growing bacterium was isolated from the lichen *Flavocetraria nivalis* and designated strain BP6-180914^T. Cells of this strain were large nonmotile rods, which reproduced by binary fission. Cells grew under oxic conditions and were able to utilize sugars and several polysaccharides, including starch and pectin. Strain BP6-180914^T was psychrotolerant and moderately acidophilic growing at 4–35 °C (optimum 20–28 °C) and between pH 4.0 and 7.5 (optimum 4.5–5.5). The major fatty acids were C_{18:1}ω7c, C_{19:0} cyclo, C_{16:0} and C_{18:0}. The polar lipids were diphosphatidylglycerols, phosphatidylglycerols, phosphatidylethanolamines, phosphatidylcholines, unidentified aminolipids, and a number of glycolipids, the major one being an unidentified glycolipid. The quinone was Q-10. The DNA G + C content was 63.65%. Comparative 16S rRNA gene sequence analysis revealed that strain BP6-180914^T was a member of the order *Hyphomicrobiales* and belonged to the family *Lichenihabitaceae* defined by the lichen-dwelling facultative aerobic chemo-organotroph *Lichenihabitans psoromatis* (92.7% sequence similarity). The results of phylogenomic and genomic relatedness analyses showed that strain BP6-180914^T could clearly be distinguished from other species in the order *Hyphomicrobiales* with average nucleotide identity values of < 74.05% and genome-to-genome distance values of < 21.1%. The AAI value of 65.9% between strain BP6-180914^T and *L. psoromatis* allowed us to assign this strain to the novel genus of the family *Lichenihabitaceae*. Therefore, it is proposed that strain BP6-180914^T represents a novel species in a new genus, *Lichenifustis flavocetrariae* gen. nov., sp. nov.; strain BP6-180914^T (=KCTC 92872^T=VKM B-3641^T=UQM 41506^T) is the type strain.

keywords:

Lichens; Hyphomicrobiales; *Lichenifustis flavocetrariae*; Calvin cycle

4-3 Materials Science, Biomaterials

A novel exopolysaccharide (p-CY01) from the Antarctic bacterium *Pseudoalteromonas* sp. strain CY01 cryopreserves human red blood cells

Kim, Sung Jin., Youn, Ui Joung., Kang, Pilsung., Kim, Tai Kyoung., Kim, Il-Chan., Han, Se Jong., Lee, Dong-Woo. and Yim, Joung Han.

Biomaterials Science. 2023. 11(21): 7146-7157.

doi: 10.1039/d3bm00917c.

Cryopreservation of human red blood cells (RBCs) is vital for regenerative medicine and organ transplantation, but current cryoprotectants (CPAs) like glycerol and hydroxyethyl starch (HES) have limitations. Glycerol requires post-thaw washing due to cell membrane penetration, while HES causes high viscosity. To address these issues, we explored exopolysaccharides (EPS) from Antarctic *Pseudoalteromonas* sp. strain CY01 as a non-penetrating CPA for RBC cryopreservation. The EPS, p-CY01, consisted mainly of repeating (1–4) glucose and (1–6) galactose linkages with a molecular mass of 1.1×10^7 Da. Through mild acid hydrolysis, we obtained low molecular weight p-CY01 (p-CY01 LM) with a molecular weight of 2.7×10^5 Da, offering reduced viscosity, improved solubility, and cryoprotective properties. Notably, combining low concentrations of penetrating CPAs (>1% glycerol and dimethyl sulfoxide) with 2.5% (w/v) p-CY01 LM demonstrated significant cryoprotective effects. These findings highlight the potential of p-CY01 LM as a highly effective CPA for human RBC cryopreservation, replacing HES and glycerol and enabling the long-term storage of biological materials.

4-4 Biology

A Study of Arctic Microbial Community Structure Response to Increased Temperature and Precipitation by Phospholipid Fatty Acid Analysis

Nam, Sungjin. and Jung, Ji Young.

Proceedings of the National Institute of Ecology of the Republic of Korea. 2023. 4(2): 86-94.

doi: 10.22920/pnie.2023.4.2.86.

Climate change is more rapid in the Arctic than elsewhere in the world, and increased precipitation and warming are expected cause changes in biogeochemical processes due to altered microbial communities and activities. It is crucial to investigate microbial responses to climate change to understand changes in carbon and nitrogen dynamics. We investigated the effects of increased temperature and precipitation on microbial biomass and community structure in dry tundra using two depths of soil samples (organic and mineral layers) under four treatments (control, warming, increased precipitation, and warming with increased precipitation) during the growing season (June–

September) in Cambridge Bay, Canada (69°N, 105°W). A phospholipid fatty acid (PLFA) analysis method was applied to detect active microorganisms and distinguish major functional groups (e.g., fungi and bacteria) with different roles in organic matter decomposition. The soil layers featured different biomass and community structure; ratios of fungal/bacterial and gram-positive/-negative bacteria were higher in the mineral layer, possibly connected to low substrate quality. Increased temperature and precipitation had no effect in either layer, possibly due to the relatively short treatment period (seven years) or the ecosystem type. Mostly, sampling times did not affect PLFAs in the organic layer, but June mineral soil samples showed higher contents of total PLFAs and PLFA biomarkers for bacteria and fungi than those in other months. Despite the lack of response found in this investigation, long-term monitoring of these communities should be maintained because of the slow response times of vegetation and other parameters in high-Arctic ecosystems.

keywords:

Climate change; High arctic; Microbial biomass; Phospholipid fatty acid analysis; Soil depth; Temporal changes

4-5 Biodiversity Conservation; Ecology

Antarctic Ecosystem Recovery Following Human-Induced Habitat Change: Recolonization of Adelie Penguins (*Pygoscelis adeliae*) at Cape Hallett, Ross Sea

Kim, Jong-U., Kim, Youmin., Oh, Younggeun., Kim, Hyun-Cheol. and Kim, Jeong-Hoon.

Diversity-Basel. 2023. 15(1).

doi: 10.3390/d15010051.

The human-induced disturbances in Antarctica have caused changes in the structure and function of ecosystems. The Cape Hallett station was established in 1957 and abandoned in 1973. The station was built inside a penguin colony, and during its operation, many penguins were deported. Herein, we compared the number of breeding pairs across different time periods after station decommission and environmental remediation. The station occupied 4.77 ha within the Adelie penguin breeding area, and 349 nests were identified inside the station border in 1960. In 1983, the station's territory decreased to 4.2 ha; meanwhile, 1683 breeding pairs were counted in the old station area. The past station area re-inhabited by Adelie penguins had 6175 nests in 2019. We assumed that recolonization might be

particularly related to artificial mounds. The results of the present study confirm the recolonization of Adelie penguins at Cape Hallett for the first time, with visual analysis of spatial-temporal changes. Additionally, we suggest that reconstruction of the artificial or enhanced habitat may be required for successful restoration. Furthermore, continuous species monitoring with specific notes are needed with management interventions to protect Antarctic ecosystems, as well as the Ross Sea region MPA.

keywords:

Antarctic seabird; Cape Hallett; human disturbance; *Pygoscelis adeliae*; recolonization; restoration; Ross Sea region Marine Protected Area

4-6 Food Science & Technology; Nutrition & Dietetics

Antarctic krill extracts enhance muscle regeneration and muscle function via mammalian target of rapamycin regulation

Lee, Seongmin., Baek, Mi-Ock., Khaliq, Sana Abdul., Parveen, Amna., Kim, Sun Yeou., Kim, Jin-Hyoung., Kim, Il-Chan and Yoon, Mee-Sup. *Journal of Functional Foods*. 2023. 103.
doi: 10.1016/j.jff.2023.105483.

Sarcopenia is a degenerative disease involving decreases in muscle mass and muscle strength. There is no effective therapeutic target or treatment for sarcopenia. Here, we isolated a new metabolite from Antarctic krill extracts (AKEs) and investigated whether AKEs promote muscle regeneration. The AKEs increased the muscle enhancer-reporter activity of insulin-like growth factor 2 as well as myogenic fusion during C2C12 myoblast differentiation in an mTOR-dependent manner but did not affect the cell cycle or apoptosis. When BaCl₂-injured tibialis anterior muscles were injected with the extracts, the central surface area of centrally nucleated regenerating muscle fibers and the grip strength of regenerated muscles were enhanced. Finally, we identified Neicosapentanoil phenylalanine as the bioactive compound in AKEs using mass spectrometry analysis. Our results suggest that AKEs augment muscle regeneration by increasing mTOR signaling. Thus, the extracts may be useful for developing treatments for sarcopenia.

keywords:

Antarctic krill extracts; mTOR; Sarcopenia; N-eicosapentanoil phenylalanine

4-7 Chemistry, Medicinal; Pharmacology & Pharmacy

Arctic Sea Ice Microalga *Chlamydomonas latifrons* KNF0041: Identification and Statistical Optimization of Medium for Enhanced Biomass and Omega-3/Omega-6

Chae, Hyunsik., Kim, Sanghee., Choi, Han-Gu., Kim, Ji Hee., Han, Se Jong. and Kim, Eun Jae.
Marine Drugs. 2023. 21(8).
doi: 10.3390/md21080454.

Polar microorganisms produce biologically active compounds that enable them to survive in harsh environments. These compounds have potential biomedical applications. The green microalga *Chlamydomonas latifrons* KNF0041, isolated from Arctic sea ice, has been found to produce polyunsaturated fatty acids (PUFAs), including omega-3 and omega-6, which have antioxidant properties. To improve the biomass production of strain KNF0041, statistical methods such as the Plackett–Burman design, Box–Behnken design, and response surface methodology (RSM) were utilized for medium optimization. The optimized medium was designed with increased potassium phosphate content and reduced acetic acid (AcOH) content. The use of the optimized medium resulted in an increase in the cell number as biomass of strain KNF0041 by 34.18% and the omega-3 and omega-6 fatty acid (FA) content by 10.04% and 58.29%, respectively, compared to that in normal TAP medium, which is known as the growth medium for *Chlamydomonas* culture. In this study, *Chlamydomonas latifrons* was discovered for the first time in the polar region and identified using morphology and molecular phylogenetic analyses, the secondary structures of the internal transcribed spacers, and optimized culture conditions. The results of this study provide an efficient method for the application of polar microalgae for the production of bioactive compounds.

keywords:

Chlamydomonas latifrons; identification; medium optimization; biomass enhancement

4-8 Biodiversity Conservation; Ecology

Arthropods, nematodes, fungi, and bacteria associated with penguin carrion in Barton Peninsula, King George Island, Antarctica

Zaini, Nur Adilla., Low, Van Lun., Gebrelasse, Selam Solomon., Ismail, Siti Sofo., Mahmud, Mohd Hafizi., Houssaini, Jamal., **Lee, Won Young.** and 2 others.

Polar Biology. 2024. 47(1): 41-52.

doi: 10.1007/s00300-023-03208-7.

Carrion decomposition contributes to the soil microbial community structure. This research aimed to identify the soil arthropod, nematode, bacterial, and fungal communities associated with penguin carrion on King George Island, Antarctica. Soil samples were collected around and beneath fresh (freshly killed penguins by the predators) and dried (decomposed more than a year) penguin carrion. Soil bacterial and fungal communities associated with the penguin carrion were analyzed using the 16S rRNA and internal transcribed spacer (ITS) gene sequencing, respectively. Arthropod identification was using Sanger sequencing and nematodes were determined using morphological identification. This study demonstrated no significant differences in arthropod and nematode, bacteria, and fungi communities between decomposition stages, soil location, and species of penguin carrion. This is the first study to identify soil arthropods, nematodes, bacterial, and fungal communities associated with penguin carrion, offering important insights into the initial documentation of the necrobiome communities in the polar region.

keywords:

Necrobiome; Arthropods; Nematodes; Bacteria; Fungi; Carrion

of inorganic nitrogen (N) have been reported. However, climate change and an increase of available N caused by anthropogenic activities have recently been reported, which may cause a drastic change in CH₄ oxidation in Arctic soils. In this study, we demonstrate that excessive levels of available N in soil cause an increase in net CH₄ emissions via the reduction of CH₄ oxidation in surface soil in the Arctic tundra. In vitro experiments suggested that N in the form of NO₃⁻ is responsible for the decrease in CH₄ oxidation via influencing soil bacterial and methanotrophic communities. The findings of our meta-analysis suggest that CH₄ oxidation in the boreal biome is more susceptible to the addition of N than in other biomes. We provide evidence that CH₄ emissions in Arctic tundra can be enhanced by an increase of available N, with profound implications for modeling CH₄ dynamics in Arctic regions.

keywords:

methane oxidation; available N; methanotrophs; bacterial diversity; moist acidic tundra; Arctic region

4-10 Multidisciplinary Sciences

Biochemical and structural basis of mercuric reductase, *GbsMerA*, from *Gelidibacter salicanalis* PAMC21136

Pardhe, Bashu Dev., **Lee, Min Ju.**, **Lee, Jun Hyuck.**, **Do, Hackwon.** and Oh, Tae-Jin.

Scientific Reports. 2023. 13(1).

doi: 10.1038/s41598-023-44968-w.

Heavy metals, including mercury, are non-biodegradable and highly toxic to microorganisms even at low concentrations. Understanding the mechanisms underlying the environmental adaptability of microorganisms with Hg resistance holds promise for their use in Hg bioremediation. We characterized *GbsMerA*, a mercury reductase belonging to the mercury-resistant operon of *Gelidibacter salicanalis* PAMC21136, and found its maximum activity of 474.7 μmol/min/mg in reducing Hg⁺². In the presence of Ag and Mn, the enzyme exhibited moderate activity as 236.5 μmol/min/mg and 69 μmol/min/mg, respectively. *GbsMerA* exhibited optimal activity at pH 7.0 and a temperature of 60 °C. Moreover, the crystal structure of *GbsMerA* and structural comparison with homologues indicated that *GbsMerA* contains residues, Tyr437' and Asp47, which may be responsible for metal transfer at the *si*-face by providing a hydroxyl group (–OH) to abstract a proton

4-9 Engineering, Environmental; Environmental Sciences

Attenuation of Methane Oxidation by Nitrogen Availability in Arctic Tundra Soils

Lee, Jaehyun., Yun, Jeongeun., Yang, Yerang., **Jung, Ji Young.**, **Lee, Yoo Kyung.**, and 4 others.

Environmental Science & Technology. 2023.

doi: 10.1021/acs.est.2c05228.

CH₄ emission in the Arctic has large uncertainty due to the lack of mechanistic understanding of the processes. CH₄ oxidation in Arctic soil plays a critical role in the process, whereby removal of up to 90% of CH₄ produced in soils by methanotrophs can occur before it reaches the atmosphere. Previous studies have reported on the importance of rising temperatures in CH₄ oxidation, but because the Arctic is typically an N-limited system, fewer studies on the effects

from the thiol group of cysteine. The complex structure with NADPH indicated that Y174 in the re-face can change its side chain direction upon NADPH binding, indicating that Y174 may have a role as a gate for NADPH binding. Moreover, the heterologous host expressing *GbsMerA* (p*GbsMerA*) is more resistant to Hg toxicity when compared to the host lacking *GbsMerA*. Overall, this study provides a background for understanding the catalytic mechanism and Hg detoxification by *GbsMerA* and suggests the application of genetically engineered *E. coli* strains for environmental Hg removal.

wall and intestinal content found in our study supports niche separation in the gut environment and emphasizes the importance of collecting intestinal wall samples in addition to intestinal content samples to understand the full picture of gut microbiome. This is the first time that the gut microbiome of mackerel icefish has been characterized using next-generation sequencing.

keywords:

gut microbiome; Antarctic fish; mackerel icefish; *Champsocephalus gunnari*; high-throughput sequencing

4-11 Fisheries; Marine & Freshwater Biology

Characterization of the Gut Microbiota of Mackerel Icefish, *Champsocephalus gunnari*

Song, Hokyung., Lee, Seungyeon., Han, Dong-Won. and Kim, Jin-Hyoung.

Fishes. 2023. 8(1).

doi: 10.3390/fishes8010013.

The gut microbiome of Antarctic fish species has rarely been studied due to difficulties in obtaining samples. The mackerel icefish, *Champsocephalus gunnari*, primary feeds on krill and is one of the key species in the food web of the Southern Ocean. In this study, we characterized the gut microbiota of *C. gunnari* by sequencing the V3–V4 region of the bacterial 16S rRNA gene based on the Illumina MiSeq sequencing platform. We collected three types of samples: (1) whole intestine, (2) intestinal wall, and (3) intestinal content. The results showed no significant difference in the alpha diversity between different sample types. However, the microbial community composition of intestinal wall samples was distinct from other sample types. The relative abundance of *Photobacterium* was higher in intestinal content compared with the walls, which could be due to their chitinolytic activity. In contrast, potential pathogens such as *Escherichia*, *Shigella*, and *Pseudomonas* relatively more abundant in the intestinal wall compared with the intestinal contents. Unlike the gut microbiome of other marine fish species, *Vibrio* and *Lactobacillus* were nearly absent in the gut microbiome of *C. gunnari*. Functional gene profile of the gut microbiome predicted by PICRUSt2 showed higher relative abundance of genes related to biodegradation of nutrients in intestinal content. In contrast, the relative abundance of genes related to biosynthesis of important metabolites, such as menaquinols, was higher in intestinal wall. The difference in the microbial community structure of intestinal

4-12 Biochemistry & Molecular Biology; Ecology; Evolutionary Biology

Chemical constituents from the Antarctic lichen *Usnea aurantiaco-atra* and their chemotaxonomic significance

Phi, Kim-Hoa., So, Jae Eun., Kim, Ji Hee., Koo, Man Hyung., Kim, Jin-Hyoung., Kim, Dockyu., Lee, Jun Hyuck., Lee, Seulah. and Youn, Ui Joung.

Biochemical Systematics and Ecology. 2023. 106.

doi: 10.1016/j.bse.2022.104581.

Chemical investigation of the Antarctic lichen *Usnea aurantiaco-atra* led to the isolation and identification of eight compounds, including a dibenzofuran derivative (1), three phenolics (2, 7, 8), a p-terphenyl (3), and three sterols (4–6). The structures of the isolated compounds (1–8) were elucidated by ¹H and ¹³C NMR spectroscopic analyses and comparisons with previously reported data. All compounds (1–8) were isolated from this species for the first time. The current study is also the first report of the identification of two compounds, pentamethoxy-p-terphenyl and 9,11-dehydroergosterol peroxide, from the *Usnea* genus. Meanwhile, the chemotaxonomic value of all isolates is also discussed in this paper.

keywords:

Usnea aurantiaco-atra; Antarctic lichen; Dibenzofuran; Sterol; p-Terphenyl

4-13 Multidisciplinary Sciences

Chromosome-level genome assembly and annotation of the Antarctica whitefin plunderfish *Pogonophryne albinpinna*

Jo, Euna., Choi, Soyun., Lee, Seung Jae., Kim, Jinmu., Choi, Eun Kyung., Cho, Minjoo., Kim, Jangyeon., Chung, Sangdeok., Lee, Jaebong., Kim, Jeong-Hoon. and Park, Hyun.

Scientific Data. 2023. 10(1).

doi: 10.1038/s41597-023-02811-x.

The Antarctic whitefin plunderfish *Pogonophryne albinpinna* belongs to the family Artedidraconidae, a key component of Antarctic benthic ecosystems within the order Perciformes and the suborder Notothenioidei. While genome research on *P. albinpinna* using short-read sequencing is available, high-quality genome assembly and annotation employing long-read sequencing have yet to be performed. This study presents a chromosome-scale genome assembly and annotation for *P. albinpinna*, utilizing a combination of Illumina short-read, PacBio long-read, and Hi-C sequencing technologies. The resulting genome assembly spans approximately 1.07 Gb, with a longest scaffold measuring 59.39 Mb and an N50 length of 41.76 Mb. Of the 1,111 Hi-C scaffolds, 23 exceeded 10 Mb and were thus classified as chromosome-level. BUSCO completeness was assessed at 95.6%. The assembled genome comprises 50.68% repeat sequences, and a total of 31,128 protein-coding genes were predicted. This study will enhance our understanding of the genomic characteristics of cryonotothenioids and facilitate comparative analyses of their adaptation and evolution in extreme environments.

waters of the southern hemisphere. One of the features of the Gadiformes order is that they have a remarkably unique immune gene repertoire that influences innate and adaptive immunity, and they lack major histocompatibility complex (MHC) class II, invariant chains (CD74), and CD4 genes. In this study, a high-quality chromosome-level genome assembly was constructed, resulting in a final assembled genome of 893.75 Mb, with an N50 scaffold length of 30.07 Mb and the longest scaffold being 39.77 Mb. Twenty-five high-quality pseudochromosomes were assembled, and the complete BUSCO rate was 93.4%. A total of 34,553 genes were structurally annotated, and 27,691 genes were functionally annotated. Among the 10 primary genes involved in MHC class II, only two ERAP1 genes and one AIRE gene were identified through the genome study. Although no specific reason for the MHC class II deficiency has been identified, it has been shown that the toll-like receptors (TLRs), which are significant to the innate immune response, are significantly expanded in *M. orangiensis*. A total of 44 TLRs have been identified, with 32 TLR13 genes distributed evenly on six different pseudochromosomes. This study is the first to reveal the whole genome of a Muraenolepididae family and provides valuable insights into the potential rationale for the MHC class II deficiency in a Gadiformes fish species.

keywords:

Muraenolepis orangiensis; Gadiformes; MHC class II; CD4; CD74; TLRs

4-14 Environmental Sciences; Marine & Freshwater Biology

Chromosome-level genome assembly of Patagonian moray cod (*Muraenolepis orangiensis*) and immune deficiency of major histocompatibility complex (MHC) class II

Kim, Jinmu., Lee, Seung Jae., Jo, Euna., Choi, EunKyung., Cho, Minjoo., Choi, Soyun., Kim, Jeong-Hoon. and Park, Hyun.

Frontiers in Marine Science. 2023. 10.

doi: 10.3389/fmars.2023.1215125.

The Patagonian moray cod, *Muraenolepis orangiensis*, belongs to the family Muraenolepididae and is the sole order of Gadiformes that inhabits the temperate and cold

4-15 Microbiology

Comparative Genomic Analysis of Biofilm-Forming Polar *Microbacterium* sp. Strains PAMC22086 and PAMC21962 Isolated from Extreme Habitats

Kim, Byeollee., Gurung, Saru., Han, So-Ra., Lee, Jun-Hyuck. and Oh, Tae-Jin.

Microorganisms. 2023. 11(7).

doi: 10.3390/microorganisms11071757.

The members of *Microbacterium* isolated from different environments are known to form peptidoglycan. In this study, we compared the biofilm-forming abilities of *Microbacterium* sp. PAMC22086 (PAMC22086), which was isolated from the soil in the South Shetland Islands and *Microbacterium* sp. PAMC21962 (PAMC21962), which was isolated from algae in the South Shetland Islands. The analysis of average nucleotide identity and phylogeny of

PAMC22086 revealed a 97% similarity to *Microbacterium oxydans* VIU2A, while PAMC21962 showed a 99.1% similarity to *Microbacterium hominis* SGAir0570. For the comparative genomic analysis of PAMC22086 and PAMC21962, the genes related to biofilm formation were identified using EggNOG and KEGG pathway databases. The genes possessed by both PAMC22086 and PAMC21962 are *cpdA*, *phnB*, *rhIC*, and *glgC*, which regulate virulence, biofilm formation, and multicellular structure. Among the genes indirectly involved in biofilm formation, unlike PAMC21962, PAMC22086 possessed *csrA*, *glgC*, and *glgB*, which are responsible for attachment and glycogen biosynthesis. Additionally, in PAMC22086, additional functional genes *rsmA*, which is involved in mobility and polysaccharide production, and *dksA*, GTPase, and *oxyR*, which play roles in cell cycle and stress response, were identified. In addition, the biofilm-forming ability of the two isolates was examined in vivo using the standard crystal violet staining technique, and morphological differences in the biofilm were investigated. It is evident from the different distribution of biofilm-associated genes between the two strains that the bacteria can survive in different niches by employing distinct strategies. Both strains exhibit distinct morphologies. PAMC22086 forms a biofilm that attaches to the side, while PAMC21962 indicates growth starting from the center. The biofilm formation-related genes in *Microbacterium* are not well understood. However, it has been observed that *Microbacterium* species form biofilm regardless of the number of genes they possess. Through comparison between different *Microbacterium* species, it was revealed that specific core genes are involved in cell adhesion, which plays a crucial role in biofilm formation. This study provides a comprehensive profile of the *Microbacterium* genus's genomic features and a preliminary understanding of biofilm in this genus, laying the foundation for further research.

keywords:

comparative genomics; polar bacteria; biofilm production; *Microbacterium*; microtiter dish biofilm formation assay

4-16 Chemistry, Multidisciplinary; Crystallography; Materials Science, Multidisciplinary

Comparison of the structure and activity of thioredoxin 2 and thioredoxin 1 from *Acinetobacter baumannii*

Chang, Ye Ji., Sung, Ji Hye., Lee, Chang Sup., Lee, Jun Hyuck. and Park, Hyun Ho.

lucrj. 2023. 10: 147-155.

doi: 10.1107/s2052252523000404.

Thioredoxin (Trx) is essential in a redox-control system, with many bacteria containing two Trxs: Trx1 and Trx2. Due to a Trx system's critical function, Trxs are targets for novel antibiotics. Here, a 1.20 Å high-resolution structure of Trx2 from *Acinetobacter baumannii* (abTrx2), an antibiotic resistant pathogenic superbug, is elucidated. By comparing Trx1 and Trx2, it is revealed that the two Trxs possess similar activity, although Trx2 contains an additional N-terminal zinc-finger domain and exhibits more flexible properties in solution. Finally, it is shown that the Trx2 zinc-finger domain might be rotatable and that proper zinc coordination at the zinc-finger domain is critical to abTrx2 activity. This study enhances understanding of the Trx system and will facilitate the design of novel antibiotics.

keywords:

Acinetobacter baumannii; crystal structure; redox homeostasis; superbugs; thioredoxin; zinc-finger domains

4-17 Genetics & Heredity; Marine & Freshwater Biology

Complete genome of *Polaribacter huanghezhanensis* KCTC 32516^T isolated from glaciomarine fjord sediment of Svalbard

Hwang, Kyuin., Choe, Hanna. and Kim, Kyung Mo.

Marine Genomics. 2023. 72.

doi: 10.1016/j.margen.2023.101068.

Polaribacter huanghezhanensis KCTC 32516^T is an aerobic, non-flagellated, Gram-negative, orange-colony-forming bacterium that was isolated from the surficial glaciomarine sediment of inner basin of Kongsfjorden, Svalbard. The sampling site is characterized by a sedimentation of organic depleted lithogenous particles from the nearby glaciers, resulting in reduction of organic matter concentration. In order to understand microbial adaptation to the oligotrophic environment, we here sequenced the complete genome of the *P. huanghezhanensis* KCTC 32516^T. The genome consists of 2,587,874 bp (G+C content of 31.5%) with a single chromosome, 2391 protein-coding genes, 39 tRNAs, and 2 rRNA operons. Our comparative analysis revealed that the *P. huanghezhanensis* possess the smallest genome in fifteen *Polaribacter* species with genome. The streamlined genome of this species, required less resource in replication,

could evolved by the nutrient deficiency in surrounding environment. Simultaneously, the 15 KOs involved in amino acid biosynthesis and anaplerotic carbon fixation is uniquely absent in the *P. huanghezhanensis*. In addition, although the advantage of small genome, other 15 KOs involved in resource recycling and stress resistance is uniquely present in sequenced genome. This result demonstrates that the sequenced genome serves as a valuable model for further studies aimed at elucidating the molecular mechanisms associated with adaptation to oligotrophic habitat.

keywords:

Polar microbiology; Genome reduction; Oligotrophy; Auxotroph; Kongsfjorden

4-18

Complete genome sequence of plant-pathogenic *Pseudomonas* sp. G2-4 from rhizosphere soil in Northern Greenland

Woo, Sungho., Kim, Mincheol., Lee, Yung Mi. and Kim, Dockyu.

Korean Journal of Microbiology. 2023; 59(2): 154-157.

doi: 10.7845/kjm.2023.3045.

A novel bacterium, *Pseudomonas* sp. G2-4, was isolated from the rhizosphere soil of *Oxyria digyna* in Northern Greenland. This strain exhibited a notable ability to secrete strong extracellular proteases and was capable of developing brown spots on hot pepper leaves and soft rot on potatoes. The complete genome sequence of the phytopathogen G2-4 consisted of one circular chromosome with 6,651,895 bp (G + C content of 60.4%). Genomic analysis discovered 5,692 protein coding sequences (CDSs), among which one CDS was identified as a putative virulence factor responsible for encoding the extracellular protease. The extracellular proteolytic activity of G2-4 would at least partially contribute to the development of disease in the pepper and potato plants.

Keywords:

bacterial pathogen; cold-adopted; crop yield; global warming; permafrost soil

4-19

Complete Genome Sequence of the Antibiotic-Resistant *Pseudomonas fluorescens* Strain Ant01, from Rhizosphere of Antarctic Moss

Hwang, Jisub., Lee, Hyoungeok., Do, Hackwon., Lee, Sung Gu., Oh, Tae-Jin., and Lee, Jun-Hyuck.

Microbiology Resource Announcements. 12(1).

doi: 10.1128/mra.01057-22.

Pseudomonas fluorescens Ant01 was isolated as an antibiotic-resistant strain from the rhizosphere of a moss from Barton Peninsula, King George Island, Antarctica. The assembled genome size is 6,249,144 bp, with 5,616 protein-coding genes, 69 tRNA genes, and 19 rRNA genes.

4-20 *Genetics & Heredity*

Complete mitochondrial genome of *Trematomus newnesi* (Perciformes, Nototheniidae)

Nguyen, Phuong Thi., Lee, Seungyeon., Jeong, Jihye., Kim, Jihun., Han, Dong-Won., Kim, Il-Chan., Lee, Jun Hyuck., Park, Jisoo. and Kim, Jin-Hyoung.

Mitochondrial DNA Part B-Resources. 2023. 8(11): 1196-1199.

doi: 10.1080/23802359.2023.2194456.

The complete mitochondrial genome of *Trematomus newnesi* was sequenced using an Illumina platform. The 18,602 bp mitogenome contains 13 protein-coding genes, two rRNAs, and 23 tRNAs (tRNA^{Met} is duplicated). The eight stop codons are TAA, TAG, CTT, GTA, AAT, ACT, AGG, and TTA. Two start codons ATG and GTG are present. The GC content is 44.4% and AT content is 55.6%. A phylogenetic tree was generated using 13 species from three families. The results showed that *T. newnesi* is closely related to *Pagothenia borchgrevinki* in Nototheniidae. This study provides fundamental data for further genetic evolutionary studies on *T. newnesi*.

keywords:

Trematomus newnesi; mitochondrial genome; Antarctic fish; Notothenoid

4-21 Microbiology

Covariance of Marine Nucleocytoplasmic Large DNA Viruses with Eukaryotic Plankton Communities in the Sub-Arctic Kongsfjorden Ecosystem: A Metagenomic Analysis of Marine Microbial Ecosystems

Kim, Kang Eun., Joo, Hyoung Min., Lee, Taek-Kyun., Kim, Hyun-Jung., Kim, Yu Jin., Kim, Bo Kyung., Ha, Sun-Yong. and Jung, Seung Won. *Microorganisms*. 2023. 11(1).
doi: 10.3390/microorganisms11010169.

Nucleocytoplasmic large DNA viruses (NCLDV) infect various marine eukaryotes. However, little is known about NCLDV diversity and their relationships with eukaryotic hosts in marine environments, the elucidation of which will advance the current understanding of marine ecosystems. This study characterizes the interplay between NCLDVs and the eukaryotic plankton community (EPC) in the sub-Arctic area using metagenomics and metabarcoding to investigate NCLDVs and EPC, respectively, in the Kongsfjorden ecosystem of Svalbard (Norway) in April and June 2018. *Gyrodinium helveticum* (Dinophyceae) is the most prevalent eukaryotic taxon in the EPC in April, during which time *Mimiviridae* (31.8%), *Poxviridae* (25.1%), *Phycodnaviridae* (14.7%) and *Pandoraviridae* (13.1%) predominate. However, in June, the predominant taxon is *Aureococcus anophagefferens* (Pelagophyceae), and the CLDVs, *Poxviridae* (32.9%), *Mimiviridae* (29.1%), and *Phycodnaviridae* (18.5%) appear in higher proportions with an increase in Pelagophyceae, Bacillariophyceae, and Chlorophyta groups. Thus, differences in NCLDVs may be caused by changes in EPC composition in response to environmental changes, such as increases in water temperature and light intensity. Taken together, these findings are particularly relevant considering the anticipated impact of NCLDV-induced EPC control mechanisms on polar regions and, therefore, improve the understanding of the Sub-Arctic Kongsfjorden ecosystem.

keywords:

Aureococcus anophagefferens; eukaryotic plankton communities; *Gyrodinium helveticum*; metagenomics; nucleocytoplasmic large DNA viruses; sub-arctic sea

(BaCYP106A6) from *Bacillus* Species

Kim, Ki-Hwa., Do, Hackwon., Lee, Chang Woo., Subedi, Pradeep., Choi, Mieyoung., Nam, Yewon., Lee, Jun Hyuck. and Oh, Tae-Jin. *Journal of Microbiology and Biotechnology*. 2023. 33(3): 387-397.
doi: 10.4014/jmb.2211.11031.

Cytochrome P450 (CYP) is a heme-containing enzyme that catalyzes hydroxylation reactions with various substrate molecules. Steroid hydroxylases are particularly useful for effectively introducing hydroxyl groups into a wide range of steroids in the pharmaceutical industry. This study reports a newly identified CYP steroid hydroxylase (*BaCYP106A6*) from the bacterium *Bacillus* sp. and characterizes it using an in vitro enzyme assay and structural investigation. Bioconversion assays indicated that *BaCYP106A1* catalyzes the hydroxylation of progesterone and androstenedione, whereas no or low conversion was observed with 11 β -hydroxysteroids such as cortisol, corticosterone, dexamethasone, and prednisolone. In addition, the crystal structure of *BaCYP106A6* was determined at a resolution of 2.8 Å to investigate the configuration of the substrate-binding site and understand substrate preference. This structural characterization and comparison with other bacterial steroid hydroxylase CYPs allowed us to identify a unique Arg295 residue that may serve as the key residue for substrate specificity and regioselectivity in *BaCYP106A6*. This observation provides valuable background for further protein engineering to design commercially useful CYP steroid hydroxylases with different substrate specificities.

keywords:

Crystal structure; cytochrome P450; steroid hydroxylase; X-ray crystallography

4-23 Multidisciplinary Sciences

Crystal structure and biochemical analysis of acetylesterase (LgEstI) from *Lactococcus garvieae*

Do, Hackwon., Yoo, Wanki., Wang, Ying., Nam, Yewon., Shin, Seung Chul., Kim, Han-Woo., Kim, Kyeong Kyu. and Lee, Jun Hyuck. *Plos One*. 2023. 18(2).
doi: 10.1371/journal.pone.0280988.

Esterase, a member of the serine hydrolase family, catalyzes the cleavage and formation of ester bonds with high regio- and stereospecificity, making them attractive biocatalysts for the synthesis of optically pure

4-22 Biotechnology & Applied Microbiology; Microbiology

Crystal Structure and Biochemical Analysis of a Cytochrome P450 Steroid Hydroxylase

molecules. In this study, we performed an in-depth biochemical and structural characterization of a novel microbial acetyl esterase, *LgEstI*, from the bacterial fish pathogen *Lactococcus garvieae*. The dimeric *LgEstI* displayed substrate preference for the short acyl chain of *p*-nitrophenyl esters and exhibited increased activity with F207A mutation. Comparative analysis with other esterases indicated that *LgEstI* has a narrow and shallow active site that may exhibit substrate specificity to short acyl chains. Unlike other esterases, *LgEstI* contains bulky residues such as Trp89, Phe194, and Trp217, which block the acyl chain channel. Furthermore, immobilized *LgEstI* retained approximately 90% of its initial activity, indicating its potential in industrial applications. This study expands our understanding of *LgEstI* and proposes novel ideas for improving its catalytic efficiency and substrate specificity for various applications.

4-24 Crystallography; Materials Science, Multidisciplinary

Crystal Structure and Functional Characterization of an S-Formylglutathione Hydrolase (*BuSFGH*) from *Burkholderiaceae* sp.

Hwang, Jisub., Do, Hackwon., Shim, Youn-Soo. and Lee, Jun Hyuck.
Crystals. 2023. 13(4).
 doi: 10.3390/cryst13040621.

S-formylglutathione hydrolases (SFGHs) catalyze the hydrolysis of S-formylglutathione to formate and glutathione using the conserved serine hydrolase catalytic triad residues (Ser-His-Asp). SFGHs have broad substrate specificity, including, for example, ester bond-containing substrates. Here, we report the crystal structure of *Burkholderiaceae* sp. SFGH (*BuSFGH*) at 1.73 Å resolution. Structural analysis showed that the overall structure of *BuSFGH* has a typical α/β hydrolase fold, with a central β -sheet surrounded by α -helices. Analytical ultracentrifugation analysis showed that *BuSFGH* formed a stable dimer in solution. The enzyme activity assay indicated that *BuSFGH* has a high preference for short-chain *p*-nitrophenyl esters, such as *p*-nitrophenyl acetate. The activity of *BuSFGH* toward *p*-nitrophenyl acetate was five times higher than that of *p*-nitrophenyl butylate. Molecular modeling studies on the *p*-nitrophenyl acetate-bound *BuSFGH* structure indicate that Gly52, Leu53, Trp96, His147, Ser148, Trp182, Phe228, and His259 residues may be crucial for substrate binding. Collectively, these results are useful for understanding the substrate-binding mechanism and substrate specificity of *BuSFGH*. They can also provide useful insights for designing modified *BuSFGH*s with

different substrate specificities.

keywords:

crystal structure; dimer; S-formylglutathione hydrolase; X-ray crystallography

4-25 Crystallography; Materials Science, Multidisciplinary

Crystal Structure and Sequence Analysis of N⁵, N¹⁰-Methylenetetrahydrofolate Dehydrogenase/Cyclohydrolase Enzyme from *Porphyromonas gingivalis*

Im, Sehyeok., Do, Hackwon., Hwang, Jisub., Shim, Youn-Soo. and Lee, Jun Hyuck.
Crystals. 2023. 13(10).
 doi: 10.3390/cryst13101489.

The methylenetetrahydrofolate dehydrogenase–cyclohydrolase (FolD) enzyme has a dual activity of N⁵,N¹⁰-methylenetetrahydrofolate dehydrogenase and cyclohydrolase. This enzyme plays a critical role in the chemical modification of tetrahydrofolate, which is an important coenzyme involved in the synthesis of DNA, RNA, and amino acids. Therefore, bacterial FolD has been studied as a potential drug target for the development of antibiotics. Here, we determined the crystal structure of FolD (*PgFolD*) from the oral pathogen *Porphyromonas gingivalis* at 2.05 Å resolution using the molecular replacement method. The crystal structure of *PgFolD* was successfully refined to a crystallographic R-factor of 21.4% ($R_{\text{free}} = 23.8\%$). The crystals belong to the space group of P₄₃22 with the unit cell parameters of *a* = 110.7 Å, *b* = 110.7 Å, and *c* = 69.8 Å, containing one subunit in the asymmetric unit. Our analytical size-exclusion chromatography results indicated that *PgFolD* forms a stable dimer in solution. Additionally, structural and sequence comparison studies with previously known FolDs revealed that *PgFolD* has a different substrate-binding site residue composition. These findings provide valuable insights for the structure-based development of specific inhibitors against the *Porphyromonas gingivalis* pathogen.

keywords:

crystal structure; drug target; *PgFolD*; X-ray crystallography

4-26 Crystallography; Materials Science, Multidisciplinary

Crystal Structure of Aspartate Semialdehyde Dehydrogenase from *Porphyromonas gingivalis*

Hwang, Jisub., Do, Hackwon., Shim, Youn-Soo. and Lee, Jun Hyuck. *Crystals*. 2023. 13(8).

doi: 10.3390/cryst13081274.

Aspartate semialdehyde dehydrogenase (ASADH) catalyzes the biosynthesis of several essential amino acids, including lysine, methionine, and threonine, and bacterial cell components. Thus, ASADH is a crucial target for developing new antimicrobial agents that can potentially disrupt the biosynthesis of essential amino acids, thereby inhibiting the growth of pathogens. Herein, the crystal structures of ASADH obtained from *Porphyromonas gingivalis* (PgASADH, UniProtKB code A0A1R4DY25) were determined in apo- and adenosine-2'-5'-diphosphate (2',5'-ADP)-bound complex forms at a resolution of 1.73 Å. The apo- and 2',5'-ADP-complexed crystals of PgASADH belonged to the space groups of I2₁2₁2₁ and C222₁, respectively. Analytical size-exclusion chromatography showed a stable PgASADH dimer in a solution. Clustering analysis and structural comparison studies performed on PgASADH and previously known ASADHs revealed that ASADHs, including PgASADH, can be classified into three types depending on sequential and structural differences at the α-helical subdomain region. These findings provide valuable insights into developing structure-based species-specific new antibacterial drugs against the oral pathogen *P. gingivalis*.

keywords:

crystal structure; oral pathogen; PgASADH; X-ray crystallography

4-27 Biochemistry & Molecular Biology; Ecology; Evolutionary Biology

Cyclic dipeptides and alkaloids from the rare actinobacteria *Streptacidiphilus carbonis* isolated from *Sphaerophorus globosus* (Huds.) Vain

Koo, Man Hyung., Kim, Eun Jae., Lee, Jun Hyuck., Han, Se Jong., Lee, Yung Mi., Lee, Seulah. and Youn, Ui Joung.

Biochemical Systematics and Ecology. 2023. 110.

doi: 10.1016/j.bse.2023.104709.

Eight compounds were isolated from the rare

actinobacteria *Streptacidiphilus carbonis* isolated from the lichen *Sphaerophorus globosus* (Huds.) Vain. collected from the Antarctic. The isolated compounds include four cyclic dipeptides (1–4) and four alkaloids (5–8), and the structures of these compounds were determined by spectroscopic analysis of NMR and MS, and by comparing with the reported data. All of the isolates (1–8) were reported for the first time from *S. carbonis*. The chemotaxonomical significance of the isolated constituents is also discussed.

keywords:

Streptacidiphilus carbonis; Actinobacteria; Cyclic dipeptide; Streptomycetaceae; Antarctic bacteria

4-28 Food Science & Technology

DB3 from Antarctic lichen inhibits the growth of B16F10 melanoma cells in vitro and in vivo

Choi, Seyeon., Kim, Huiji., Shin, Seong-Ah., Kim, Moonsu., Moon, Sun Young., Kim, Minji., Lee, Seulah., Lee, Jun Hyuck., Park, Hyun Ho., Youn, Ui Joung. and Lee, Chang Sup.

Applied Biological Chemistry. 2023. 66(1).

doi: 10.1186/s13765-023-00835-w.

Malignant melanoma is a fatal disease with an increasing global incidence. Despite numerous studies focused on anti-cancer drugs, a variety of side effects of cancer treatment remain challenging. Thus, there is a pressing need to identify novel anti-cancer agents with minimal cytotoxicity and side effects. DB3 (1,3,7,9-tetrahydroxy-2,8-dimethyl-4,6-di[ethanoyl]dibenzofuran) is a member of the dibenzofuran family and is extracted from *Ramalina terebrata* (Antarctic lichen). We investigated if DB3 exerted an antitumor effect on B16F10 melanoma cells. The results revealed that DB3 exerted time- and dose-dependent reduction of cell viability by inducing apoptosis and significantly suppressing cell proliferation through cell cycle arrest in the G0/G1 phase in B16F10 melanoma cells. Additionally, DB3 impeded the migration and invasiveness of B16F10 cells. Subsequently, we observed that DB3 decreased the expression levels of Cdk4/Cyclin D1 and the phosphorylation of p38, JNK, ERK, and AKT. Furthermore, DB3 decreased melanoma tumor growth in a mouse tumor syngraft model. Based on these findings, we propose that DB3 possesses potential for use as an anti-cancer agent for melanoma treatment.

keywords:

Anti-cancer; DB3; Proliferation; Migration; Invasion

4-29 *Plant Sciences***De Novo Transcriptome Assembly and Comparative Analysis of Differentially Expressed Genes Involved in Cold Acclimation and Freezing Tolerance of the Arctic Moss *Aulacomnium turgidum* (Wahlenb.) Schwaegr**

Kang, Pilsung., Yoo, Yo-Han., Kim, Dong-Il., Yim, Joung Han. and Lee, Hyoungseok.

Plants-Basel. 2023. 12(6).

doi: 10.3390/plants12061250.

Cold acclimation refers to a phenomenon in which plants become more tolerant to freezing after exposure to non-lethal low temperatures. *Aulacomnium turgidum* (Wahlenb.) Schwaegr is a moss found in the Arctic that can be used to study the freezing tolerance of bryophytes. To improve our understanding of the cold acclimation effect on the freezing tolerance of *A. turgidum*, we compared the electrolyte leakage of protonema grown at 25 °C (non-acclimation; NA) and at 4 °C (cold acclimation; CA). Freezing damage was significantly lower in CA plants frozen at –12 °C (CA-12) than in NA plants frozen at –12 °C (NA-12). During recovery at 25 °C, CA-12 demonstrated a more rapid and greater level of the maximum photochemical efficiency of photosystem II than NA-12, indicating a greater recovery capacity for CA-12 compared to NA-12. For the comparative analysis of the transcriptome between NA-12 and CA-12, six cDNA libraries were constructed in triplicate, and RNA-seq reads were assembled into 45,796 unigenes. The differential gene expression analysis showed that a significant number of AP2 transcription factor genes and pentatricopeptide repeat protein-coding genes related to abiotic stress and the sugar metabolism pathway were upregulated in CA-12. Furthermore, starch and maltose concentrations increased in CA-12, suggesting that cold acclimation increases freezing tolerance and protects photosynthetic efficiency through the accumulation of starch and maltose in *A. turgidum*. A de novo assembled transcriptome can be used to explore genetic sources in non-model organisms.

keywords:

Aulacomnium turgidum; cold acclimation; de novo assembly; freezing stress; RNA-seq

4-30**Depolymerization and decomplexation of soil humic acids by an Antarctic *Pseudomonas* strain**Kim, Dockyu., Youn, Ui Joung., Kim, Eungbin. and Lee, Hyoungseok. *Korean Journal of Microbiology*. 59(4).

doi: 10.7845/kjm.2023.3083.

With recent rapid warming in the maritime Antarctic, the susceptibility of soil organic matter to microbial decomposition is an emerging topic related to CO₂ emission and vegetation changes. Soil humic acids (HA) enter the Antarctic ecosystems as small-soluble organic compounds resulting from microbial decomposition. Antarctic and commercial HAs were incubated with Antarctic *Pseudomonas* sp. PAMC 29040 with an esterase activity and structural changes in the resulting HA samples were then investigated. Gel permeation chromatography revealed the depolymerization of the large molecular fractions of both Antarctic and commercial HAs. Solid-state ¹³C-nuclear magnetic resonance spectroscopy showed an increase in the aromaticity degree which can be attributed to the increased intensity of aromatic-C signals upon the cleavage of interior C–C and C–O–C linkages (e.g., decomplexation by esterase activity), while the Fourier-transform infrared spectroscopy did not provide any information on the changes in the functional groups, such as Ar–OH and Ar–COOH, or bonding patterns in the HAs. To the best of our knowledge, this is the first report showing direct evidence of HA decomposition capacity by soil bacteria in an Antarctic terrestrial ecosystem.

Keywords:

Pseudomonas; Antarctic tundra; bacterial degradation; humic substances; structural changes

4-31**Distribution characteristics of Antarctic silverfish (*Pleuragramma antarcticum*) in the Ross Sea, Antarctica**

Lee, Sara., Oh, Wooseok., La, Hyoungsul., Son, Wuju., Kim, Jeong-Hoon. and Lee, Kyoungmoon.,

Journal of the Korean Society of Fisheries Technology. 2023. 59(2).

doi: 10.3796/KSFOT.2023.59.2.117.

This study used hydroacoustic method to identify the

vertical and horizontal distribution of Antarctic silverfish in the Ross Sea, Antarctica. In February and December 2018, Antarctic silverfish was detected up to 250 meters, and was mainly distributed in water depths of 20 to 30 meters. The horizontal distribution of Antarctic silverfish was mostly undetected in February, and December showed a relatively stronger distribution than that of February. Antarctic silverfish is characterized by their distribution near sea ice.

keywords:

Ross sea; Antarctic silverfish; Hydroacoustic survey; Mean volume backscattering strength

4-32

Distribution of Colored Dissolved Organic Matter (CDOM) in Marian Cove, King George Island, Antarctica During the Summer Season

Lee, Boyeon., Min, Jun-Oh., Kim, Bo Kyung., Shim, Chorom. and Ha, Sun-Yong.

Journal of the Korean Society for Marine Environment & Energy. 2023. 26(3).

doi: 10.7846/JKOSMEE.2023.26.3.282.

Rapid climate change is progressing in the Antarctic coastal area and has various influences on the environmental conditions. The spatiotemporal distribution and the source of colored dissolved organic matter (CDOM) were investigated in Marian Cove, King George Island, Antarctica, during the summer season in 2019 and 2020. The temperature in 2019 and 2020 were $0.42 \sim 1.44$, $-0.02 \sim 2.48$ °C, respectively, while salinity was 34.1 ± 0.16 psu in 2019 and 33.9 ± 0.41 psu in 2020. Phytoplankton biomass (chlorophyll-a, Chl-a) in 2020 was 1.49 ± 1.22 $\mu\text{g L}^{-1}$ which was two times higher than in 2019 (0.65 ± 0.61 $\mu\text{g L}^{-1}$). The absorption coefficient at 355 nm (aCDOM(355)) showed a wide range of $0.17 \sim 10.59$ m^{-1} in 2019, and a significantly lower value of $0.04 \sim 0.50$ m^{-1} in 2020. CDOM was positively correlated with salinity ($r_s=0.55$, $p<0.05$) and the whole water column was vertically and horizontally well-mixed, suggesting that CDOM in Marian Cove mostly originated from the organic matter in the influent from Maxwell Bay. There may be a resuspension of sediments accompanied by tidal current or wind in the cove, which probably contributed to the increase in CDOM at the bottom. These results imply that organic matter changes in Marian Cove, which exhibits narrow and shallow topography, are mainly driven by physical factors. Long-term monitoring of CDOM may provide fundamental data for understanding

climate-related organic matter cycles.

keywords:

Colored dissolved organic matter(CDOM); Marian Cove; Antarctica; Organic matter cycle

4-33 Immunology

Editorial: Structural immunology of molecular innate immunity

Lee, Jun Hyuck. and 2 others.

Frontiers in Immunology. 2023. 14.

doi: 10.3389/fimmu.2023.1284121.

keywords:

cGAS-STING; complement receptors; innate immunity; structure; TLR

4-34

Effect of Water Temperature, Fish Age, and MS-222 Concentration on the Anesthetization of River Pufferfish, *Takifugu obscurus*

Lee, Seungyeon., Nguyen, Phuong Thi., Song, Ho-Kyung., Hur, Sung Pyo. and Kim, Jin-Hyung.

Korean Journal of Ichthyology. 2023. 35(2).

doi: 10.35399/ISK.35.2.1.

The river pufferfish (*Takifugu obscurus*) is a valuable species in aquaculture and genetic studies. Usage of fish anesthetics aids in the easier handling of fish during aquaculture. However, there are no studies on appropriate conditions required for effective anesthetization of pufferfish. This study aims to determine the optimal conditions (fish age, water temperature, anesthetic concentration) needed for the most common fish anesthesia, MS-222, to anesthetize *T. obscurus*. We tested three different water temperatures (20°C, 24°C, and 28°C), three different anesthetic concentrations (125 mg/L, 150 mg/L, and 175 mg/L), and two different fish ages (one- and two-year-old). Appropriate anesthetization conditions for *T. obscurus* ranged from 150 mg/L to 175 mg/L of MS-222 at 24°C to 28°C for one-year-old fish. For two-year-old fish, the appropriate conditions ranged from 150 mg/L to 175 mg/L of MS-222 at 28°C. However, to minimize

side effects and risks, 150 mg/L of MS-222 at 24°C for one-year-old fish and 175 mg/L of MS-222 at 28°C for two-year-old fish are recommended for effective anesthetization.

keywords:

River pufferfish; Takifugu obscurus; anesthesia; recovery; MS-222

4-35 *Geosciences, Multidisciplinary; Soil Science; Water Resources*

Effects of deglaciation on the succession of methanotrophic communities in inland and tidewater glaciers in the high Arctic, Svalbard

Yun, Jeongeun., Yang, Yerang., Zhou, Xue., Lee, Jaehyun., Choi, Jiwon., Kim, Mincheol., Gyeong, Hyeryeon., and 2 others.

Catena. 2023. 231.

doi: 10.1016/j.catena.2023.107267.

The high Arctic region of Svalbard has undergone significant landscape transformations due to accelerated deglaciation driven by climate warming. The expansion of exposed soil surfaces during rapid deglaciation provides new habitats for plants and microorganisms and contributes to ecosystem succession. The primary succession process has the potential to impact methane flux by influencing the activities of methanotrophs and methanogens. While the primary succession of plant communities following glacier retreat has been extensively studied, microbial succession, in particular that of methanotrophs and methanogens, is still poorly understood. Moreover, previous investigations have focused on the forelands of inland or mountainous glaciers, neglecting those of tidewater glaciers that extend to the coastal line. In this study, we investigated the abundance of methanotrophs and methanogens, as well as methanotrophic communities along a 100-year soil chronosequence in the forelands of inland and tidewater glaciers in Svalbard. The abundance of methanotrophs showed a gradual increase with soil age in both glacier types, while the abundance of methanogens exhibited significant differences only in tidewater glaciers. Our results revealed clear trends in the structure of methanotrophic communities with an increase in their diversity during the deglaciation process in both glacier types. These trends were mediated by changes in soil physicochemical properties such as soil organic carbon and total nitrogen. Our findings indicate that methane oxidation may be enhanced by the increase in the abundance and diversity of methanotrophs in both glacier

types throughout the successional stages, and that carbon and nitrogen contents play a crucial role in structuring the community at different stages of succession in the glacier forefield. These insights significantly contribute to our understanding of microbial dynamics during deglaciation and their implications for methane dynamics in the high Arctic.

keywords:

Climate change; Glacier retreat; Succession; Arctic; Methanotrophs

4-36 *Ecology; Marine & Freshwater Biology*

Effects of temperature and starvation on life history traits and fatty acid profiles of the Antarctic copepod *Tigriopus kingsejongensis*

Yoon, Deok-Seo., Choi, Hyuntae., Sayed, Alaa El Din H., Shin, Kyung-Hoon., Yim, Joung Han., Kim, Sanghee. and 2 others.

Regional Studies in Marine Science. 2023. 57.

doi: 10.1016/j.rsma.2022.102743.

Changes in temperature and starvation are stressors that can modulate metabolism and fatty acid (FA) composition among zooplankton. However, studies on FA modulation have not been conducted on Antarctic zooplankton. In this study, we aimed to understand the changes in life history parameters and FA profiles associated with starvation at four temperatures (4, 8, 14, and 18 °C) in the Antarctic copepod *Tigriopus kingsejongensis*. In our results, higher temperatures accelerated the development of *T. kingsejongensis* and increased total offspring. In addition, the production of reactive oxygen species increased with temperature, reflecting an increase in metabolic rate. FA analysis revealed that starvation and higher temperatures decreased the polyunsaturated fatty acid (PUFA) proportion but increased the saturated fatty acid proportion of *T. kingsejongensis*. Even though the proportion of other PUFAs decreased, docosahexaenoic acid and docosapentaenoic acid were increased by starvation and higher temperatures. Our data provide a better understanding of FA regulation in Antarctic copepods in response to external stressors.

keywords:

Antarctic copepod; *Tigriopus kingsejongensis*; Temperature; Fatty acid profile; Life history traits

4-37 Microbiology

Elucidation of cold adaptation in *Glaciimonas* sp. PAMC28666 with special focus on trehalose biosynthesis

Shrestha, Prasansah., Karmacharya, Jayram., Han, So-Ra., Lee, Jun Hyuck. and Oh, Tae-Jin.

Frontiers in Microbiology. 2023. 14.

doi: 10.3389/fmicb.2023.1280775.

Glaciimonas sp. PAMC28666, an extremophilic bacterium thriving in Antarctic soil and belonging to the *Oxalobacteraceae* family, represents the only complete genome of its genus available in the NCBI database. Its genome measures 5.2 Mb and comprises 4,476 genes (4,350 protein-coding and 72 non-coding). Phylogenetic analysis shows the strain PAMC28666 in a unique branch within the genus *Glaciimonas*, closely related to *Glaciimonas* alpine Cr9-12, supported by robust bootstrap values. In addition, strain PAMC28666 showed 77.08 and 23.3% ANI and DDH, respectively, with *Glaciimonas* sp. PCH181. This study focuses on how polar strain PAMC28666 responds to freeze-thaw conditions. Experimental results revealed a notable survival rate of 47.28% when subjected to a temperature of 15°C for a period of 10 days. Notably, two genes known to be responsive to cold stress, Trehalose 6-phosphate synthase (*otsA*) and Trehalose 6-phosphate phosphatase (*otsB*), exhibited increased expression levels as the temperature shifted from 25°C to 15°C. The upregulation of *otsAB* and the consequent synthesis of trehalose play pivotal roles in enhancing the cold resistance of strain PAMC28666, offering valuable insights into the correlation between trehalose production and adaptation to cold stress. Furthermore, research into this neglected cold-adapted variation, like *Glaciimonas* sp. PAMC28666, has the potential to shed light on how trehalose is produced in cold-adapted environments. Additionally, there is potential to extract trehalose compounds from this strain for diverse biotechnological applications, including food and cosmetics, with ongoing research exploring its unique properties.

keywords:

Antarctica; cold shock proteins; extremophiles; *Glaciimonas* sp.; trehalose biosynthesis

Emerging Immune Checkpoint Molecules on Cancer Cells: CD24 and CD200

Moon, Sun Young., Han, Minjoo., Ryu, Gyoungah., Shin, Seong-Ah., Lee, Jun Hyuck. and Lee, Chang Sup.

International Journal of Molecular Sciences. 2023. 24(20).

doi: 10.3390/ijms242015072.

Cancer immunotherapy strategies are based on the utilization of immune checkpoint inhibitors to instigate an antitumor immune response. The efficacy of immune checkpoint blockade, directed at adaptive immune checkpoints, has been demonstrated in select cancer types. However, only a limited subset of patients has exhibited definitive outcomes characterized by a sustained response after discontinuation of therapy. Recent investigations have highlighted the significance of immune checkpoint molecules that are overexpressed in cancer cells and inhibit myeloid lineage immune cells within a tumor microenvironment. These checkpoints are identified as potential targets for anticancer immune responses. Notably, the immune checkpoint molecules CD24 and CD200 have garnered attention owing to their involvement in tumor immune evasion. CD24 and CD200 are overexpressed across diverse cancer types and serve as signaling checkpoints by engaging their respective receptors, Siglec-10 and CD200 receptor, which are expressed on tumor-associated myeloid cells. In this review, we summarized and discussed the latest advancements and insights into CD24 and CD200 as emergent immune checkpoint moieties, further delving into their therapeutic potentials for cancer treatment.

keywords:

immune checkpoint molecules; CD24; CD200; Siglec-10; CD200 receptor

4-39 Microbiology

Environmental Adaptation of Psychrophilic Bacteria *Subtercola* spp. Isolated from Various Cryospheric Habitats

Lee, Hanbyul., Cho, Yong-Joon., Cho, Ahnna. and Kim, Ok-Sun.

Journal of Microbiology. 2023. 61(7): 663-672.

doi: 10.1007/s12275-023-00068-y.

Subtercola boreus K300^T is a novel psychrophilic strain that was isolated from permanently cold groundwater in Finland and has also been found in several places in

4-38 Biochemistry & Molecular Biology; Chemistry, Multidisciplinary

Antarctica including lake, soil, and rocks. We performed genomic and transcriptomic analyses of 5 strains from Antarctica and a type strain to understand their adaptation to different environments. Interestingly, the isolates from rocks showed a low growth rate and smaller genome size than strains from the other isolation sources (lake, soil, and groundwater). Based on these habitat-dependent characteristics, the strains could be classified into two ecotypes, which showed differences in energy production, signal transduction, and transcription in the clusters of orthologous groups of proteins (COGs) functional category. In addition, expression pattern changes revealed differences in metabolic processes, including uric acid metabolism, DNA repair, major facilitator superfamily (MFS) transporters, and xylose degradation, depending on the nutritional status of their habitats. These findings provide crucial insights into the environmental adaptation of bacteria, highlighting genetic diversity and regulatory mechanisms that enable them to thrive in the cryosphere.

keywords:

Adaptation; Psychrophile *Subtercola* spp.; Ecotype; Comparative genomics; Transcriptome; Cryosphere

4-40 *Biochemistry & Molecular Biology; Chemistry, Multidisciplinary*

Feruloyl Esterase (LaFae) from *Lactobacillus acidophilus*: Structural Insights and Functional Characterization for Application in Ferulic Acid Production

Jeon, Sangeun., Hwang, Jisub., Do, Hackwon., Le, Ly Thi Huong Luu., Lee, Chang Woo., Yoo, Wanki., Lee, Min Ju., Shin, Seung Chul., Kim, Kyeong Kyu., Kim, Han-Woo. and Lee, Jun Hyuck.

International Journal of Molecular Sciences. 2023. 24(13).

doi: 10.3390/ijms241311170.

Ferulic acid and related hydroxycinnamic acids, used as antioxidants and preservatives in the food, cosmetic, pharmaceutical and biotechnology industries, are among the most abundant phenolic compounds present in plant biomass. Identification of novel compounds that can produce ferulic acid and hydroxycinnamic acids, that are safe and can be mass-produced, is critical for the sustainability of these industries. In this study, we aimed to obtain and characterize a feruloyl esterase (*LaFae*) from *Lactobacillus acidophilus*. Our results demonstrated that *LaFae* reacts with ethyl ferulate and can be used to effectively produce ferulic acid from

wheat bran, rice bran and corn stalks. In addition, xylanase supplementation was found to enhance *LaFae* enzymatic hydrolysis, thereby augmenting ferulic acid production. To further investigate the active site configuration of *LaFae*, crystal structures of unliganded and ethyl ferulate-bound *LaFae* were determined at 2.3 and 2.19 Å resolutions, respectively. Structural analysis shows that a Phe34 residue, located at the active site entrance, acts as a gatekeeper residue and controls substrate binding. Mutating this Phe34 to Ala produced an approximately 1.6-fold increase in *LaFae* activity against *p*-nitrophenyl butyrate. Our results highlight the considerable application potential of *LaFae* to produce ferulic acid from plant biomass and agricultural by-products.

keywords:

crystal structure; *LaFae*; ferulic acid; feruloyl esterase; X-ray crystallography

4-41 *Multidisciplinary Sciences*

Flyways and migratory behaviour of the Vega gull (*Larus vegae*), a little-known Arctic endemic

Gilg, Olivier., van Bemmelen, Rob S. A., Lee, Hansoo., Park, Jin-Young., Kim, Hwa-Jung., Kim, Dong-Won., Lee, Won Young. and 2 others.

Plos One. 2023. 18(2).

doi: 10.1371/journal.pone.0281827.

Large gulls are generalist predators that play an important role in Arctic food webs. Describing the migratory patterns and phenology of these predators is essential to understanding how Arctic ecosystems function. However, from all six large Arctic gull taxa, including three long-distance migrants, to date seasonal movements have been studied only in three and with small sample sizes. To document the flyways and migratory behaviour of the Vega gull, a widespread but little-studied Siberian migrant, we monitored 28 individuals with GPS loggers over a mean period of 383 days. Birds used similar routes in spring and autumn, preferring coastal to inland or offshore routes, and travelled 4000 – 5500 km between their breeding (Siberia) and wintering grounds (mainly the Republic of Korea and Japan). Spring migration mainly occurred in May, and was twice as fast and more synchronized among individuals than autumn migration. Migration bouts mainly occurred during the day and twilight, but rates of travel were always higher during the few night flights. Flight altitudes were nearly always higher during migration bouts than during other

bouts, and lower during twilight than during night or day. Altitudes above 2000m were recorded during migrations, when birds made non-stop inland flights over mountain ranges and vast stretches of the boreal forest. Individuals showed high inter-annual consistency in their movements in winter and summer, indicating strong site fidelity to their breeding and wintering sites. Within-individual variation was similar in spring and autumn, but between individual variation was higher in autumn than in spring. Compared to previous studies, our results suggest that the timing of spring migration in large Arctic gulls is likely constrained by snowmelt at breeding grounds, while the duration of migration windows could be related to the proportion of inland versus coastal habitats found along their flyways ('fly-and-forage' strategy). Ongoing environmental changes are hence likely in short term to alter the timing of their migration, and in long term possibly affect the duration if e.g. the resource availability along the route changes in the future.

4-42 *Biochemistry & Molecular Biology; Chemistry, Medicinal; Food Science & Technology*

GmMPK6 Positively Regulates Salt Tolerance through Induction of *GmRbohI1* in Soybean

Son, Seungmin., Kim, Jitae., An, Chung Sun., Kim, Song Lim., Lee, Hyoungeok. and Im, Jong Hee.

Antioxidants. 2023. 12(3).

doi: 10.3390/antiox12030601.

Salt stress is a critical environmental stress that impairs plant growth and development, especially in crop productivity; therefore, understanding the salt response in plants is the basis for their development of salt tolerance. Under salinity, soybean mitogen-activated protein kinase 6 (GmMPK6) is activated and positively regulates reactive oxygen species (ROS) generation. However, it is not yet elucidated how GmMPK6 regulates ROS generation and its role in salt tolerance. Here, we show that GmMPK6, solely activated in NaCl treatment, and gene expression of *GmRbohI1* was not only reduced by MPK inhibitor SB202190 in NaCl treatment, but also increased in a GMKK1-expressing protoplast. Furthermore, SB202190 and the NADPH-oxidase inhibitor, diphenyleneiodonium chloride, increased susceptibility to salt stress. The expression of *GmRD19A* was induced by NaCl treatment, but this expression was compromised by SB202190. Consequently, we revealed that GmMPK6 induces ROS generation through

the transcriptional regulation of *GmRbohI1* and increases salt tolerance in soybean.

keywords:

mitogen-activated protein kinase; reactive oxygen species; respiratory burst oxidase homolog; salt stress; soybean

4-43 *Biotechnology & Applied Microbiology; Microbiology*

H₂O₂-Driven Hydroxylation of Steroids Catalyzed by Cytochrome P450 CYP105D18: Exploration of the Substrate Access Channel

Pardhe, Bashu Dev., Kwon, Kyoung Pyo., Park, Jong Kook., Lee, Jun Hyuck. and Oh, Tae-Jin.

Applied and Environmental Microbiology. 2023. 89(1).

doi: 10.1128/aem.01585-22.

CYP105D18 supports H₂O₂ as an oxygen surrogate for catalysis well and shows high H₂O₂ resistance capacity. We report the hydroxylation of different steroids using H₂O₂ as a cosubstrate. Testosterone was regiospecifically hydroxylated to 2 β -hydroxytestosterone. Based on the experimental data and molecular docking, we predicted that hydroxylation of methyl testosterone and nandrolone would occur at position 2 in the A-ring, while hydroxylation of androstenedione and adrenosterone was predicted to occur in the B-ring. Further, structure-guided rational design of the substrate access channel was performed with the mutagenesis of residues S63, R82, and F184. Among the mutants, S63A showed a marked decrease in product formation, while F184A showed a significant increase in product formation in testosterone, nandrolone, methyl testosterone, androstenedione, and adrenosterone. The catalytic efficiency (k_{cat}/K_m) toward testosterone was increased 1.36-fold in the F184A mutant over that in the wild-type enzyme. These findings might facilitate the potential use of CYP105D18 and further engineering to establish the basis of biotechnological applications.

keywords:

cytochrome P450; H₂O₂-driven hydroxylation; site-directed mutagenesis; steroid

4-44 *Biochemical Research Methods; Biochemistry & Molecular Biology; Biotechnology & Applied Microbiology*

Heterologous protein production using *Psychrobacter* sp. PAMC 21119 analyzed with a green fluorescent protein-based reporter system

Lee, Min Ju., Kim, Bomi., Kim, Kitae., Lee, Jun Hyuck. and Do, Hackwon.

Protein Expression and Purification. 2023. 212.

doi: 10.1016/j.pep.2023.106352.

Insolubility and low expression are typical bottlenecks in the production of proteins for studying their function and structure using X-ray crystallography or nuclear magnetic resonance spectroscopy. Cold-active enzymes from polar microorganisms have unique structural features that render them unstable and thermolabile, and are responsible for decreased protein yield in heterologous expression systems. To address these challenges, we developed a heterologous protein expression system using a psychrophilic organism, *Psychrobacter* sp. PAMC 21119, as a protein expression host with its own promoter. We screened 11 promoters and evaluated their strength using quantitative real-time polymerase chain reaction and a reporter system harboring the *SfGFP* gene. The highest expression was achieved using promoters RH96_RS13655 (P21119_20930) and RH96_RS15090 (P21119_23410), regardless of the temperature used. The p20930 strain exhibited a maximum expression level 19.6-fold higher than that of its control at 20 degrees C and produced approximately 0.5 mg of protein per gram of dry cell weight. To our knowledge, this is the first report of a low-temperature recombinant protein expression system developed using *Psychrobacter* sp. that can be used to express various difficult-to-express and cold-active proteins.

keywords:

Recombinant protein expression; Cold-active enzyme; Promoter; Cold-adapted bacteria; *Psychrobacter* sp.

4-45 *Plant Sciences*

High-quality genome assembly and genetic mapping reveal a gene regulating flesh color in watermelon (*Citrullus lanatus*)

Nie, Hualin., Kim, Moonkyo., and 10 others.

Frontiers in Plant Science. 2023. 14.

doi: 10.3389/fpls.2023.1142856.

The unique color and type characteristics of watermelon fruits are regulated by many molecular mechanisms. However, it still needs to be combined with more abundant genetic data to fine-tune the positioning. We assembled genomes of two Korean inbred watermelon lines (cv. 242-1 and 159-1) with unique color and fruit-type characteristics and identified 23,921 and 24,451 protein-coding genes in the two genomes, respectively. To obtain more precise results for further study, we resequenced one individual of each parental line and an F₂ population composed of 87 individuals. This identified 1,539 single-nucleotide polymorphisms (SNPs) and 80 InDel markers that provided a high-density genetic linkage map with a total length of 3,036.9 cM. Quantitative trait locus mapping identified 15 QTLs for watermelon fruit quality-related traits, including β -carotene and lycopene content in fruit flesh, fruit shape index, skin thickness, flesh color, and rind color. By investigating the mapping intervals, we identified 33 candidate genes containing variants in the coding sequence. Among them, Cla97C01G008760 was annotated as a phytoene synthase with a single-nucleotide variant (A $\rightarrow$ G) in the first exon at 9,539,129 bp of chromosome 1 that resulted in the conversion of a lysine to glutamic acid, indicating that this gene might regulate flesh color changes at the protein level. These findings not only prove the importance of a phytoene synthase gene in pigmentation but also explain an important reason for the color change of watermelon flesh.

keywords:

watermelon; genome assembly; linkage map; quantitative trait locus (QTL); carotenoid biosynthesis; phytoene synthase

4-46 *Plant Sciences*

High-Quality Genome Resource of a Novel *Venturiaceae* sp. KMAF11, Isolated from Diseased *Colobanthus quitensis*, an Antarctic Flowering Plant

Jin, Hongshi., Yu, Jihyeon., Kaleku, Jesse., Lee, Yelim., Park, Eunsook., Lee, Hyoungseok., Kim, Han-Woo. and Lee, Jungeun.

Plant Disease. 2023. 107(3): 911-914.

doi: 10.1094/pdis-03-22-0706-a.

In summary, a novel fungal strain, KMAF11, isolated from diseased Antarctic plants, is believed to belong to the *Venturiaceae* sp., a common phytopathogenic fungal group. This fungus may have been dormant in the leaves or rhizosphere of *C. quitensis*, an Antarctic flowering plant,

but it is presumed to induce disease in *C. quitensis* due to a change in the habitat environment. Genomic information on latent pathogenic fungi associated with vascular plants in Antarctica has not yet been reported. In this study, we report the first high-quality genome dataset for this fungus. This dataset provides important information about the genes involved in the fungal lifestyle. Further studies of these genes will contribute to elucidating the molecular interactions between pathogenic fungi and plants inhabiting Earth's extreme regions

keywords:

Antarctica; *Colobanthus quitensis*; genome; pathogenic fungi; Venturiaceae

4-47 Zoology

Homology of the head sensory structures between Heterotardigrada and Eutardigrada supported in a new species of water bear (Ramazzottiidae: *Ramazzottius*)

Kihm, Ji-Hoon., Zawierucha, Krzysztof., Rho, Hyun Soo. and Park, Tae-Yoon S.

Zoological Letters. 2023. 9(1).

doi: 10.1186/s40851-023-00221-w.

Phylum Tardigrada is represented by microscopic eight-legged panarthropods that inhabit terrestrial and marine environments. Although tardigrades are emerging model animals for areas of research including physiology, evolutionary biology, and astrobiology, knowledge of their external morphology remains insufficient. For instance, homologies between marine and terrestrial relatives largely remain unexplored. In the present study we provide detailed pictures of the head sensory organs in a new tardigrade, *Ramazzottius groenlandensis* sp. nov. Specimens were collected from a mixed moss and lichen sample on Ella Island, East Greenland. The new species differs from congeneric species in the presence of polygonal sculpturing on the dorsal cuticle, which is accentuated in the posterior region of the body, a lateral papilla on leg IV, and distinctive egg morphology. A Bayesian phylogenetic analysis (18S rRNA + 28S rRNA + COI) places the new species within the genus *Ramazzottius* with high confidence. Interestingly, the new species shows a full set of well-developed cephalic organs, which correspond to all sensory fields found in eutardigrades. Details on the full set of head organs were present only for heterotardigrades. The surface of these

organs is covered with small pores, which presumably play a sensory role. This discovery suggests the homology of head sensory structures between heterotardigrades and eutardigrades, implying that the distinctive arrangement and positioning of sensory organs on the head is a plesiomorphic feature of tardigrades. Moreover, we find that the *Ramazzottius oberhaeuseri* morphotype forms a morphogroup, not a monophyletic species complex.

keywords:

Cephalic sensory structure; Arctic; Ancestral character; Morphogroup; Greenland

4-48 Microbiology

***Hymenobacter canadensis* sp. nov., isolated from freshwater of the pond in Cambridge Bay, Canada**

Kim, Woohyun., Jang, Seonghan., Chae, Namyi., Kim, Mincheol., Yeh, Jung-Yong., Kim, Sanghee. and Lee, Yung Mi.

International Journal of Systematic and Evolutionary Microbiology. 2023. 73(6).

doi: 10.1099/ijsem.0.005913.

A Gram-stain-negative, aerobic, reddish-coloured, rod-shaped and non-motile strain PAMC 29467^T, was isolated from freshwater of the pond in Cambridge Bay, Canada. Strain PAMC 29467^T was closely related to *Hymenobacter yonginensis* (98.1% 16S rRNA gene similarity). Genomic relatedness analyses showed that strain PAMC 29467^T is distinguishable from *H. yonginensis* based on average nucleotide identity (91.3%) and digital DNA–DNA hybridization values (39.3%). The major fatty acids (>10%) of strain PAMC 29467^T were summed feature 3 (C_{16:1} ω7c and/or C_{16:1} ω6c), C_{15:0} iso, C_{16:1} ω5c and summed feature 4 (C_{17:1} iso I and/or anteiso B). The major respiratory quinone was menaquinone-7. The genomic DNA G+C content was 61.5mol%. Strain PAMC 29467^T was separated from the type species in the genus *Hymenobacter* by its distinct phylogenetic position and some physiological characteristics. As a result, a novel species is proposed, with the name *Hymenobacter canadensis* sp. nov. (type strain, PAMC 29467^T=KCTC 92787^T=JCM 35843^T).

keywords:

Hymenobacter canadensis; novel species; Arctic.

4-49 Biochemistry & Molecular Biology; Chemistry, Applied; Polymer Science

Identification and evaluation of CAZyme genes, along with functional characterization of a new GH46 chitosanase from *Streptomyces* sp. KCCM12257

Paudel, Lakshan., Pardhe, Bashu Dev., Han, So-Ra., Lee, Jun Hyuck. and Oh, Tae-Jin.

International Journal of Biological Macromolecules. 2023. 253.

doi: 10.1016/j.ijbiomac.2023.127457.

The genomic analysis of *Streptomyces* sp. KCCM12257 presented 233 CAZyme genes with a predominant glycosyl hydrolase family. This contributes degradation of various polysaccharides including chitin and chitosan, and other promising candidates for the production of different oligosaccharides. We screened the strain providing different polysaccharides as a sole source of carbon and strain KCCM12257, showed higher activity towards colloidal chitosan. Further, we identified and characterized a new chitosanase (MDI5907146) of GH46 family. There was no activity towards chitin, carboxymethylcellulose, or even with chitosan powder. This enzyme acts on colloidal chitosan and hydrolyzes it down into monoacetyl chitobiose, which consists of two glucosamine units with an acetyl group attached to them. The maximum enzyme activity was observed at pH 6.5 and 40 °C using colloidal chitosan as a substrate. The Co²⁺ metal ions almost double the reaction as compared to other metal ions. The dissociation constant (K_m) and of colloidal chitosan ($\geq 90\%$ and $\geq 75\%$ DD) were 3.03 mg/ml and 5.01 mg/ml respectively, while maximum velocity (V_{max}) values were found to be 36 mg/ml, and 30 $\mu\text{M}/\mu\text{g}/\text{min}$, respectively. Similarly, catalytic efficiency (K_{cat}/K_m) of colloidal chitosan with $\geq 90\%$ DD was 1.9 fold higher than colloidal chitosan with $\geq 75\%$ DD.

keywords:

CAZyme; Chitosanase; Whole genome

4-50 Food Science & Technology

Improved natural food colorant production in the filamentous fungus *Monascus ruber* using CRISPR-based engineering

Yoon, Hye Ree., Han, Suk., Shin, Seung Chul. and 2 others.

Food Research International. 2023. 167.

doi: 10.1016/j.foodres.2023.112651.

Monascus pigments have various food industry applications and are pharmacologically active. Genome sequencing-based clustered regularly interspaced short palindromic repeats (CRISPR)/CRISPR-associated protein 9 (Cas9) technology has been implemented to increase pigment production in *Monascus*. To increase pigment production in *M. ruber* KACC46666, the CRISPR/Cas9 system was used to introduce mutations in two negative regulator genes (*MpigI* and *MpigI'*), among other genes involved in the *Monascus* pigment biosynthesis pathway. Dual single-guide RNAs were constructed to inactivate *MpigI* and *MpigI'*. After CRISPR/Cas9 inactivation, yellow, orange, and red pigment expression in the resulting $\Delta\text{MpigI}16-7$ strain (among several Cas9-mediated mutants studied) was 2.5-, 12.4-, and 18.5-fold, respectively, higher than that in the wild-type strain. This study provides valuable information regarding CRISPR-guided metabolic engineering for natural colorant production.

keywords:

Monascus ruber; *Monascus* pigment; CRISPR; Cas9; Fungal metabolic engineering; Natural colorant production; Genome editing

4-51 Biodiversity Conservation Ecology

Length-weight relationships and condition factors of six notothenioid fish species occurring off King George Island and Northern Victoria Land (Antarctica)

Kim, Jihun., Lee, Seungyeon., Nguyen, Phuong Thi., Han, Dong-Won., Kim, IL-Chan. and Kim, Jin-Hyoung.

Polar Biology. 2023. 46(10): 1145-1150.

doi: 10.1007/s00300-023-03178-w.

This research was conducted to study length-weight relationships (LWR) and condition factors of six Antarctic notothenioid fish species including blackfin icefish (*Chaenocephalus aceratus*), single-angle icefish (*Chionodraco hamatus*), marbled rockcod (*Notothenia rossii*), black rockcod (*Notothenia coriiceps*), emerald rockcod (*Trematomus bernacchii*), and dusky rockcod (*Trematomus newnesi*) from the King Sejong Station on King George Island and Jang Bogo Station on the Northern Victoria Land. A total of 232 specimens were collected by fishing on the icebreaking research vessel ARAON from December 2020 to February

2021. The LWR parameters and condition factors differed depending on species, which can be affected by their distribution, species characteristics, and gravidity status. The exponent b values in LWR ($W = aL^b$) ranged from 2.593 to 5.184. Four species including *C. aceratus*, *C. hamatus*, *N. rossii*, and *T. bernacchii* followed positive allometric growth, *T. newnesi* followed negative allometric growth, and only *N. coriiceps* showed isometric growth. These results can be helpful in understanding the ecological and growth conditions of six fish species living in the Antarctic Ocean, providing more information for future research on Antarctic fish.

keywords:

Notothenioidae; Length-weight relationships; Condition factors; Antarctic fish

4-52 Biochemistry & Molecular Biology; Pharmacology & Pharmacy; Toxicology

Macrosphelides from Antarctic fungus *Pseudogymnoascus* sp. (strain SF-7351) and their neuroprotective effects on BV2 and HT22 cells

Liu, Zhiming., Vinh, Le Ba., Tuan, Nguyen Quoc., Lee, Hwan., Kim, Eunae., Kim, Youn-Chul., Sohn, Jae Hak., Yim, Jong Han. and 3 others.

Chemico-Biological Interactions. 2023. 385.

doi: 10.1016/j.cbi.2023.110718.

Strategies for reducing inflammation in neurodegenerative diseases have attracted increasing attention. Herein, we discovered and evaluated the neuroprotective potential of fungal metabolites isolated from the Antarctic fungus *Pseudogymnoascus* sp. (strain SF-7351). The chemical investigation of the EtOAc extract of the fungal strain isolate revealed a novel naturally occurring *epi*-macrosphelide J (1), a novel secondary metabolite macrosphelide N (2), and three known compounds, namely macrosphelide A (3), macrosphelide B (4), and macrosphelide J (5). Their structures were established unambiguously using spectroscopic methods, such as one-dimensional and two-dimensional nuclear magnetic resonance (1D and 2D-NMR) spectroscopy, high-resolution electrospray ionization mass spectrometry (HR-ESI-MS), and gauge-including atomic orbital (GIAO) NMR chemical shift calculations, with the support of the advanced statistical method DP4+. Among the isolated metabolites, the absolute configuration of *epi*-macrosphelide J (1) was

further confirmed using single-crystal X-ray diffraction analysis. The neuroprotective effects of the isolated metabolites were evaluated in lipopolysaccharide (LPS)-induced BV2 and glutamate-stimulated HT22 cells. Only macrosphelide B (4) displayed substantial protective effects in both BV2 and HT22 cells. Molecular mechanisms underlying this activity were investigated using western blotting and molecular docking studies. Macrosphelide B (4) inhibited the inflammatory response by reducing the nuclear translocation of NF- κ B (p65) in LPS-induced BV2 cells and induced the Nrf2/HO-1 signaling pathway in both BV2 and HT22 cells. The neuroprotective effect of macrosphelide B (4) is related to the interaction between Keap1 and p65. These results suggest that macrosphelide B (4), present in the fungus *Pseudogymnoascus* sp. (strain SF-7351), may serve as a candidate for the treatment of neurodegenerative diseases.

keywords:

Antarctic fungi; Macrosphelides; Nrf2; Neuroprotection; Molecular docking; NF-kappa B

4-53

Metagenomic Analysis of Antarctic Penguins Gut Microbial Dynamics by using Fecal DNA of Adélie (*Pygoscelis adeliae*) and Emperor (*Aptenodytes forsteri*) Penguins in Ross Sea, Antarctica

Choi, Soyun., Lee, Seung Jae., Cho, Minjoo., Choi, Eunkyung., Kim, Jinmu., Kim, Jeong-Hoon. and 2 others.

Journal of Marine Life Science. 2023. 8(1).

doi: 10.23005/ksmls.2023.8.1.43.

This study applied a metagenomic analysis of the penguins' gut microbiome from fecal samples of Adélie Penguin (*Pygoscelis adeliae*) and Emperor Penguin (*Aptenodytes forsteri*) living along the Ross Sea, Antarctica. As a result of taxonomic analysis, 7 phyla and 18 families were mainly present in the gut microbiome of Adélie and Emperor penguins. To assess microbial diversity, we performed alpha diversity and OTU abundance analyses. It was confirmed that the Adélie Penguin's gut microbial species had a higher diversity than Emperor Penguin's. Based on the Beta diversity analysis using PCoA, differences were observed in the clustering between Adélie and Emperor penguins, respectively. Through the KEGG pathway analysis using PICRUSt, the nucleoside and nucleotide biosynthesis pathway was the most prevalent in Adélie and Emperor

penguins. This study enabled a comparison and analysis of the composition and diversity of the gut microbiome in Adélie and Emperor Penguins. It could be utilized for future research related to penguin feeding habits and could serve as a foundation for analyzing the gut microbiomes of various other Antarctic organisms

Keywords:

Pygoscelis adeliae; *Aptenodytes forsteri*; Ross sea; Metagenome; Gut microbiome analysis

4-54 Multidisciplinary Sciences

Microplastics in gastrointestinal tracts of gentoo penguin (*Pygoscelis papua*) chicks on King George Island, Antarctica

Kim, Youmin., and 9 others.

Scientific Reports. 2023. 13(1).

doi: 10.1038/s41598-023-39844-6.

Microplastics (< 5 mm) have been found in marine ecosystems worldwide, even in Antarctic ecosystems. In this study, the stomach and upper intestines of 14 dead gentoo penguin (*Pygoscelis papua*) chicks were collected and screened for microplastics on King George Island, a gateway to Antarctic research and tourism. A total of 378 microplastics were identified by Fourier-transform infrared spectroscopy, with 27.0 ± 25.3 microplastics per individual. The detected number of microplastics did not increase with the mass of penguin chicks, suggesting no permanent accumulation of microplastics. However, the concentration of microplastics was much higher (9.1 ± 10.8 microplastics per individual within the size range 100–5000 μm) than the previously reported concentration in the penguin feces, and a greater number of smaller microplastics were found. Marine debris surveys near the breeding colony found various plastic (79.3%) to be the most frequent type of beached debris, suggesting that local sources of marine plastic waste could have contributed to microplastic contamination of penguin chicks being fed by parents that forage in nearby seas. This finding confirms the presence of microplastics in an Antarctic ecosystem and suggests the need for stronger waste management in Antarctica and a standardized scheme of microplastic monitoring in this once-pristine ecosystem.

4-55 Plant Sciences; Marine & Freshwater Biology

Morphology and phylogenetic relationships of two Antarctic strains within the genera *Carolibrandtia* and *Chlorella* (Chlorellaceae, Trebouxiophyceae)

Chae, Hyunsik., Kim, Eun Jae., Kim, Han Soon., Choi, Han-Gu., Kim, Sanghee. and Kim, Ji Hee.

Algae. 2023. 38(4): 241-252.

doi: 10.4490/algae.2023.38.11.30.

The genera *Carolibrandtia* and *Chlorella* have been described as small green algae with spherical cell shapes that inhabit various environments. Species of these genera are often difficult to identify because of their simple morphology and high phenotypic plasticity. We investigated two small coccoid strains from Antarctica based on morphology, molecular phylogeny by two alignment methods which have been applied to previous phylogenetic studies of the genus *Chlorella*, and comparison of the secondary structures of nuclear small subunit (SSU) and internal transcribed spacer (ITS) rDNA sequences. Light microscopy of two strains revealed spherical cells containing chloroplasts with pyrenoids, and the morphological characteristics of the strains were nearly identical to those of other *Chlorella* species. However, based on the phylogenetic analyses of nuclear SSU and ITS rDNA sequences, it was determined that the Antarctic microalgal strains belonged to two genera, as the *Chlorella* and *Carolibrandtia*. In addition, the secondary structures of the SSU and ITS2 sequences were analyzed to detect compensatory base changes (CBCs) that were used to identify and describe the two strains. A unique CBC in the SSU rDNA gene was decisive for distinguishing strain CCAP 211/45. The ITS2 rDNA sequences for each strain were compared to those obtained previously from other closely related species. Following the comparison of morphological and molecular characteristics, we propose KSF0092 as a new species, *Chlorella terrestris* sp. nov., and the reassignment of the strain *Chlorella antarctica* CCAP 211/45 into *Carolibrandtia antarctica* comb. nov.

keywords:

Antarctica; *Carolibrandtia*; *Chlorella*; morphology; nuclear SSU and ITS rDNA

4-56 Multidisciplinary Sciences

Nesting chinstrap penguins accrue large quantities of sleep through seconds-long microsleeps

Libourel, Paul-Antoine., Lee, Won Young., Achin, I., Chung, Hosung, and 2 others.

Science. 2023. 382(6674): 1026-1031.

doi: 10.1126/science.adh0771.

Microsleeps, the seconds-long interruptions of wakefulness by eye closure and sleep-related brain activity, are dangerous when driving and might be too short to provide the restorative functions of sleep. If microsleeps do fulfill sleep functions, then animals faced with a continuous need for vigilance might resort to this sleep strategy. We investigated electroencephalographically defined sleep in wild chinstrap penguins, at sea and while nesting in Antarctica, constantly exposed to an egg predator and aggression from other penguins. The penguins nodded off >10,000 times per day, engaging in bouts of bihemispheric and unihemispheric slow-wave sleep lasting on average only 4 seconds, but resulting in the accumulation of >11 hours of sleep for each hemisphere. The investment in microsleeps by successfully breeding penguins suggests that the benefits of sleep can accrue incrementally.

The mitogenome architecture was also variable, categorized into four types (A–D): type A = ancestral type with a basic composition; type B = those with inverse transpositions; type C = those with inverted duplications; and type D = those with both inversion and duplication. The palindromic and inverted repeats were consistently found in flanking regions of the rearrangement, especially near the *cob* and *nad6* genes. The three rearranged mitogenome architectures (types B, C, D) are the first report of these in red algae. Phylogenetic analyses of 23 protein-coding genes supported the current familial classification of the Ceramiales, implying that the diversity of mitogenome architecture preceded the phylogenetic relationships. Our study suggests that palindromic and inverted repeats may drive mitogenome architectural variation.

keywords:

genome rearrangement; mitogenome architecture; molecular evolution; palindromic repeat; red algae

4-57 Plant Sciences; Marine & Freshwater Biology

Novel rearrangements in the mitochondrial genomes of the Ceramiales (Rhodophyta) and evolutionary implications

Seo, Min Ho., Kang, Shin Chan., Kim, Kyeong Mi., Kwak, Min Seok., Jo, Jihoon., Choi, Han-Gu, and 2 others.

Algae. 2023. 38(4): 253-264.

doi: 10.4490/algae.2023.38.12.2.

The Ceramiales is the most diverse and species-rich group (2,669 spp.) of red algae, and it is widely distributed from tropical to polar oceans. Mitochondrial genomes (mitogenomes) and other genes have contributed to our knowledge regarding the classification and phylogeny of this diverse red algal group; however, the mitogenome architecture remains understudied. Here, we compared 42 mitogenomes, including 19 newly generated in this study, to expand our knowledge. The number of genes in mitogenome varied from 43 to 68 due to gene duplication.

4-58 Marine & Freshwater Biology; Oceanography

Phase Shift in Vertical Distribution of Macroalgal Assemblages on Udo Islet, Jeju, Korea, After a Decade of Revisiting

Kang, Jeong Chan, Lee, Hyung Woo, Ko, Young Wook and Kim, Myung Sook.

Ocean Science Journal. 2023. 58(4).

doi: 10.1007/s12601-023-00119-w.

We investigated seasonal macroalgal assemblages using virtual transect lines and 0.25 m⁻² quadrats from the upper intertidal zone to subtidal 15 m depth during the period from May 2019 to February 2020 at Udo Islet, Jeju Island. A total of 191 species (15 Chlorophyta, 36 Ochrophyta, and 140 Rhodophyta) were observed among the quadrats, with annual mean biomass of 1998.8 g wet wt m⁻². To confirm the decadal variation of the macroalgal assemblage in Udo, we compared our data with previous observations during 2009–2010 at the same locations reported by Kang et al. We were able to confirm that species diversity did not decrease, although subtidal biomass showed a considerable decrease. Notably, the biomass of non-calcareous macroalgae was considerably reduced, whereas calcareous algal biomass doubled despite maintaining the distribution of dominant species. This changing pattern of macroalgal assemblage is similar with the early process of sea-barrenness reported by previous studies on the Jeju coast. In this study, it was not

possible to identify the cause of the decrease in abundance of non-calcareous algae, as the survey focused on only macroalgal assemblage without verifying any environmental factors. Further studies identifying additional factors that might be directly connected to marine deforestation, including physiological, chemical, and biological factors, are essential to recovering or at least maintaining the macroalgal community of Udo Islet.

keywords:

A decadal revisit; Macroalgal assemblage; Marine deforestation; Temporal change; Udo Islet

4-59

Phytoplankton Variability in Response to Glacier Retreat in Marian Cove, King George Island, Antarctica in 2021-2022 Summer

Shim, Chorom., Min, Jun-Oh., Lee, Boyeon., Hong, Seo-Yeon. and Ha, Sun-Yong.

Journal of the Korean Society of Marine Environment and Safety. 2023. 29(5).

doi: 10.7837/kosomes.2023.29.5.417.

Rapid climate change has resulted in glacial retreat and increased meltwater inputs in the Antarctic Peninsula, including King George Island where Marian Cove is located. Consequently, these phenomena are expected to induce changes in the water column light properties, which in turn will affect phytoplankton communities. To comprehend the effects of glacial retreat on the marine ecosystem in Marian Cove, we investigated on phytoplankton biomass (chlorophyll-a, chl-a) and various environment parameters in this area in December 2021 and January 2022. The average temperature at the euphotic depth in January 2022 (1.41 ± 0.13 °C) was higher than that in December 2021 (0.87 ± 0.17 °C). Contrastingly, the average salinity was lower in January 2022 (33.9 ± 0.10 psu) than in December 2021 (34.1 ± 0.12 psu). Major nutrients, including dissolved inorganic nitrogen, phosphate, and silicate, were sufficiently high, and thus, did not act as limiting factors for phytoplankton biomass. In December 2021 and January 2022, the mean chl-a concentrations were 1.03 ± 0.64 and 0.66 ± 0.15 $\mu\text{g L}^{-1}$, respectively. The mean concentration of suspended particulate matter (SPM) was 24.9 ± 3.54 mg L^{-1} during the study period, with elevated values observed in the vicinity of the inner glacier. However, relative lower chl-a concentrations were observed near the inner glacier,

possibly due to high SPM load from the glacier, resulting in reduced light attenuation by SPM shading. Furthermore, the proportion of nanophytoplankton exceeded 70% in the inner cove, contributing to elevated mean fractions of nanophytoplankton in the glacier retreat marine ecosystem. Overall, our study indicated that freshwater and SPM inputs from glacial meltwater may possibly act as main factors controlling the dynamics of phytoplankton communities in glacier retreat areas. The findings may also serve as fundamental data for better understanding the carbon cycle in Marian Cove.

Keywords:

Phytoplankton; Suspended particulate matter; Marian Cove; Glacier retreat; Antarctica

4-60 *Biology*

Polar microalgae extracts protect human HaCaT keratinocytes from damaging stimuli and ameliorate psoriatic skin inflammation in mice

Lim, YoonHee., Park, So-Hyun., Kim, Eun Jae., Lim, HeeJun., Jang, Jinsun., Hong, In-Sun., Kim, Sanghee. and Jung, YunJae.

Biological Research. 2023. 56(1).

doi: 10.1186/s40659-023-00454-1.

Background: Polar microalgae contain unique compounds that enable them to adapt to extreme environments. As the skin barrier is our first line of defense against external threats, polar microalgae extracts may possess restorative properties for damaged skin, but the potential of microalgae extracts as skin protective agents remains unknown.

Purpose: This study aimed to analyze compound profiles from polar microalgae extracts, evaluate their potential as skin epithelial protective agents, and examine the underlying mechanisms.

Methods: Six different polar microalgae, *Micractinium* sp. (KSF0015 and KSF0041), *Chlamydomonas* sp. (KNM0029C, KSF0037, and KSF0134), and *Chlorococcum* sp. (KSF0003), were collected from the Antarctic or Arctic regions. Compound profiles of polar and non-polar microalgae extracts were analyzed using gas chromatography-mass spectrometry (GC-MS). The protective activities of polar microalgae extracts on human keratinocyte cell lines against oxidative stress, radiation, and psoriatic cytokine exposure were assessed. The potential anti-inflammatory mechanisms mediated by KSF0041, a polar microalga with protective

properties against oxidative stress, ultraviolet (UV) B, and an inflammatory cytokine cocktail, were investigated using RNA-sequencing analysis. To evaluate the therapeutic activity of KSF0041, an imiquimod-induced murine model of psoriatic dermatitis was used.

Results: Polar microalgae contain components comparable to those of their non-polar counterparts, but also showed distinct differences, particularly in fatty acid composition. Polar microalgae extracts had a greater ability to scavenge free radicals than did non-polar microalgae and enhanced the viability of HaCaT cells, a human keratinocyte cell line, following exposure to UVB radiation or psoriatic cytokines. These extracts also reduced barrier integrity damage and decreased mRNA levels of inflammatory cytokines in psoriatic HaCaT cells. Treatment with KSF0041 extract altered the transcriptome of psoriatic HaCaT cells toward a more normal state. Furthermore, KSF0041 extract had a therapeutic effect in a mouse model of psoriasis.

Conclusions: Bioactive compounds from polar microalgae extracts could provide novel therapeutics for damaged and/or inflamed skin.

keywords:

Polar microalgae; Compound profiles; Barrier protection; Psoriasis; Anti-inflammation

4-61

Potato soft rot caused by psychrotolerant *Pseudomonas* sp. from subarctic tundra soil

Woo, Sungho., Lee, Yung Mi. and Kim, Dockyu.

Research in Plant Disease. 2023. 29(4):399-404.

doi: 10.5423/RPD.2023.29.4.399.

Agricultural activities and the number of farms in the subarctic regions have been increasing annually after the coronavirus disease 2019 pandemic to achieve food self-sufficiency. Potatoes are vulnerable to soft rot bacteria at all stages of production, storage, and transportation. A novel bacterium, *Pseudomonas* sp. N3-W, isolated from Alaska tundra soil, grows at 5-25°C and produces extracellular protease(s). N3-W caused necrotic spots (hypersensitivity) in hot pepper leaves and soft rot disease (pathogenicity) in potato tubers. The psychrotolerant N3-W caused significant soft rot symptoms on potatoes at a broad temperature range (5°C, 15°C, and 25°C). In contrast, mesophilic *Pectobacterium carotovorum* KACC 16999 induced severe rotting symptoms in potatoes at their optimal growth temperature of 15°C and

25°C. However, it barely produced symptoms at 5°C, which is the appropriate storage and transportation temperature for potatoes. The results of pathogenicity testing imply that psychrotolerant soft rot pathogens from polar regions may cause severe soft rot not only during the crop growing season but also during storage and transportation. Our study indicates the possibility of new plant pathogen emergence and transmission due to the expansion of crop cultivation areas caused by permafrost thawing in response to recent polar warming.

Keywords:

Global warming; Outbreak; Permafrost thawing; Plant pathogen; Soil microbes

4-62 *Biodiversity Conservation; Ecology; Environmental Sciences*

Quantifying annual spatial consistency in chick-rearing seabirds to inform important site identification

Beal, Martin., Catry, Paulo., Phillips, Richard A., Oppel, Steffen., Arnould, John P. Y., Bogdanova, Maria I., Bolton, Mark., Carneiro, Ana P. B., Clatterbuck, Corey., Conners, Melinda., Daunt, Francis., Delord, Karine., Elliott, Kyle., Fromant, Aymeric., Granadeiro, Jose Pedro., Green, Jonathan A., Halsey, Lewis G., Hamer, Keith C., Ito, Motohiro., Jeavons, Ruth., Kim, Jeong-Hoon., Kokubun, Nobuo., Koyama, Shiho., Lane, Jude V., Lee, Won Young., and 22 others.

Biological Conservation. 2023. 281.

doi: 10.1016/j.biocon.2023.110025.

Animal tracking has afforded insights into patterns of space use in numerous species and thereby informed area-based conservation planning. A crucial consideration when estimating spatial distributions from tracking data is whether the sample of tracked animals is representative of the wider population. However, it may also be important to track animals in multiple years to capture changes in distribution in response to varying environmental conditions. Using GPS-tracking data from 23 seabird species, we assessed the importance of multi-year sampling for identifying important sites for conservation during the chick-rearing period, when seabirds are most spatially constrained. We found a high degree of spatial overlap among distributions from different years in most species. Multi-year sampling often captured a significantly higher portion of reference distributions (based on all data for a population) than sampling in a single year. However, we estimated that data from a single year would

on average miss only 5 % less of the full distribution of a population compared to equal-sized samples collected across three years (min: -0.3% , max: 17.7% , $n = 23$). Our results suggest a key consideration for identifying important sites from tracking data is whether enough individuals were tracked to provide a representative estimate of the population distribution during the sampling period, rather than that tracking necessarily take place in multiple years. By providing an unprecedented multi-species perspective on annual spatial consistency, this work has relevance for the application of tracking data to informing the conservation of seabirds

keywords:

Biotelemetry; Animal tracking; Area-based conservation; Protected areas; Marine spatial planning; Key biodiversity areas; Sampling effort; Spatial consistency

4-63 *Marine & Freshwater Biology; Zoology*

Rare Observation of a Living Southern Elephant Seal (*Mirounga leonina*) at Terra Nova Bay, Victoria Land Coast, Ross Sea, Antarctica

Kim, Jong- U., Oh, Younggeun., Kim, Youmin. and Kim, Jeong-Hoon.
Aquatic Mammals. 2023. 49(5): 475-479.
doi: 10.1578/am.49.5.2023.475.

keywords:

Mirounga leonina; Southern Elephant Seal

4-64 *Geography, Physical; Geosciences, Multidisciplinary*

Responses of dissolved organic carbon to freeze-thaw cycles associated with the changes in microbial activity and soil structure

Kim, You Jin., Kim, Jinhyun. and Jung, Ji Young.
Cryosphere. 2023. 17(7): 3101-3114.
doi: 10.5194/tc-17-3101-2023.

Arctic warming accelerates snowmelt, exposing soil surfaces with shallow or no snow cover to freeze–thaw cycles (FTCs) more frequently in early spring and late autumn. FTCs influence Arctic soil C dynamics by increasing or decreasing the amount of dissolved organic carbon (DOC); however,

mechanism-based explanations of DOC changes that consider other soil biogeochemical properties are limited. To understand the effects of FTCs on Arctic soil responses, we designed microcosms with surface organic soils from Alaska and investigated several soil biogeochemical changes for seven successive temperature fluctuations of freezing at $-9.0 \pm 0.3^\circ\text{C}$ and thawing at $6.2 \pm 0.3^\circ\text{C}$ for 12 h each. FTCs significantly changed the following soil variables: soil CO₂ production (CO₂), DOC and total dissolved nitrogen (TDN) contents, two DOC quality indices (SUVA₂₅₄ and A₃₆₅/A₂₅₄), microaggregate (53–250 µm) distribution, and small-sized mesopore (0.2–10 µm) proportion. Multivariate statistical analyses indicated that the FTCs improved soil structure at the scale of microaggregates and small-sized mesopores, facilitating DOC decomposition by soil microbes and changes in DOC quantity and quality by FTCs. This study showed that FTCs increased soil CO₂ production, indicating that FTCs affected DOC characteristics without negatively impacting microbial activity. Soil microaggregation enhanced by FTCs and the subsequent increase in microbial activity and small-sized pore proportion could promote DOC decomposition, decreasing the DOC quantity. This study provides a mechanism-based interpretation of how FTCs alter DOC characteristics of the organic soil in the active layer by incorporating structural changes and microbial responses, improving our understanding of Arctic soil C dynamics.

4-65 *Multidisciplinary Sciences*

Reversible intracellular acidification and depletion of NTPs provide a potential physiological origin for centuries of dormancy in an Antarctic freshwater copepod

Reed, Katherine A., Williamson, R. Thomas., Lee, Sung Gu., Lee, Jun Hyuck. and Covi, Joseph A.
Scientific Reports. 2023. 13(1).
doi: 10.1038/s41598-023-40180-y.

A great diversity of crustacean zooplankton found in inland and coastal waters produce embryos that settle into bottom sediments to form an egg bank. Embryos from these banks can remain dormant for centuries, creating a reservoir of genetic diversity. A large body of literature describes the ecological and evolutionary importance of zooplankton egg banks. However, literature on the physiological traits behind dormancy in crustacean zooplankton are limited. Most data on the physiology of dormancy comes from research on one species of anostracan, the brine shrimp, *Artemia franciscana*.

Anoxia-induced dormancy in this species is facilitated by a profound and reversible acidification of the intracellular space. This acidification is accompanied by a reversible depletion of adenosine triphosphate (ATP). The present study demonstrates that acidification of the intracellular space also occurs in concert with a depletion of nucleoside triphosphates (NTPs) in the Antarctic copepod, *Boeckella poppei*. Like *A. franciscana*, the depletion of NTPs and acidification are rapidly reversed during aerobic recovery in *B. poppei*. These data provide the first comparative evidence that extreme dormancy under anoxia in crustacean zooplankton is associated with intracellular acidification and an ability to recover from the depletion of ATP.

4-66 Marine & Freshwater Biology; Oceanography

Soil microbial community composition along chronosequence of the introduction of *Phragmites australis* at Suncheon Bay

Chaudhary, Doongar R., Kim, Jinhyun. and Kang, Hojeong.
Estuarine Coastal and Shelf Science. 2023. 290.
 doi: 10.1016/j.ecss.2023.108405.

Vegetations of coastal wetlands play a vital role in providing numerous ecological services to the coastal ecosystem and are also key factors affecting the biogeochemical processes in the soil. The acreage of *Phragmites australis* is expanding and gradually replacing the *Suaeda japonica* at Suncheon Bay, Republic of Korea. However, the changes in soil microbial community composition caused by *Phragmites* introduction is poorly characterized. In the present study, soil cores were collected to a depth of 1 m (divided into 10 segments of 10 cm) from *Suaeda*-vegetated, the boundary of *Suaeda*- and *Phragmites*-vegetated, *Phragmites*-vegetated marshes (after 5 and 10 years of the introduction). These samples were analyzed for physico-chemical characteristics, enzyme activities, soil microbial community (phospholipid fatty acids profiling) and abundance of functional genes related to the methane cycle (*mcrA*, *pmoA* and *dsrA*). Results showed that introduction the of *Phragmites* increased the water content, pH and dissolved organic carbon content in the soil. The contents of total PLFA and microbial group biomarkers of PLFA were observed to be higher in the surface soil and decreased with soil depth. Early introduction of *Phragmites* (10 yr) sediments had the significantly highest concentrations of total as well as other microbial biomarkers PLFAs compared with other salt marshes. The

relative abundance of biomarker PLFAs of Gram-negative bacteria was significantly higher in *Phragmites* compared to other salt marshes. The abundance of *mcrA* was significantly highest in *Phragmites* salt marshes (10 yr) and mixed salt marshes while the abundance of *mcrA*, *pmoA* and *dsrA* were lowest in *Suaeda* marshes. Our results reflect the chronological effects of the introduction of *Phragmites* on the physicochemical and microbial community composition which contribute to establishing the relationship between the plant introduction and soil biogeochemical processes in coastal salt marshes.

keywords:

Coastal ecosystem; Functional genes; Halophytes; Methane cycling; Microbial community composition; *Phragmites australis*; *Suaeda japonica*

4-67 Multidisciplinary Sciences

Soil organic carbon is a key determinant of CH₄ sink in global forest soils

Lee, Jaehyun., Oh, Youmi., Lee, Sang Tae., Seo, Yeon Ok., Yun, Jeongeun., Yang, Yerang., Kim, Jinhyun., and 2 others.
Nature Communications. 2023. 14(1).
 doi: 10.1038/s41467-023-38905-8.

Soil organic carbon (SOC) is a primary regulator of the forest–climate feedback. However, its indicative capability for the soil CH₄ sink is poorly understood due to the incomplete knowledge of the underlying mechanisms. Therefore, SOC is not explicitly included in the current model estimation of the global forest CH₄ sink. Here, using in-situ observations, global meta-analysis, and process-based modeling, we provide evidence that SOC constitutes an important variable that governs the forest CH₄ sink. We find that a CH₄ sink is enhanced with increasing SOC content on regional and global scales. The revised model with SOC function better reproduces the field observation and estimates a 39% larger global forest CH₄ sink (24.27 Tg CH₄ yr⁻¹) than the model without considering SOC effects (17.46 Tg CH₄ yr⁻¹). This study highlights the role of SOC in the forest CH₄ sink, which shall be factored into future global CH₄ budget quantification.

4-68 Remote Sensing

Spectral unmixing-based Arctic plant species analysis using a spectral library and terrestrial hyperspectral Imagery: A case study in Adventdalen, Svalbard

Yang, Junyoung., Lee, Yoo Kyung. and Chi, Junhwa.
International Journal of Applied Earth Observation and Geoinformation.
 2023. 125.
 doi: 10.1016/j.jag.2023.103583.

Remote sensing is an invaluable tool for monitoring the rapid changes in Arctic vegetation distribution caused by global warming. Although hyperspectral data consisting of contiguous spectral bands enables the quantitative analysis of remote sensing data, mapping Arctic vegetation using hyperspectral remote sensing remains challenging due to the difficulty in acquiring data from the region. Additionally, the mixed pixel issue, which represents a mixture of more than one plant species due to low-spatial resolution, hinders accurate mapping of Arctic vegetation. To address these limitations, we collected hyperspectral information on the dominant plant species, such as shrubs and graminoids, in Adventdalen, Svalbard, and investigated effective methods for mapping Arctic vegetation using spectral unmixing. First, labeled datasets were constructed for Arctic plant species by extracting pixel data from terrestrial hyperspectral images. A spectral library was developed using the labeled datasets and used for spectral unmixing as endmembers. We employed three established classifiers, random forest, support vector machine, and one-dimensional convolutional neural network (1D-CNN) for hyperspectral image classification. Subsequently, we quantitatively and qualitatively compared the classification performances of these machine learning-based classifiers to determine the optimal classification method for validation purposes. The first derivative spectra of smoothed reflectance ($R_{s,FD}$) and the 1D-CNN classifier were used to identify ground truth by classifying pixels of Arctic vegetation because they achieved the highest statistical accuracies of 0.9892 (Kappa = 0.9880) and 0.9352 (Kappa = 0.9280) for the two independent test sets and produced the most accurate vegetation maps. The spectral library using the $R_{s,FD}$ spectrum showed high spectral discriminability and potential for estimating the abundance of classes from simulated mixed pixels, resulting in good agreement with the ground truth. Accordingly, our findings provide valuable insights and references for large-scale mapping studies using remote sensing data and offer effective monitoring strategies for Arctic vegetation changes in response to climate change.

keywords:

Hyperspectral image; Arctic vegetation mapping; Machine learning classification; Spectral library; Spectral unmixing

4-69 Biochemistry & Molecular Biology; Ecology; Evolutionary Biology

Steroids from the Antarctic lichen *Ramalina terebrata* and their chemotaxonomical significance

Lee, Seulah., Lee, Jun Hyuck. and Youn, Ui Joung.
Biochemical Systematics and Ecology. 2023. 107.
 doi: 10.1016/j.bse.2023.104583.

Four steroids (1–4) were isolated from the Antarctic lichen, *Ramalina terebrata* (Ramalinaceae), along with a lupane type triterpenoid (5) and an anthraquinone derivative (6). The structures of the isolated compounds were characterized by comprehensive spectroscopic analyses and LC-MS analysis. The isolated compounds were identified as brassicasterol (1), (22E,24R)-24-methylcholesta-5,22-diene-3 β ,7 α -diol (2), ergosterol peroxide (3), 9,11-dehydroergosterol peroxide (4), lupeol (5) and parietin (6). It is the first report of the identification of steroids and a triterpenoid from *R. terebrata*. The chemotaxonomical significance of the isolated compounds is also discussed.

keywords:

Ramalina terebrata; Antarctic lichen; Steroid; Terpenoid; Anthraquinone

4-70 Biochemistry & Molecular Biology; Chemistry, Multidisciplinary

Structural and Biochemical Insights into Bis(2-hydroxyethyl) Terephthalate Degrading Carboxylesterase Isolated from Psychrotrophic Bacterium *Exiguobacterium antarcticum*

Hwang, Jisub., Yoo, Wanki., Shin, Seung Chul., Kim, Kyeong Kyu., Kim, Han-Woo., Do, Hackwon. and Lee, Jun Hyuck.
International Journal of Molecular Sciences. 2023. 24(15).
 doi: 10.3390/ijms241512022.

This study aimed to elucidate the crystal structure and

biochemically characterize the carboxylesterase *EaEst2*, a thermotolerant biocatalyst derived from *Exiguobacterium antarcticum*, a psychrotrophic bacterium. Sequence and phylogenetic analyses showed that *EaEst2* belongs to the Family XIII group of carboxylesterases. *EaEst2* has a broad range of substrate specificities for short-chain *p*-nitrophenyl (*p*NP) esters, 1-naphthyl acetate (1-NA), and 1-naphthyl butyrate (1-NB). Its optimal pH is 7.0, losing its enzymatic activity at temperatures above 50 °C. *EaEst2* showed degradation activity toward bis(2-hydroxyethyl) terephthalate (BHET), a polyethylene terephthalate degradation intermediate. We determined the crystal structure of *EaEst2* at a 1.74 Å resolution in the ligand-free form to investigate BHET degradation at a molecular level. Finally, the biochemical stability and immobilization of a crosslinked enzyme aggregate (CLEA) were assessed to examine its potential for industrial application. Overall, the structural and biochemical characterization of *EaEst2* demonstrates its industrial potency as a biocatalyst.

keywords:

carboxylesterases; *Exiguobacterium antarcticum*; biocatalyst

4-71 Chemistry, Multidisciplinary; Crystallography; Materials Science, Multidisciplinary

Structural and biochemical insights into PsEst3, a new GHSR-type esterase obtained from *Paenibacillus* sp. R4

Son, Jonghyeon., Choi, Woong., Kim, Hyun., Kim, Minseo., Lee, Jun Hyuck., Shin, Seung Chul. and Kim, Han-Woo.

lucrj. 2023. 10: 220-232.

doi: 10.1107/s2052252523001562.

PsEst3, a psychrophilic esterase obtained from *Paenibacillus* sp. R4, which was isolated from the permafrost of Alaska, exhibits relatively high activity at low temperatures. Here, crystal structures of PsEst3 complexed with various ligands were generated and studied at atomic resolution, and biochemical studies were performed to analyze the structure-function relationship of PsEst3. Certain unique characteristics of PsEst3 distinct from those of other classes of lipases/esterases were identified. Firstly, PsEst3 contains a conserved GHSRA/G pentapeptide sequence in the GxSxG motif around the nucleophilic serine. Additionally, it contains a conserved HGFR/K consensus sequence in the oxyanion hole, which is distinct from that in other lipase/esterase families, as well as a specific domain composition

(for example a helix-turn-helix motif) and a degenerative lid domain that exposes the active site to the solvent. Secondly, the electrostatic potential of the active site in PsEst3 is positive, which may cause unintended binding of negatively charged chemicals in the active site. Thirdly, the last residue of the oxyanion hole-forming sequence, Arg44, separates the active site from the solvent by sealing the acyl-binding pocket, suggesting that PsEst3 is an enzyme that is customized to sense an unidentified substrate that is distinct from those of classical lipases/esterases. Collectively, this evidence strongly suggests that PsEst3 belongs to a distinct family of esterases.

keywords:

X-ray crystallography; protein structure; structure-function relationship; esterases; ligand selectivity; protein engineering; structure determination; enzyme mechanisms; PsEst3; *Paenibacillus* sp. R4

4-72 Fisheries; Immunology; Marine & Freshwater Biology; Veterinary Sciences

Structure of fish TRAF4 and its implication in TRAF4-mediated immune cell and platelet signaling

Kim, Chang Min., Jang, Hyunseok., Hong, Eunmi., Lee, Jun Hyuck. and Park, Hyun Ho.

Fish & Shellfish Immunology. 2023. 132.

doi: 10.1016/j.fsi.2022.108462.

Due to an increasing interest in immunity and signal transduction in teleost fish, important key signaling molecules associated with the immune response, including TRAF molecules, have been recently cloned and characterized. To better understand the role of TRAF4 in fish immune signaling and compare it with the human system, our study cloned the TRAF4 gene from the Antarctic yellowbelly rockcod *Notothenia coriiceps* (ncTRAF4) and purified the protein. Here, we report the first crystal structure of teleost fish TRAF4. Based on biochemical characterization, our findings elucidated the mechanisms through which signaling molecules gain cold adaptivity. Additionally, we identified a platelet receptor GPIIb homolog in *N. coriiceps* (ncGPIIb) and found that the "RRFERLFKEARRTS" region of this homolog directly binds to ncTRAF4, indicating that ncTRAF4 also recognizes the "RLXA" motif for receptor interactions and further TRAF4-mediated cellular signaling. Collectively, our findings provide novel insights into the mechanisms of

TRAF4-mediated immune cell and platelet signaling in fish and the structural flexibility-mediated cold adaptiveness of signaling molecules.

keywords:

Cold adaptivity; Crystal structure; Innate immunity; Protein-protein interaction; TRAF4

4-73 *Biotechnology & Applied Microbiology; Microbiology*

Synthesis of Short-Chain Alkyl Butyrate through Esterification Reaction Using Immobilized *Rhodococcus* Cutinase and Analysis of Substrate Specificity through Molecular Docking

Won, Seok-Jae., **Yim, Joung Han.** and Kim, Hyung Kwoun.
Journal of Microbiology and Biotechnology. 2023. 33(2): 268-276.
 doi: 10.4014/jmb.2211.11022.

Alkyl butyrate with fruity flavor is known as an important additive in the food industry. We synthesized various alkyl butyrates from various fatty alcohol and butyric acid using immobilized *Rhodococcus* cutinase (*Rcut*). Esterification reaction was performed in a non-aqueous system including heptane, isooctane, hexane, and cyclohexane. As a result of performing the alkyl butyrate synthesis reaction using alcohols of various chain lengths, it was found that the preference for the alcohol substrate had the following order: C6 > C4 > C8 > C10 > C2. Through molecular docking analysis, it was found that the greater the hydrophobicity of alcohol, the higher the accessibility to the active site of the enzyme. However, since the number of torsions increased as the chain length increased, it became difficult for the hydroxyl oxygen of the alcohol to access the ^γO of serine at the enzyme active site. These molecular docking results were consistent with substrate preference results of the *Rcut* enzyme. The *Rcut* maintained the synthesis efficiency at least for 5 days in isooctane solvent. We synthesized as much as 452 mM butyl butyrate by adding 100 mM substrate daily for 5 days and performing the reaction. These results show that *Rcut* is an efficient enzyme for producing alkyl butyrate used in the food industry.

keywords:

Cutinase; esterification; alkyl butyrate; molecular docking; substrate specificity

4-74 *Genetics & Heredity*

The complete chloroplast genome of an Arctic lycophyte, *Huperzia arctica* (Tolm.) Sipliv. 1973 (Lycopodiaceae)

Hwang, Youngsim., **Lee, Yoo Kyung.,** Son, Yowhan. and **Lee, Hyoungseok.**
Mitochondrial DNA Part B-Resources. 2023. 8(12): 1391-1395.
 doi: 10.1080/23802359.2023.2292144.

Huperzia arctica (Tolm.) Sipliv. 1973 is a lycophyte species belonging to the Lycopodiaceae family, which is widely distributed in the Arctic region of Svalbard, Norway. To determine its taxonomic position, we sequenced the chloroplast genome of *H. arctica*. The complete chloroplast genome of *H. arctica* is 153,956 bp in length with 122 annotated genes, including 87 protein-coding genes, 31 tRNA genes, and 4 rRNA genes. To evaluate its evolutionary position, we performed phylogenetic analysis using 36 conserved orthologous protein-coding gene sequences from the chloroplast genomes of *H. arctica* and publicly available data from other Lycopodiaceae. *H. arctica* formed a monophyletic group with four other *Huperzia* species: *H. lucidula*, *H. serrata*, *H. crispata*, and *H. javanica*. However, it appeared as a separate species with a highly supported bootstrap value.

keywords:

Arctic; chloroplast genome; *huperzia arctica*; lycopodiaceae; phylogeny

4-75 *Genetics & Heredity*

The complete mitochondrial genome of an Antarctic moss, *Andreaea regularis* Mull. Hal. 1890 (Andreaeaceae)

Min, Kyungwon., Sulaiman, Syahril., Lee, Hyodong., Kang, Pilsung., Yoon, Young-Jun. and **Lee, Hyoungseok.**
Mitochondrial DNA Part B-Resources. 2023. 8(6): 704-708.
 doi: 10.1080/23802359.2023.2226258.

In the present study, we determined the complete mitochondrial genome of *Andreaea regularis* Müll. Hal. 1890, a lantern moss of the genus *Andreaea* Hedw. (Andreaeaceae). The *A. regularis* mitochondrial genome, with a total length of 118,833 bp, consists of 40 protein-coding genes, 3 ribosomal RNA genes, and 24 transfer RNA genes. A phylogenetic tree

constructed with 19 complete mitochondrial genomes composed of liverworts, hornworts, and 15 mosses showed that Andreaeales formed the closest sister to Sphagnales before divergence of the remaining moss groups, indicating *A. regularis* being one of the earliest mosses. Our findings could be beneficial to investigate the bryophyte evolution.

keywords:

Andreaeales; bryophyte; mitogenome; phylogeny; rock moss

4-76 *Marine & Freshwater Biology; Oceanography*

The dynamics of growth and maturation age in the scallop *Adamussium colbecki* in Terra Nova Bay, Antarctica

Choi, Sun Kyeong., Kang, Yun Hee., Moon, Kyeonglim., Seo, In-Soo., Kim, Sanghee. and Park, Sang Rul.

Estuarine Coastal and Shelf Science. 2023. 294.

doi: 10.1016/j.ecss.2023.108537.

The endemic Antarctic scallop *Adamussium colbecki*, one of the most common bivalve species, plays an important ecological role in Antarctic ecosystems. In this study, we investigated the size frequency structure, shell height, and gonadosomatic index (GSI) of *A. colbecki* in coastal areas near Jang Bogo Antarctic Research Station in Terra Nova Bay. A generalized von Bertalanffy growth function was fitted to shell height-at-age measurements of 389 individuals ($H_{\infty} = 115.4$ mm and $K = 0.064$ year⁻¹). Large-sized individuals (70–84 mm) of *A. colbecki* were ~2X as prevalent, accounting for more than 50% of the overall density. Individuals younger than 6 years showed a lower growth rate compared to that reported in previous studies. GSI indicated that sexual maturity of both females and males was observed in individuals over 50 mm shell height at the age of approximately 9 years. The maturity was delayed by two to four years when compared with previous data in Terra Nova Bay due to the low growth rates of the young population. Therefore, the low growth rate of young individuals and the delayed maturity age may have deleterious effects on population growth. The information reported here provides baseline scientific data that can be used to develop better informed management decisions and aid in defining an effective management strategy for Antarctic scallops.

keywords:

Adamussium colbecki; Antarctic scallop; Age; Growth rate; Sexual maturity

4-77 *Environmental Sciences; Public, Environmental & Occupational Health*

The glacier melting process is an invisible barrier to the development of Antarctic subtidal macroalgal assemblages

Ko, Young Wook., Lee, Dong Seok., Kim, Jeong Ha., Ha, Sun-Yong., Kim, Sanghee. and Choi, Han-Gu.

Environmental Research. 2023. 233.

doi: 10.1016/j.envres.2023.116438.

Ecological macroalgal succession in glacier-free areas has remained at the pioneer seral stage despite six decades of glacial retreat at Marian Cove, King George Island, Antarctica. With the rapid melting of glaciers in the West Antarctic Peninsula owing to global warming, a massive amount of meltwater is flowing into the coast, creating marine environmental gradients such as turbidity, water temperature, and salinity. This study examined the spatial and vertical distributions (up to a depth of 25 m) of macroalgal assemblages from nine sites in Maxwell Bay and Marian Cove. The macroalgal assemblages were analyzed for six sites located 0.2, 0.8, 1.2, 2.2, 3.6, and 4.1 km away from the glacier, including three sites where the glacial retreat history of Marian Cove could be estimated. To investigate the effects of meltwater, differences in the coastal environment were analyzed based on data collected from five stations located 0.4, 0.9, 3.0, 4.0, and 5.0 km away from the glacier. The macroalgal assemblages and marine environment were divided into two groups—inside and outside the cove—based on the region 2–3 km away from the glacier, which has been ice-free since 1956 and shows significant differences. In the three sites near the glacier front, *Palmaria decipiens* was dominant, and three to four species were distributed, whereas in the two sites outside the cove, nine and 14 species appeared, respectively, similar to the assemblage of the other three sites in Maxwell Bay. *Palmaria decipiens*, a representative opportunistic pioneer species in Antarctica, is dominant because of its physiological adaptation despite the high turbidity and low water temperature of the glacier front. This study shows that macroalgal assemblages in Antarctic fjord-like coves respond to glacial retreat and are valuable in understanding the macroalgal succession in Antarctica.

keywords:

Macroalgal assemblage; Antarctica; Glacial retreat history; Ecological succession; Subtidal; Marian cove

4-78 *Multidisciplinary Sciences*

The leaderless communication peptide (LCP) class of quorum-sensing peptides is broadly distributed among Firmicutes

Aggarwal, Shifu., Huang, Elaine., Do, Hackwon., and 6 others.

Nature Communications. 2023. 14(1).

doi: 10.1038/s41467-023-41719-3.

The human pathogen *Streptococcus pyogenes* secretes a short peptide (leaderless communication peptide, LCP) that mediates intercellular communication and controls bacterial virulence through interaction with its receptor, RopB. Here, we show that LCP and RopB homologues are present in other Firmicutes. We experimentally validate that LCPs with distinct peptide communication codes act as bacterial intercellular signals and regulate gene expression in *Streptococcus salivarius*, *Streptococcus porcinus*, *Enterococcus malodoratus* and *Limosilactobacillus reuteri*. Our results indicate that LCPs are more widespread than previously thought, and their characterization may uncover new signaling mechanisms and roles in coordinating diverse bacterial traits.

to general distribution of tables and diagrams that were discontinuously expressed. The coastscape was expressed more quantitatively and continuously, and was also useful for explaining temporal changes such as summer abundance can be described as a shift from *I. cordata* to *P. antarcticus*. In addition, in terms of species composition, this study area corresponds to the middle to lower intertidal zone and shows the highest species diversity in King George Island, so it is expected to provide important information for the researches in Antarctic intertidal zones.

keywords:

Antarctica; Contour plot; Intertidal zone; Macroalgae; Assemblage shift

4-80 *Microbiology*

The Revision of Lichen Flora Around Maxwell Bay, King George Island, Maritime Antarctic

So, Jae Eun., Halda, Josef P. P., Hong, Soon Gyu., Hur, Jae-Seoun. and Kim, Ji Hee.

Journal of Microbiology. 2023. 61(2): 159-173.

doi: 10.1007/s12275-023-00015-x.

Since the floristic study of lichens at the Barton and Weaver Peninsulas of King George Island in 2006, there have been intense investigations of the lichen flora of the two peninsulas as well as that of Fildes Peninsula and Ardley Island in Maxwell Bay, King George Island, South Shetland Islands, maritime Antarctic. In this study, a total of 104 species belonging to 53 genera, are identified from investigations of lichens that were collected in austral summer seasons from 2008 to 2016. Phenotypic and molecular analyses were incorporated for taxonomic identification. In particular, 31 species are found to be endemic to the Antarctic and 22 species are newly recorded to the Maxwell Bay region. *Lepra dactylina*, *Stereocaulon caespitosum*, and *Wahlenbergiella striatula* are newly recorded in the Antarctic, and the previously reported taxon *Cladonia furcata* is excluded from the formerly recorded list due to misidentification. We also provide ecological and geographical information about lichen associations and habitat preferences.

keywords:

Lichen; Lichen taxonomy; Antarctic lichen diversity; Ecological traits

4-79 *Ecology; Geosciences, Multidisciplinary*

The rapid shift of intertidal macroalgal assemblage from vertical shoreline profiles in Barton Peninsula, King George Island, Antarctica during summer

Ko, Young Wook., Lee, Dong Seok., Kim, Sanghee., Ha Kim, Jeong. and Choi, Han-Gu.

Polar Science. 2023. 35.

doi: 10.1016/j.polar.2023.100927.

Temporal variability and the vertical shoreline profile of an intertidal macroalgal assemblage were examined on the coast of Barton Peninsula, Maxwell Bay, King George Island, Antarctica. Sampling was performed during the three austral summer seasons from November 2016 to January 2019. The sampling interval for the summer shift was 1–2 months. Eighteen algal species were identified, with 75% relative coverage of the predominant red alga *Iridaea cordata* and endemic brown alga *Phaeurus antarcticus*. Temporal variation in the macroalgal assemblage showed 78.35% similarity between one month and 64.61% similarity between two months. Contour plots for visualizing macroalgal distribution were first attempted in this study, and compared

The Safety and Efficacy of 1-Monoeicosapentaenoin Isolated from the Trebouxiophyceae *Micractinium* on Anti-Wrinkle: A Split-Face Randomized, Double-Blind Placebo-Controlled Clinical Study

Kim, Ki Mo., Ji, Kon-Young., Choi, Yoon Jung., Heo, Jong Beom., Youn, Ui Joung., Kim, Sanghee., and 6 others.

Journal of Clinical Medicine. 2023. 12(2).

doi: 10.3390/jcm12020587.

The skin aging process is governed by intrinsic and extrinsic factors causing skin wrinkles, sagging, and loosening. The 1-monoeicosapentaenoin (1-MEST) is a component isolated from *Micractinium*, a genus of microalgae (Chlorophyta, Trebouxiophyceae). However, the anti-wrinkle effects of 1-MEST are not yet known. This study aimed to evaluate the anti-wrinkle effects of 1-MEST in vitro and in clinical trials. The cytotoxicity of 1-MEST was investigated in vitro using the MTS assay in human epidermal keratinocytes (HEKs). Expression of matrix metalloproteinase (MMP)-1 and MMP-9 was determined by ELISA in HEKs irradiated with UVB after treatment with 1-MEST. A split-face randomized, double-blind, placebo-controlled study was conducted to evaluate the safety and efficacy of 1-MEST. The study evaluated wrinkle parameters and visual assessment, self-efficacy and usability questionnaires, and adverse events. The study showed that the 1-MEST was not cytotoxic in HEKs, suppressed MMP-1 secretion and MMP-9 protein expression in HEKs irradiated with UVB. The wrinkle parameters and mean visual assessment score were significantly decreased in the test group after 12 weeks and differed from the control group. There were no significant differences in efficacy and usability. Adverse effects were also not observed. The 1-MEST showed anti-wrinkle properties to slow down or prevent skin aging.

keywords:

Trebouxiophyceae *Micractinium*; 1-monoeicosapentaenoin; clinical trial; skin wrinkle; anti-aging; matrix metalloproteinase

Part 5.

Policy & Technology

5-1

A Review on precautionary regarding international norms for protecting marine environment in areas beyond national jurisdiction

Moh, Youngdawng., Lee, Changyoul., Lee, Kilwon., and Seo, Wonsang.

Law & Policy Review. 2023. 29(1):97-120.

doi: 10.36727/jjpr.29.1.202303.004.

In 2023, the international community will continue the negotiations on the UN BBNJ agreement and the ISA regulations for the exploitation of mineral resources in the Area. The two legal instruments on sustainable use of and conservation of the marine biodiversity in the areas beyond national jurisdiction are critical because they will shape the mankind's future activities therein. However, our limited scientific knowledge and information on the areas beyond national jurisdiction makes us advance our activities therein against risk which are still unknown to us. Recognizing the risk and uncertainty, the international community seems to have reached consensus on applying and adopting the precaution both in the UN BBNJ agreement and the ISA exploitation regulations. However, there is still a divergence on the legal status of precaution between States. A group of States believes that precaution is already one of principles in international law but the other group still sees it as an approach. However, this article has found the question whether precaution should be a principle or an approach is not meaningful in terms of effectiveness. This article argues what matters in constructing the effective precaution regime in the area beyond national jurisdiction is how to define risk and uncertainty which are two pillars in the concept precaution. In this vein, this study proposed the new precautionary regime in the areas beyond national jurisdiction based on the analysis on the new instruments' relation to existing legal instruments and on the nature of marine biodiversity. The legal and policy suggestions

are setting the level of risk high as reflected in the Rio Declaration and the level of uncertainty low to prevent precautionary approach or principle from being applicable to all the activities beyond national jurisdiction

Keywords:

Precautionary; Areas Beyond National Jurisdiction; BBNJ; International Seabed Authority; Draft Exploitation Regulations

5-2

A Study on the Analysis of Polar Media Coverage Using Topic Modeling and Network Analysis

Choi, JiHyun. and Hwang, Youna.

The Journal of the Korea Contents Association. 2023. 23(3):27-37.

doi: 10.5392/JKCA.2023.23.03.027.

This study attempted to examine the main keywords, topics, and changes that appear in domestic media reports related to polar regions, and to explore the direction of future media reports. To this end, topic modeling and network analysis were performed by extracting polar article data reported in domestic daily newspapers for 18 years. As a result of topic modeling analysis, eight topics were derived, and based on this, it could be summarized into three perspectives: "the front line of the climate crisis", "the subject of research and exploration", and "international relations". As a result of keyword analysis by period, it was confirmed that domestic media reports viewed the polar region as an unknown world or exploration object, and the approach as a scientific research object began to appear relatively late. In addition, as climate crisis keywords appeared at the same time in general and scientific reports, it was found that the climate crisis began to be recognized as a research issue that requires scientific response, not only as a social issue. This study is significant in that it empirically and systematically analyzed the trends and changes in media reports related to polar regions by using news big data for the first time in Korea. It is expected that this can be used as a basis for the direction of media reporting and strategic approaches that can promote public understanding and interest in polar regions.

Keywords:

Polar; Antarctic; Arctic; Topic Modeling Analysis; Network Analysis

5-3

An Exploratory Study of the Zerowaste Appeals of Fund Creator - Analysing Semantic Networks of the Crowdfunding Platform's Project Descriptions

Jeon, Seung., Hwang, Youna. and Choi, Jihyun.

The Journal of the Korea Contents Association. 2023. 23(10):49-61.

doi: 10.5392/JKCA.2023.23.10.049.

This study explores the relations and contexts of keywords posted on crowdfunding platforms and how creators appeal to Zerowaste values. For the study, we collected the text of completed project descriptions on a crowdfunding website for nine years and conducted a semantic network analysis. The results showed that creators intended to produce zero-waste items, reflecting the trend towards greener consumption and alternatives to plastic. To satisfy their environmentalist, the creators adopted the "waste-free" concept even for products unrelated to waste reduction, and have shown a tendency to exploit environmental terminology in texts. By examining the language of green promotions, this study provides a theoretical and practical basis for crowdfunding and green products.

Keywords:

Zerowaste; Green Products; Crowdfunding; Semantic Network Analysis

5-4

Analyzing the Characteristics of Korea's recent Arctic Policies based on the Arctic Policy Model - Focusing on expanding cooperation with Europe

Seo, Hyunkyo.

Journal of European Union Studies. 2023. 67:197-227.

doi: 10.18109/jeus.2023.67.197.

After becoming an observer of the Arctic Council in 2013, the Korean government set the 1st Masterplan for the Korea's Arctic Policy (2013-2017) as a follow-up action in the same year. The 2nd Masterplan for Korea's Arctic Policy (2018-2022) was announced as a follow-up the 1st Masterplan, and Korea's Arctic policy system was established step by step. Afterwards, the Ministry of Oceans and Fisheries (MOF)

declared the '2050 Polar Vision' in December 2018 to prepare a long-term vision for Korea's polar policy. The Polar Activities Promotion Act, led by MOF, in April 2021, was enacted and Korea laid the legal foundation for systematic fostering and support of integrated 'Arctic and Antarctic activities' in Korea. In November of the same year, 'Arctic Activities Strategy for 2050' was announced to establish a long-term direction for Arctic policies. And finally, in November 2022, MOF established and announced the 1st Basic Plan for the Polar Activity Promotion (2023-2027) based on the Polar Activities Promotion Act. The Polar Activities Promotion Act, led by MOF, in April 2021, was enacted and Korea laid the legal foundation for systematic fostering and support of integrated 'Arctic and Antarctic activities' in Korea. In November of the same year, 'Arctic Activities Strategy for 2050' was announced to establish a long-term direction for Arctic policies. And finally, in November 2022, MOF established and announced the 1st Basic Plan for the Polar Activity Promotion (2023-2027) based on the Polar Activities Promotion Act. In this study, precedent domestic and foreign studies related to the establishment of Arctic policies in Korea were analyzed, and the policy framework and contents from the 1st Masterplan for the Arctic Policy (2013-2017) to the 1st Polar Activities Promotion Basic Plan (2023-2027) were reviewed. In particular, based on the 'Korea Arctic Policy Model' developed through the research of Hyunkyo SEO (2019), 'Arctic Activities Strategy for 2050' and the 1st Basic Plan for the Polar Activity Promotion were analyzed, and differences and characteristics were examined. In conclusion, based on the analysis results, the policy directions of the 2nd Basic Plan for the Polar Activity Promotion (2028-2032), which correspond to the 2nd term polar policy of Korea, were proposed. Finally, recent governmental policies & projects based measures to strengthen cooperation with Europe were presented.

Keywords:

'The 1st Masterplan for Korea's Arctic Policy'; '2050 Polar Vision'; Arctic Activities Strategy for 2050; The Polar Activities Promotion Act' The 1st Basic Plan for the Polar Activity Promotion

5-5 Engineering, Environmental; Environmental Sciences

Catalytic behavior of nitrous acid for acetaminophen transformation during the freezing process

Ahn, Yong-Yoon., Kim, Jungwon. and Kim, Kitae.

Journal of Hazardous Materials. 2023. 456.

doi: 10.1016/j.jhazmat.2023.131652.

This study demonstrates the transformation of acetaminophen by reactive nitrous acid in a frozen solution and its abnormal stoichiometry. The chemical reaction between acetaminophen and nitrous acid (AAP/ NO_2^- system) was negligible in the aqueous solution; however, the reaction rapidly progressed if the solution started to freeze. The ultrahigh performance liquid chromatography-electrospray ionization tandem mass spectrometry measurements showed that polymerized acetaminophen and nitrated acetaminophen were formed in the proceeding reaction. Electron paramagnetic resonance spectroscopy measurements showed that nitrous acid oxidized acetaminophen via a one-electron transfer reaction producing acetaminophen-derived radical species, which is the cause of acetaminophen polymerization. We demonstrated that a relatively smaller dose of nitrite than acetaminophen caused significant acetaminophen degradation in the frozen AAP/ NO_2^- system and revealed that the dissolved oxygen content notably affected acetaminophen degradation. We showed that the reaction occurs in a natural Arctic lake matrix (nitrite and acetaminophen spiked). Considering that the freezing phenomenon is common in the natural environment, our research provides a possible scenario for the freezing chemistry of nitrite and pharmaceuticals in environmental chemistry.

keywords:

Nitrite; Ice; Abnormal stoichiometry; Freeze concentration; Pharmaceuticals

5-6 *Environmental Studies; Transportation; Transportation Science & Technology*

Effects of Arctic commercial shipping on environments and communities: context, governance, priorities

Huntington, Henry P., Olsen, Julia., Zdor, Eduard., Zagorskiy, Andrey., Shin, Hyoung Chul. and 5 others.

Transportation Research Part D-Transport and Environment. 2023. 118.

doi: 10.1016/j.trd.2023.103731.

Increasing shipping traffic in the Arctic Ocean creates an emerging need to understand the consequences of maritime operations on the Arctic environment and coastal

Indigenous and non-Indigenous communities, as well as potential governance responses. To address this need, we examine recent shipping trends and assess their impact on Arctic environments and communities. Our arguments are novel, and are built around contemporary empirical investigations and published scientific studies, reports, and government documents. The paper concludes that the environmental and community impacts vary across the Arctic and that greater international co-ordination is needed to learn from experience, to share assets and capacities, and to guide responsible and sustainable development of Arctic shipping. Given the possibility for opening of the Transpolar Sea Route within the coming decades, further proactive steps, such as developing a governance framework, could help Arctic shipping avoid rather than attempt to correct problems.

keywords:

Shipping; Arctic routes; Indigenous peoples; Local communities; Social and environmental concerns; Risks

5-7 *Engineering, Electrical & Electronic; Optics*

Miniaturized tapered-slot ultra-wideband Vivaldi antenna for ice sounding radar

Won, Hoyun., Hong, Yang-Ki., Choi, Minyeong., Lee, Woncheol., Taylor, Drew., Chung, Changhyun. and Lee, Joohan.

Microwave and Optical Technology Letters. 2023. 65(10): 2808-2813.

doi: 10.1002/mop.33777.

This paper presents a novel high-gain, miniaturized, and ultra-wideband tapered-slot Vivaldi antenna (TSVA) for ice-sounding radar applications. To miniaturize the antenna and improve the impedance matching and antenna gain of conventional TSVA, tapered slot edge, circular cavity, rectangular cavity, inner circular patch, and rectangular slit structures are newly designed and introduced. The simulation results show that the size of the designed Vivaldi antenna is reduced by 15% and increases the peak realized gain by up to 5.1 dBi, compared to the conventional Vivaldi antenna. The optimized Vivaldi antenna was fabricated and characterized for its antenna performance. The simulated results are in good agreement with the measured results.

keywords:

high-gain; miniaturization; rectangular cavity; tapered-slot Vivaldi antenna; ultra-wideband

5-8 *Environmental Sciences; Geography, Physical;
Geosciences, Multidisciplinary*

Researchers on ice? How the COVID-19 pandemic has impacted Antarctic researchers

Liggett, Daniela., Herbert, Andrea., Badhe, Renuka., Charnley, Gina E. C., Hudson, K. P. C., Kelman, Ilan., **Lee, Won Sang**, and 5 others.
Antarctic Science. 2023. 35(2): 141-160.
doi: 10.1017/s0954102023000020.

The COVID-19 pandemic and pandemic-related measures have impacted the lives and work-related activities of Antarctic researchers. To explore these impacts, we designed, piloted and disseminated an online survey in English, Russian, Spanish and Chinese in late 2020 and early 2021. The survey explored how the pandemic affected the productivity of Antarctic researchers, their career prospects and their mental wellbeing. Findings exposed patterns of inequities. For instance, of the 406 unique responses to the survey, women appeared to have been affected more adversely than men, especially in relation to mental health, and early-career researchers were disadvantaged more than their mid- or late-career colleagues. Overall, a third of the research participants reported at least one major negative impact from the pandemic on their mental health. Approximately half of the participants also mentioned that the COVID-19 pandemic had some positive effects, especially in terms of the advantages that working from home brought and opportunities to attend events, network or benefit from training workshops online. We conclude with a series of recommendations for science administrators and policymakers to mitigate the most serious adverse impacts of the pandemic on Antarctic research communities, with implications for other contexts where scientific activities are conducted under extreme circumstances.

keywords:

academia; Antarctic research community; fieldwork; gender; mental health; pandemic; survey

5-9

극지용 무인지상로봇 플랫폼 GENTU 개발

Chung, Changhyun., Kim, Hyoung-Kwon., Yoon, Dong-jin. And Lee, Joohan.
로봇과인간. 2023. 20(1):19-27.

Keyword Index

'2050 Polar Vision'	5-4
'The 1st Masterplan for Korea's Arctic Policy'	5-4
1D-Var retrieval	1-24
1-monoecosapentaenoin	4-81
3-D laser scanner	1-61

A

A decadal revisit	4-58
Abnormal stoichiometry	5-5
academia	5-8
accelerated glacier melting	1-41
Acid rain	3-3
Acinetobacter baumannii	4-16
acoustic characteristics	3-41
acoustic modeling	3-41
Actinobacteria	4-27
Active continental margin	2-27
Active layer	1-10, 1-42
Adamussium colbecki	4-76
Adaptation	4-39
Aerosol	1-11
Aerosols	3-24
Age	4-76
Air-sea CO ₂ exchange	3-40
Air-sea CO ₂ flux	3-5
Alaskan Coastal Current	3-47
alkyl butyrate	4-73
Alkyl-PAHs	3-12
altitude	1-64
Amino acids	1-11, 3-39
Ammonia oxidizing archaea	3-53
Ammonia-oxidizing archaea	3-49
amoA gene	3-53
Amundsen Sea Polynya	3-46
analytical Green's function	3-14
Ancestral character	4-47
Andreaeales	4-75
anesthesia	4-34
Animal tracking	4-62
anorthosite	2-15

Antarctic	5-2
Antarctic bacteria	4-27
Antarctic Bottom Water (AABW)	3-29
Antarctic copepod	4-36
Antarctic Earth-system science	3-9
Antarctic fish	4-11, 4-20, 4-51
Antarctic fungi	4-52
Antarctic Ice Sheet	1-22
Antarctic Ice Shelf	1-23
Antarctic krill extracts	4-6
Antarctic lichen	4-12, 4-69
Antarctic lichen diversity	4-80
Antarctic Peninsula	3-35
Antarctic polynyas	3-21
Antarctic region	1-9
Antarctic research community	5-8
Antarctic scallop	4-76
Antarctic sea ice	3-29
Antarctic sea ice extent (SIE) in the Indian Ocean sector	1-68
Antarctic seabird	4-5
Antarctic shallow fjords	3-20
Antarctic silverfish	4-31
Antarctic tundra	4-30
Antarctica	1-11, 1-19, 1-29, 1-30, 1-35, 1-39, 1-69, 3-43, 3-44, 4-32, 4-37, 4-46, 4-55, 4-59, 4-77, 4-79
Anterior sclerite	2-36
Anthraquinone	4-69
anthropogenic emission	1-12
anti-aging	4-81
Anti-cancer	4-28
Anti-inflammation	4-60
Aptenodytes forsteri	4-53
Aqueous organic compounds	1-13
Araon	3-34
Archaeal distribution	3-53
Arctic	1-69, 1-72, 3-15, 4-35, 4-47, 4-74, 5-2
Arctic Activities Strategy for 2050	5-4
Arctic Holocene	3-22
Arctic Ocean	1-4, 1-37, 1-51, 1-60, 3-11, 3-24, 3-27, 3-34, 3-42, 3-47, 3-53, 3-54
Arctic region	4-9
Arctic routes	5-6

Arctic sea ice	1-62
Arctic SIE	1-66
Arctic Svalbard.	3-12
Arctic vegetation mapping	4-68
Arctic warming	1-18
Arctic winter sea ice	1-24
Arctic.	4-48
Area-based conservation	4-62
Areas Beyond National Jurisdiction	5-1
Arthropoda	2-18
Arthropods	4-8
Artiopoda	2-1
As(III) oxidation	1-31
Assemblage shift	4-79
Asteroids	2-13
atmosphere	1-36, 3-9
Atmosphere-ocean interaction	1-69
Atmospheric acid deposition	3-3
Atmospheric proton loading	3-3
Aulacomnium turgidum	4-29
<i>Aureococcus anophagefferens</i>	4-21
Autofiring module	3-48
Autoliths	2-33
Auxotroph	4-17
available N	4-9
Ayu Trough	2-32
Azimuth	3-1

B

Back-arc basin	2-35
Bacteria	4-8
bacterial degradation	4-30
bacterial diversity	4-9
bacterial pathogen	4-18
Barrier protection	4-60
Barrow Canyon	3-47
Basin	2-11
Bathymetric Position Index	1-23
Bay of Bengal	1-34
BBNJ	5-1
Bear Peninsula	1-29
Bellingshausen Sea	3-16
Below-cloud scavenging	1-48

Bering Strait	3-47
biocatalyst	4-70
biofilm production	4-15
Biogeochemistry	3-7, 3-9, 3-46
biomass enhancement	4-7
Biomolecular composition	3-15
biopolymeric carbon (BPC)	3-52
Biotelemetry	4-62
Birnessite	2-31
boreal-winter climate	1-15
bottom current	1-30, 3-17
bottom simulating reflector	2-16
Boundary currents	3-47
Bransfield Strait	2-35
bryophyte	4-75
Burger number	3-50
Burgess Shale-type	2-18
BVOC	3-34

C

Calvin cycle	4-2
Calving line	2-26
Cambrian	2-18
Cambrian explosion	2-5
Cambrian trilobites	2-28
Cambridge Bay	3-52
Canadian Beaufort Sea	2-16, 3-37
Cape Hallett	4-5
carbon cycle	3-5
carbon stable isotope (C-13)	3-31
carboxylesterases	4-70
Carolibrandtia	4-55
carotenoid biosynthesis	4-45
Carrion	4-8
Cas9	4-50
cassiterite	2-20
CAZyme	4-49
CD200	4-38
CD200 receptor	4-38
CD24	4-38
CD4	4-14
CD74	4-14
cell carbon biomass	3-20

Cephalic sensory structure	4-47
cGAS-STING	4-33
<i>Champsocephalus gunnari</i>	4-11
chemical reactions in ice	1-38
Chitosanase	4-49
Chl-a (chlorophyll a)	3-52
Chlamydomonas latifrons	4-7
Chlorella	4-55
chlorophyll	1-18
Chlorophyll-a concentration	3-21
chloroplast genome	4-74
Chondrites	2-13
Chromophoric dissolved organic matter (CDOM)	3-51
Chukchi Sea	3-27
Chukchi Sea circulation	3-47
CL	2-20
clay minerals	2-14
Climate change	1-33, 1-64, 1-72, 4-4, 4-35
clinical trial	4-81
CMEs	1-45
CMIP5	1-18
CMIP6	1-18
CMIP6 multi-models	1-54
Coastal ecosystem	4-66
coastal processes	3-9
coastal upwelling	3-50
Cobalt tungstate	1-13
Coefficient of divergence	1-65
cold acclimation	4-29
Cold adaptivity	4-72
cold shock proteins	4-37
Cold-active enzyme	4-44
Cold-adapted bacteria	4-44
cold-adopted	4-18
cold-water cavity ice shelf	3-43
Cold-water coral	2-11
Colobanthus quitensis	4-46
Colored dissolved organic matter(CDOM)	4-32
Community Atmosphere Model 5	1-15
Community composition	3-8
comparative genomics	4-15, 4-39
complement receptors	4-33
Compound profiles	4-60

computing aspects	2-19
Condition factors	4-51
Continental alkaline magmatism	2-33
Continental shelf sediments	2-26
Contour plot	4-79
contourite	1-30, 3-16
Convective activity	1-68
Co-occurrence network	3-38
copepod	3-11
Cosmogenic Nuclides Surface Exposure Dating	1-32
coupled wave activity	1-36
Cretaceous	2-27
CRISPR	4-50
crop yield	4-18
cross-disciplinary observing system	3-9
Crowdfunding	5-3
cryosphere	1-72, 4-39
Crystal mush	2-33
Crystal structure	4-16, 4-22, 4-24, 4-25, 4-26, 4-40, 4-72
current driven upwelling	3-50
Cutinase	4-73
Cyclic dipeptide	4-27
cytochrome P450	4-22, 4-43

D

Data assimilation	1-17, 1-24, 1-52, 1-69
Data interpolating empirical orthogonal function	3-21
DB3	4-28
de novo assembly	4-29
Deep Ocean	3-53
delayed impact of the ENSO	1-70
Diatom	3-15
Diatoms	3-20, 3-36
Dibenzofuran	4-12
diel vertical migration	3-11
Digital surface model	1-20, 1-63
dimer	4-24
Dimethyl sul fide (DMS)	1-43
Dimethylsulfoniopropionate (DMSP)	1-43
Dirafinesquina	2-21
Dissolved organic carbon	3-44

DMS	3-24, 3-34
DMSP lyase activity (DLA)	1-43
Dominant factor	3-13
Doppler effect	3-1
Draft Exploitation Regulations	5-1
Drake Passage	3-17
Drift	1-59, 1-60
drug target	4-25
Drygalski Basin	2-26
Dust event frequency	1-33
dynamical core	1-15

E

Earth System Model	1-18
East Antarctic Ice Sheet	1-32
East Asian marginal sea	3-3
East Asian Summer Monsoon	1-1
East Sea	2-11
East Siberian Sea	3-11, 3-27
East Siberian shelf	3-41
Eastern Ross Sea	3-32
Ecological succession	4-77
Ecological traits	4-80
Ecotype	4-39
eDNA	3-22
El Niño-Southern Oscillation	1-1
Electrical resistivity tomography	1-10
emissivity	1-24
emitting layer temperature	1-24
ENSO	1-57
ENSO teleconnection	1-70
enzyme mechanisms	4-71
ERSEM	3-33
esterases	4-71
esterification	4-73
Eu anomaly	2-15
Eu isotope fractionation	2-15
Euarthropoda	2-1
eukaryotic plankton communities	4-21
European Incoherent Scatter (EISCAT)	1-46
Exiguobacterium antarcticum	4-70
Extreme sea ice	1-66
extremophiles	4-37

F

Fast grain boundary diffusion	2-4
Fatty acid profile	4-36
feldspar crystallization	2-15
Fe-Mg interdiffusion	2-4
Ferromanganese nodule	2-31
ferulic acid	4-40
feruloyl esterase	4-40
FGOALS-f2	1-66
fieldwork	5-8
Finite difference method	2-4
Fixed-wing unmanned aerial vehicle	1-20
fjord winds	3-35
Floating algae	3-28
fluid inclusions	2-20
fluorescent dissolved organic matter	3-10
Forecast verification/skill	1-52, 1-69
Freeze concentration	5-5
freeze concentration effect	2-14
freezing stress	4-29
frequency-domain reverse-time migration	3-14
freshwater residence time	3-35
Frost heave	1-42
FTIR spectroscopy	3-15
full-band frequency seismic imaging	3-14
Functional genes	4-66
Fungal metabolic engineering	4-50
Fungi	4-8
Fusopsis	3-30

G

Gadiformes	4-14
gas hydrate	3-37
gas hydrate stability zone	2-16
Gas seepage	2-11
GC	1-9
gender	5-8
Generalized Ekman theory	3-28
genome	4-46
genome assembly	4-45
Genome editing	4-50
genome rearrangement	4-57
Genome reduction	4-17

Geochemistry	2-35, 3-36
geomagnetic activity	1-58
Geomagnetic field	2-9
Geomagnetic storm	1-45
geometric evaluation	1-27
Geometry	3-1
GEOTRACES	3-7, 3-46
Glacial Collapse	1-22, 1-32
glacial freshwater	3-20
Glacial retreat history	4-77
Glacier	1-4, 1-20
Glacier retreat	1-41, 4-35, 4-59
Glaciimonas sp.	4-37
Glaciomarine Landform	1-23
Glaciovolcanic Landform	1-32
global plate reconstruction	2-32
Global warming	4-18, 4-61
GPS tracker	1-59
grain size	1-62
Green Products	5-3
greenhouse gas	1-12
Greenland	1-19, 1-20, 1-63, 4-47
Grounding line	2-26
Growth rate	4-76
gut microbiome	4-11
Gut microbiome analysi	4-53
<i>Gyrodinium helveticum</i>	4-21

H

H ₂ O ₂ -driven hydroxylation	4-43
Halophytes	4-66
Hamborgbukta	2-8
Hans Moosmuller	1-49
heat flow measurement	2-16
High arctic	4-4
high Arctic environments	1-41
High ice phase	1-68
High-Altitude Interferometer WIND Experiment (HIWIND)	1-46
high-gain	5-7
High-resolution mass spectrometry	1-39
high-throughput sequencing	4-11
HPLC	3-31

human disturbance	4-5
humic substances	4-30
<i>huperzia arctica</i>	4-74
Hwanghae District	2-28
Hydroacoustic survey	4-31
hydrography	3-9
Hydroperoxyl radical	1-31
Hymenobacter canadensis	4-48
hyperspectral	1-27
Hyperspectral image	4-68
Hyphomicrobiales	4-2
Hypostome	2-36

I

Ice	5-5
Ice algae	3-8, 3-15
ice chemistry	2-14
ice mass balance	1-19
Ice particle template	1-31
Ice sheet	2-26
ice sheet variation	3-16
Ice shelf	2-26
ice shelf water	3-19
ice shelves	3-29
iceberg scouring	2-8
Icebreaker ARAON	1-37
ice-free Arctic	1-54
Icelandic waters	1-43
identification	4-7
Image reconstruction	3-1
imaging	2-19
immune checkpoint molecules	4-38
Imputation	3-21
Indian summer monsoon	1-34
Indian summer monsoon rainfall	1-68
Indigenous peoples	5-6
Indonesian throughflow	1-34
innate immunity	4-33, 4-72
interleaving layer	3-19
International Seabed Authority	5-1
Intertidal zone	4-79
Invasion	4-28
inversion	2-19

IOD	1-57
ionosphere	1-25, 1-36
Ionosphere responses	1-45
iron (oxyhydr)oxides	1-41
iron source	2-14
Isolation basins	3-36
Isotopic compositions	3-7
Izanagi Plate	2-27

J

Jigunsan Formation	2-21
Jigunsania	2-21

K

Key biodiversity areas	4-62
kibara belt	2-20
kinetic energy conversion	1-70
King George Island	3-40
King Sejong Station	1-35
Kjaerina	2-21
Kongsfjorden	4-17
Korean IBRV Araon	1-9

L

La Niña-like mean state	1-1
Labrum	2-36
LaFae	4-40
Lagerstätten	2-18
LA-ICP-MS	2-20
Lake	1-42
Lake sediments stratigraphy	3-36
lamination	3-16
large eddy simulation	3-19
Latitudinal distribution	1-47
Length-weight relationships	4-51
Lichen	4-80
Lichen taxonomy	4-80
Lichenifustis flavocetrariae	4-2
Lichens	4-2
LiDAR	1-27, 1-63
Life history traits	4-36

ligand selectivity	4-71
Light absorption	3-8
linkage map	4-45
lithofacies	2-8
Little Ice Age	2-8
lobopodian	2-5
Local communities	5-6
Local Last Glacial Maximum	1-32
long-term trend	1-35
Low ice phase	1-68
lycopodiaceae	4-74

M

Machine learning classification	4-68
mackerel icefish	4-11
Macro -tidal environment	3-13
Macroalgae	4-79
Macroalgal assemblage	4-58, 4-77
Macrosphelides	4-52
magmatic differentiation	2-15
Magnesium isotope self-diffusion	2-4
magnetite formation	2-14
Magnetized seafloor	2-9
Magnetometer	2-9
manganese dioxide	1-38
Manganese oxide minerals	2-31
Marginal ice zone	3-54
Marian Cove	3-35, 3-40, 4-32, 4-59, 4-77
Marine deforestation	4-58
Marine ecosystem model	3-2
Marine Ice Cliff Instability	1-22
Marine Ice Sheet Instability	1-22
Marine Isotope Stage 9	3-17
Marine magnetic survey	2-9
Marine organic aerosol	1-39, 1-47
marine sediments	3-22
marine seismic	3-37
Marine spatial planning	4-62
matrix metalloproteinase	4-81
Maxwell Bay	3-40
Mean volume backscattering strength	4-31
medium optimization	4-7

megacrystic phengite	2-37
Melt flux	3-42
Melt pond	3-42
melt rate	3-19
Melt-ponds	3-54
meltwater	3-19
mental health	5-8
mesopause	1-64
mesosphere	1-64
mesosphere-lower thermosphere	1-44
mesospheric wind	1-35
metabarcoding	3-22
Metabolic activity	3-38
Metagenome	4-53
metagenomics	4-21
Metatranscriptomics	3-49
meteor	1-64
meteor radar	1-35, 1-44, 1-64
Meteorological information	1-37
Methane cycling	4-66
methane oxidation	4-9
methanotrophs	4-9, 4-35
Methylmercury	3-42
MHC class II	4-14
Microbacterium	4-15
microbial assembly	3-22
Microbial biomass	4-4
Microbial community composition	4-66
Microbial distribution	3-54
Microbial eukaryotes	3-38
microtiter dish biofilm formation assay	4-15
microwave temperature sounding	1-24
microzooplankton	3-30
midnight sun	3-11
mid-ocean ridge basalts	2-32
Migration	4-28
miniaturization	5-7
Mining activity	3-12
Mirounga leonina	4-63
mitochondrial genome	4-20
mitogen-activated protein kinase	4-42
mitogenome	4-75
mitogenome architecture	4-57

MLT	1-35
moist acidic tundra	4-9
molecular docking	4-52, 4-73
molecular evolution	4-57
Monascus pigment	4-50
Monascus ruber	4-50
Moore Dome	1-29
morphoanatomy	2-18
Morphogroup	4-47
morphological evolution	2-5
morphology	4-55
MS-222	4-34
MSA	3-24
MS-MS	1-9
mTOR	4-6
multi-sensor system	1-27
Muraenolepis orangiensis	4-14
MV420 mud volcano	2-16

N

nanophytoflagellates	3-20
Natural colorant production	4-50
Necrobiome	4-8
N-eicosapentanoyl phenylalanine	4-6
Nematodes	4-8
Neodymium Isotope	1-4
neodymium isotopes	1-41
Network Analysis	5-2
Neuroprotection	4-52
NF-kappa B	4-52
nitrification and denitrification processes	1-12
Nitrite	5-5
Nitrogen isotope	3-39
nitrous oxide	1-12
nonlinear interaction	1-44
Nonradical mechanism	1-13
North Korea	2-28
Northwest Africa	2-13
Notothenioidi	4-51
Notothenoid	4-20
novel species	4-48
Nrf2	4-52
nuclear SSU and ITS rDNA	4-55

nucleocytoplasmic large DNA viruses	4-21
Numerical modeling	3-13
numerical simulation	3-43
numerical solution	1-25
Numerical weather prediction/forecasting	1-52, 1-69
nutrient	1-18
Nutrient concentrations	3-15
Nutrient utilization	3-17

O

observations	3-29
ocean	1-36
Ocean color	3-21
Ocean current	3-28
ocean freshening	3-29
ocean warming	3-29
ocean-driven basal melt	3-43
ocean-ice shelf interaction	3-43
Ocean-sea ice-atmosphere interaction	1-47
oligotrichs	3-30
Oligotrophy	4-17
Onion-shell	2-13
oral pathogen	4-26
Orbitrap mass spectrometry	1-47
Orbitrap-MS	1-39
Ordovician	2-13
ore micro-textures	2-20
Organic aerosol	1-9
Organic matter cycle	4-32
organic matters	3-52
organoiodine compounds	1-38
Orthorectification image	1-20
Outbreak	4-61
Oxygen isotopes	2-13

P

p -Terphenyl	4-12
Pacific Arctic Ocean	3-39
Paenibacillus sp. R4	4-71
Paleoceanography	1-4
Paleo-glacier Reconstruction	1-23
paleoneuroanatomy	2-18

Paleo-productivity	1-34
palindromic repeat	4-57
Panarthropoda	2-5
pandemic	5-8
Parameterization Cunningham correction factor	1-48
Partial pressure of CO ₂ (pCO ₂)	3-40
Particle Tracking Experiment	3-28
Particulate organic carbon	3-44
Passive microwave	1-21
passive microwave (PMW)	1-62
pathogenic fungi	4-46
Patterned ground	1-10
PDO	1-66
Permafrost	1-10, 1-42
permafrost soil	4-18
Permafrost thawing	4-61
Peroxymonosulfate activation	1-13
Persistent toxic substances	3-12
PgASADH	4-26
PgFold	4-25
Phaeocystis antarctica	3-51
Phaeocystis pouchetii	3-51
Pharmaceuticals	5-5
Philippine Sea Plate	2-32
Phoenix Ridge	2-35
Phospholipid fatty acid analysis	4-4
Photoprotection	3-8
Photoreactivity	3-51
Phragmites australis	4-66
phylogeny	4-74, 4-75
physics-based ionospheric model	1-25
phytoene synthase	4-45
Phytoplankton	1-51, 3-31, 3-44, 4-59
phytoplankton biomass	3-27
Phytoplankton bloom	1-11, 3-49
phytoplankton size fractions	3-20
phytoplankton size structure	3-27
pigment production	3-31
Pigments	3-8
Piropsis	3-30
planetary waves	1-44
Plant pathogen	4-61
Platinum group elements	2-33

Pleistocene	3-32
PM _{2.5} pollution	1-65
POC flux	3-33
Polar	5-2
polar bacteria	4-15
Polar front	3-2
polar ionosphere	1-46
polar marine ecosystem	3-33
Polar marine phytoplankton	3-51
Polar microalgae	4-60
Polar microbiology	4-17
Polydisperse aerosol	1-48
Polynya	3-2, 3-49
Precautionary	5-1
Primary production	3-2
Pristine marine aerosol	1-9
Proliferation	4-28
Promoter	4-44
Protected areas	4-62
protein engineering	4-71
protein structure	4-71
Protein-protein interaction	4-72
Protist	3-38
Provenance	1-34, 2-27
Proxy	1-4
PsEst3	4-71
Pseudomonas	4-30
Psoriasis	4-60
<i>Psychrobacter</i> sp.	4-44
Psychrophile <i>Subtercola</i> spp.	4-39
Pyeongnam Basin	2-28
Pygoscelis adeliae	4-5, 4-53

Q

quantitative trait locus (QTL)	4-45
quartz vein	2-37

R

radiative transfer model	1-62
radiometric evaluation	1-27
radiosonde observations	1-17
Ramalina terebrata	4-69

Raman spectroscopy	2-31
rare earth elements	2-32
reactive iodine	1-38
reactive oxygen species	4-42
recolonization	4-5
Recombinant protein expression	4-44
recovery	4-34
rectangular cavity	5-7
red algae	4-57
redox cycle of iodine species	1-38
redox homeostasis	4-16
REE composition	2-37
Relative sea-level	3-36
resonances	1-36
respiratory burst oxidase homolog	4-42
restoration	4-5
Risks	5-6
river discharge	1-51, 3-10
River pufferfish	4-34
RNA-seq	4-29
rock moss	4-75
Ross Ice Shelf	1-36
Ross orogen	2-37
Ross sea	1-30, 2-26, 3-2, 3-44, 4-31, 4-53
Ross Sea region Marine Protected Area	4-5
Ross Sea-far East Antarctic Region	3-9
rossby wave propagation	1-70
Rubble-pile	2-13
Russell glacier	1-63

S

S2S prediction	1-66
Saccharides	1-9
salt stress	4-42
Sampling effort	4-62
SAR interferometry	1-42
Sarcopenia	4-6
Sargassum horneri	3-28
Satellite observations	1-52
SBAS	1-42
Scavenging coefficient	1-48
Sea ice	1-57, 1-59, 1-60, 1-61, 3-8, 3-9, 3-42, 3-52

sea ice concentration	1-51
Sea ice elevation	1-61
Sea ice thickness	1-21
sea level change	1-19
Sea Level Rise	1-22
sea surface warming	1-54
Sea water observation	1-37
Seafloor depression	2-11
seafloor morphology	1-30
Seafloor mound	2-11
seasonal predictability	1-15
seawater exchange	3-35
Sediment	3-12
sedimentary deposition	3-22
Sedimentary process	3-32
sedimentation rate	2-32
seismic airgun sound	3-41
seismic oceanographic imaging	3-14
seismic reflection	3-37
seismic stratigraphy	1-30
Semantic Network Analysis	5-3
Sentinel-1	1-42
Seoul metropolitan area	1-67
sesquiterpenes	3-34
Sexual maturity	4-76
S-formylglutathione hydrolase	4-24
shallow seismic stratigraphy	2-8
shelf sediment shoaling	3-10
Shipborne measurement	1-47
Shipping	5-6
Siglec-10	4-38
SIJQA campaign	1-67
Sinking particle	3-39
Sino-Korean platform	2-21
Sirius Passet Lagerstätte	2-1
site-directed mutagenesis	4-43
site-specific N-15 isotopomer	1-12
skin wrinkle	4-81
Small unmanned aerial vehicle	1-63
Snow	3-42
snow and sea ice model	1-24
snow depth (SD)	1-62
snow-pit	1-29

Social and environmental concerns	5-6
Soil depth	4-4
Soil microbes	4-61
sound propagation	3-41
source signature	3-41
South China-affinity terrane (SAT)	2-28
South Pacific Meridional Mode	1-1
Southern Elephant Seal	4-63
Southern Ocean	3-2, 3-5, 3-29
Southwestern continental shelf of Ulleung	2-11
soybean	4-42
Spatial consistency	4-62
Spatial resolution	3-1
Spatiotemporal distribution	1-65
SPBM	3-33
Spectral library	4-68
Spectral unmixing	4-68
specular meteor radar	1-58
Speed	1-59
Sphaeropsis	3-30
spreading rate	2-32
SSU rRNA	3-38
Steroid	4-43, 4-69
steroid hydroxylase	4-22
Sterol	4-12
Stone circle	1-10
Streptacidiphilus carbonis	4-27
Streptomycetaceae	4-27
structural changes	4-30
structure	4-33
structure determination	4-71
structure-function relationship	4-71
Suaeda japonica	4-66
sub-arctic sea	4-21
Subduction	2-35
Subglacial Landform	1-22
submarine permafrost	3-37
substrate specificity	4-73
Subtidal	4-77
Succession	4-35
Sulfate radical	1-13
Sulfides	2-33
Summer ice draft	1-21

Summer sea ice	1-21
superbugs	4-16
surface CO ₂ partial pressure (pCO ₂)	3-5
surface diatom production	3-16
surface radiation budget	1-72
Surface Roughness	1-23
Surface water production	3-17
survey	5-8
Suspended particulate matter	4-59
sympagic diatoms	3-33
sympagic ecosystem model	3-33
Synoptic	1-67
Synthetic Aperture Radar	1-42, 3-1
Synthetic aperture radar, Tracker with global positioning system	1-60

T

Taebaeksan Basin	2-21
Takifugu obscurus	4-34
tapered-slot Vivaldi antenna	5-7
taphonomy	2-18
Tardigrada	2-5
Tectonic setting	2-27
Temperature	4-36
Temporal change	4-58
Temporal changes	4-4
terminal moraine	2-8
Terpenoid	4-69
Thaw subsidence	1-42
the Amundsen Sea low (ASL)	1-70
The Gyeongsang Basin	2-27
The Korean Peninsula	2-27
The Pleiades Volcanic Field	2-33
The Polar Activities Promotion Act' The 1st Basic Plan for the Polar Activity Promotion	5-4
thermal modeling	2-16
thermocline structures in the shallow water column in the Arctic Ocean	3-14
Thermokarst	1-42
thioredoxin	4-16
TID induced by TAD	1-45
Tidal flat	3-13
tidal forcing	3-35
Tidal modulation	3-13

tides	1-44
Tigriopus kingsejongensis	4-36
Time-lag	1-65
tintinnids	3-30
tipping point	1-41
TLR	4-33
TLRs	4-14
Todorokite	2-31
Topic Modeling Analysis	5-2
Total alkalinity	3-3
Total suspended particle	3-3
trace elements	2-20
Trace metals	3-7, 3-46
Trace-metal-clean seawater sampling	3-48
tracer experiments	3-43
TRAF4	4-72
Trajectory	1-59, 3-1
Transboundary transport process	1-67
Transcriptome	4-39
transmission loss	3-41
Transparent exopolymer particle	3-44
Trebouxiophyceae <i>Micractinium</i>	4-81
trehalose biosynthesis	4-37
<i>Trematomus newnesi</i>	4-20
Trilobites	2-36
Trough-mouth fan	3-32
Turbidites	3-32
turbulence	3-19

U

UAV	1-27
Udo Islet	4-58
Ulleung Basin	3-48
ultra-wideband	5-7
Ulva prolifera	3-28
under-dense echo	1-58
underwater ambient noise	3-41
U-Pb zircon age	2-37
upwelling age (UA)	3-50
Usnea aurantiaco-atra	4-12
UV-incubation experiment	3-51

V

Variation of dust	1-33
Vector magnetic field	2-9
Venturiaceae	4-46
verification	1-17
Vertical export	3-2

W

Warmer interglacial	3-17
Water mass	3-54
Water masses	3-47
watermelon	4-45
Wave dissipation	3-13
Weather anomaly pattern	1-65
Weathering activity	1-34
West Antarctic	1-57
western Antarctic Peninsula	3-5
Western Arctic Ocean	3-10
Western North Pacific subtropical high	1-1
White sea	3-36
Whole genome	4-49
wind driven upwelling	3-50
WO3 nanosheet	1-31
wolframite	2-20

X

X-ray crystallography	4-22, 4-24, 4-25, 4-26, 4-40, 4-71
-----------------------	---------------------------------------

Y

YOPP-SH SOP	1-17
-------------	------

Z

Zerowaste	5-3
zinc-finger domains	4-16
Zonal and meridional winds	1-45

Author Index

A

Ahn, Yong-Yoon	1-13, 1-14, 1-31, 1-53, 5-5
Ahn, Youngkyu	1-41, 3-23

B

Bae, Minji	3-23
------------	------

C

Chae, Hyunsik	4-7, 4-55
Chang, Chaewon	1-55
Cho, Ahnna	4-39
Cho, Kyoung-Ho	3-6, 3-10, 3-25, 3-27, 3-38, 3-45, 3-47, 3-48, 3-54
Cho, Yong-Joon	4-39
Choe, Yong-Hoe	2-30
Choi, Hakkyum	2-9, 2-32
Choi, Han-Gu	4-7, 4-55, 4-57, 4-77, 4-79
Choi, Hyoung Gyu	1-30, 1-37
Choi, Jung-Ok	3-5, 3-25
Choi, Woong	4-71
Choi, Yeonjin	1-30, 2-16, 3-41
Choi, Yonghan	1-6, 1-17, 1-52
Chung, Changhyun	1-27, 5-7, 5-9
Chung, Eui-Seok	1-1, 1-26, 1-54
Chung, Hosung	4-56
Chung, Hyun Young	1-14, 2-14, 3-25

D

Do, Hackwon	4-10, 4-19, 4-22, 4-23, 4-24, 4-25, 4-26, 4-40, 4-44, 4-70, 4-78
-------------	--

E

Eayrs, Clare	1-69
--------------	------

G

Gim, Yeontae	1-40
Gyeong, Hyeryeon	4-35

H

Ha, Sangbeom	2-26
Ha, Sun-Yong	1-39, 3-15, 3-35, 3-45, 3-51, 3-52, 4-21, 4-32, 4-59, 4-77
Ham, Young-Bae	1-16, 1-28, 1-46
Han, Changhee	1-55
Han, Dong-Won	4-11, 4-20, 4-51
Han, Se Jong	4-3, 4-7, 4-27
Han, Yeongcheol	1-55
Hong, Jong Kuk	1-30, 2-16, 2-31, 3-37, 3-41, 3-45
Hong, Sang Bum	1-29, 1-55
Hong, Soon Gyu	4-80
Hur, Soon Do	1-55
Hwang, Jisub	4-19, 4-24, 4-25, 4-26, 4-40, 4-70
Hwang, Kyuin	4-17
Hwang, Youna	5-2, 5-3

I

Im, Sehyeok	4-25
-------------	------

J

Jang, Eunho	1-9, 1-39, 1-40, 1-43, 1-47
Jang, Jiye	1-39, 1-47
Jang, Kwangchul	1-4, 1-5, 2-8, 3-12, 3-22, 3-23, 1-41
Jang, Seonghan	4-48
Jee, Geonhwa	1-16, 1-25, 1-28, 1-35, 1-36, 1-45, 1-71
Jeon, Mi Hae	3-10, 3-25
Jeon, Misa	3-20
Jeong, Jihye	4-20
Jeong, Yongsik	1-27, 1-63
Jin, Emilia Kyung	1-19, 1-57, 1-70, 3-19, 3-43
Jin, Hongshi	4-46
Jin, Young Keun	2-16, 2-31, 3-37, 3-41
Jinku, Park	1-59, 1-60, 1-61
Jo, Euna	4-13, 4-14
Joe, Young Jin	2-8
Joo, Hyoung Min	4-21
Jun, Sang-Yoon	1-8, 1-15
Jung, Hyejin	1-55
Jung, Ji Young	4-4, 4-9, 4-64
Jung, Jikhan	2-28
Jung, Jinyoung	3-6, 3-7, 3-10, 3-25, 3-27, 3-38, 3-45, 3-46, 3-48, 3-49, 3-54

K

Kang, Hyojin	1-40
Kang, Myung-Il	3-16, 3-17
Kang, Pilmo	2-20
Kang, Pilsung	4-3, 4-29, 4-75
Kang, Seung-Goo	1-30, 2-16, 3-14
Kang, Sung-Ho	3-25, 3-27, 3-39, 3-41, 3-45
Kihm, Ji-Hoon	2-5, 4-47
Kim, Bo Kyung	4-21
Kim, Bomi	1-14, 1-53, 4-44
Kim, Byeong-Hoon	1-19, 3-19
Kim, Dahae	3-12, 3-23
Kim, Dockyu	4-12, 4-18, 4-30, 4-61
Kim, Eun Jae	4-7, 4-27, 4-55, 4-60
Kim, Eunsol	1-28
Kim, Han-Woo	4-23, 4-40, 4-46, 4-70, 4-71
Kim, Hwayoung	2-3, 2-13
Kim, Hyeong-Gyu	1-8
Kim, Hyoung-Kwon	5-9
Kim, Hyoungjun	1-30
Kim, Hyun	4-71
Kim, Hyun-Cheol	1-20, 1-21, 1-24, 1-27, 1-37, 1-42, 1-59, 1-60, 1-61, 1-62, 1-63, 1-72, 3-1, 3-21, 4-5
Kim, Il-Chan	4-3, 4-6, 4-20, 4-51
Kim, Jee-Hoon	3-11, 3-38, 3-52
Kim, Jeong-Han	1-16, 1-44, 1-46, 1-58, 1-64
Kim, Jeong-Hoon	3-21, 3-44, 4-1, 4-5, 4-13, 4-14, 4-31, 4-53, 4-62, 4-63
Kim, Ji Hee	4-7, 4-12, 4-55, 4-80
Kim, Ji-Eun	1-46
Kim, Jihun	4-20, 4-51
Kim, Jin-Hyoung	4-6, 4-11, 4-12, 4-20, 4-34, 4-51
Kim, Jinhyun	4-64, 4-66, 4-67
Kim, Jong Min	1-21
Kim, Jong- U	4-5, 4-63
Kim, Jong-Min	1-62, 1-67
Kim, Joo-Hong	1-6, 1-8, 1-35, 1-65, 3-25
Kim, Jung-Hyun	1-41
Kim, Kitae	1-31, 1-38, 1-53, 2-14, 3-5, 3-25, 4-44, 5-5
Kim, Kwansoo	1-10
Kim, Kyung Mo	4-17
Kim, Mincheol	4-18, 4-35, 4-48
Kim, Minseo	4-71
Kim, Moonkyo	4-45

Kim, Myung-Seok	3-13
Kim, Nak Kyu	2-13
Kim, Ok-Sun	4-39
Kim, Sanghee	2-5, 4-7, 4-36, 4-48, 4-55, 4-60, 4-77, 4-79, 4-81
Kim, Seong-Joong	1-12, 1-17, 1-33, 1-51, 1-66, 1-68
Kim, Seung Hee	1-20, 1-62, 1-63
Kim, So Young	3-45
Kim, Suhwan	1-37
Kim, Sumin	2-19
Kim, Sung Jin	4-3
Kim, Sunghan	1-30, 1-34, 2-7, 3-16, 3-17, 3-32
Kim, Tae-Wan	3-7, 3-35, 3-46, 3-48
Kim, Taehwan	2-12, 2-37
Kim, Tai Kyoung	4-3
Kim, Woohyun	4-48
Kim, Yeonggi	3-35
Kim, You Jin	4-64
Kim, Youmin	4-5, 4-54, 4-63
Ko, Young Wook	4-58, 4-77, 4-79
Koo, Man Hyung	4-12, 4-27
Kwon, Hyuck-Jin	1-16, 1-46

L

La, Hyoung Sul	3-2, 3-4, 3-11, 3-41, 3-44, 3-45, 4-31
Lee, Bang Yong	1-43, 1-47
Lee, Boyeon	4-32, 4-59
Lee, Chang Woo	4-22, 4-40
Lee, Changsup	1-16, 1-35, 1-44, 1-45, 1-46, 1-58, 1-64, 4-16, 4-28, 4-38
Lee, Choon-Ki	1-19
Lee, Donghyuck	1-19
Lee, Du Hyeong	1-2
Lee, Hanbyul	4-39
Lee, Hyodong	4-75
Lee, Hyoungseok	4-19, 4-29, 4-30, 4-42, 4-46, 4-74, 4-75
Lee, Jae Il	1-30, 2-26, 2-27, 2-35, 3-16, 3-17, 3-18
Lee, Ji-Hee	1-46
Lee, Jong Ik	2-12, 2-23, 2-33
Lee, Joohan	1-3, 1-27, 5-7, 5-9
Lee, Jun Hyuck	4-10, 4-12, 4-15, 4-16, 4-19, 4-20, 4-22, 4-23, 4-24, 4-25, 4-26, 4-27, 4-28, 4-33, 4-37, 4-38, 4-40, 4-43, 4-44, 4-49, 4-65, 4-69, 4-70, 4-71, 4-72
Lee, Jungeun	4-46

Lee, Khanghyun	1-55
Lee, Mi Jung	2-15, 2-33, 2-37
Lee, Min Ju	4-10, 4-40, 4-44
Lee, Min Kyung	1-30, 1-50, 3-16, 3-17
Lee, Mirinae	2-11, 2-28
Lee, Na-Mi	1-67
Lee, Sang Hoon	3-7
Lee, Sanghee	1-55
Lee, Seungmi	1-55
Lee, Seungyeon	4-11, 4-20, 4-34, 4-51
Lee, Sung Gu	4-19, 4-65
Lee, Sungjae	1-27
Lee, Won Sang	1-19, 1-29, 1-36, 1-57, 3-9, 3-19, 3-29, 3-43, 5-8
Lee, Won Young	4-8, 4-41, 4-56, 4-62
Lee, Yelim	4-46
Lee, Yoo Kyung	4-9, 4-68, 4-74
Lee, Youngju	3-10, 3-25, 3-27, 3-38, 3-45, 3-54
Lee, Yung Mi	4-2, 4-18, 4-27, 4-48, 4-61

M

Min, Jun-Oh	3-31, 4-32, 4-59
Min, Kyungwon	4-75
Minji, Seo	1-59, 1-60, 1-61, 1-72
Mo, Ahra	3-3, 3-5, 3-40
Moon, Heung Soo	3-16
Moon, Jangil	1-55
Moon, Jong Kuk	3-27, 3-38, 3-42

N

Na, Ji Sung	3-19
Nagao, Keisuke	2-23
Nam, Seung-II	1-4, 1-5, 1-41, 2-8, 3-12, 3-22, 3-23, 3-26, 3-36, 3-45
Nam, Sungjin	4-4
Nam, Yewon	4-22, 4-23
Nguyen, Phuong Thi	4-20, 4-34, 4-51
Noh, El	1-8
Noh, Young-Chan	1-6, 1-24, 1-52

O

Oh, Yeongju	2-21, 2-28, 2-30
Oh, Younggeun	4-5, 4-63
On, Jong-Kuk M.	3-30

P

Park, Changkun	2-2, 2-3, 2-4, 2-6, 2-10, 2-17, 2-22, 2-24, 2-25, 2-29, 2-34, 2-38
Park, Jeong-won	1-59, 1-60, 1-61, 1-62
Park, Jieun	1-59, 1-60, 1-61
Park, Jinku	3-16, 3-17, 3-21, 3-28, 3-50
Park, Jisoo	3-2, 3-5, 3-20, 4-20, 3-35, 3-40, 3-44, 3-48, 3-49
Park, Jiyeon	1-9, 1-39, 1-40, 1-47
Park, Keunbo	1-10
Park, Keyhong	3-5, 3-24, 3-34, 3-40
Park, Ki-Tae	1-9, 1-11, 1-13, 1-14, 1-39, 1-40, 1-43, 1-47
Park, Sang-Jong	1-17, 1-40, 1-56, 3-20, 3-35
Park, Sung-Hyun	2-32
Park, Tae-Yoon S.	2-1, 2-5, 2-18, 2-21, 2-28, 2-30, 2-36, 4-47
Park, Taewook	3-45
Park, Yongcheol	1-30
Phi, Kim-Hoa	4-12

R

Rhee, Hyun Hee	1-7, 1-22, 1-23, 1-32
Rhee, Tae Siek	3-33, 3-41

S

Seo, Hyunkyo	5-4
Seo, Wonsang	5-1
Shahrezaei, Iman Heidarpour	3-1
Shim, Chorom	4-32, 4-59
Shin, Dongseob	1-37
Shin, Hyoung Chul	3-9, 3-41, 5-6
Shin, Seung Chul	4-23, 4-40, 4-50, 4-70, 4-71
So, Jae Eun	4-12, 4-80
Son, Jonghyeon	4-71
Son, Wuju	3-11, 3-41, 3-44, 4-31
Son, Yeong-Ju	3-36
Song, Ho-Kyung	4-34
Sulaiman, Syahril	4-75

Sungjae, Lee	1-20, 1-37, 1-63, 3-21
--------------	------------------------

W

Woo, Sungho	4-18, 4-61
-------------	------------

Y

Yang, Eun Jin	1-18, 1-51, 3-4, 3-6, 3-8, 3-10, 3-11, 3-18, 3-20, 3-25, 3-27, 3-30, 3-38, 3-39, 3-40, 3-41, 3-42, 3-45, 3-48, 3-49, 3-53, 3-54
Yang, Junyoung	4-68
Yim, Joung Han	4-3, 4-29, 4-36, 4-52, 4-73
Yoo, Hyeju	3-44
Yoo, Jaeill	3-35
Yoo, Kyu-Cheul	1-30, 2-26, 3-16, 3-17
Yoo, Yo-Han	4-29
Yoon, Dong-jin	5-9
Yoon, Young Jun	1-9, 1-39, 1-40, 1-43, 1-47, 1-48, 1-49, 3-25
Youn, Ui Joung	4-3, 4-12, 4-27, 4-28, 4-30, 4-69, 4-81
Yu, Jihyeon	4-46
Yun, Sukyoung	1-36

KOPRI ABSTRACTS

Volume 15 (2023)

KOPRI ABSTRACTS contains journal articles written by KOPRI researchers and other researchers funded by KOPRI. It is published once a year and has distributed worldwide by KOPRI since launching in 2014. In 2004, KOPRI was established as an autonomous institute in KORDI (current, KIOST). Volume 1 (1984-2003) contains KORDI's research activities in the arctic and the antarctic.

Published on	July 2024
Published by	Korea Polar Research Institute
Editor-in Chief	Kang, Min gu vitamin9@kopri.re.kr
Managing Editor	Kim, Mi yeon mykim@kopri.re.kr Kim, Nam hee nhkim6@kopri.re.kr
Editorial Board	Kim, Seong-Joong (Vice President) Chung, Eiu-Seok (Climate Science) Kim, Jong-U (Life Science) Kim, JeeHoon (Marine Science) Na, Ji Sung (Climate Science) Park, Changkun (Geo Science)
Editorial office	KOPRI Library 26 Songdomirae-ro, Yeonsu-gu, Incheon, 21990, Korea
Cover Photo Design	Joo, Hyoungh min Designcrew
ISSN	2289-0734