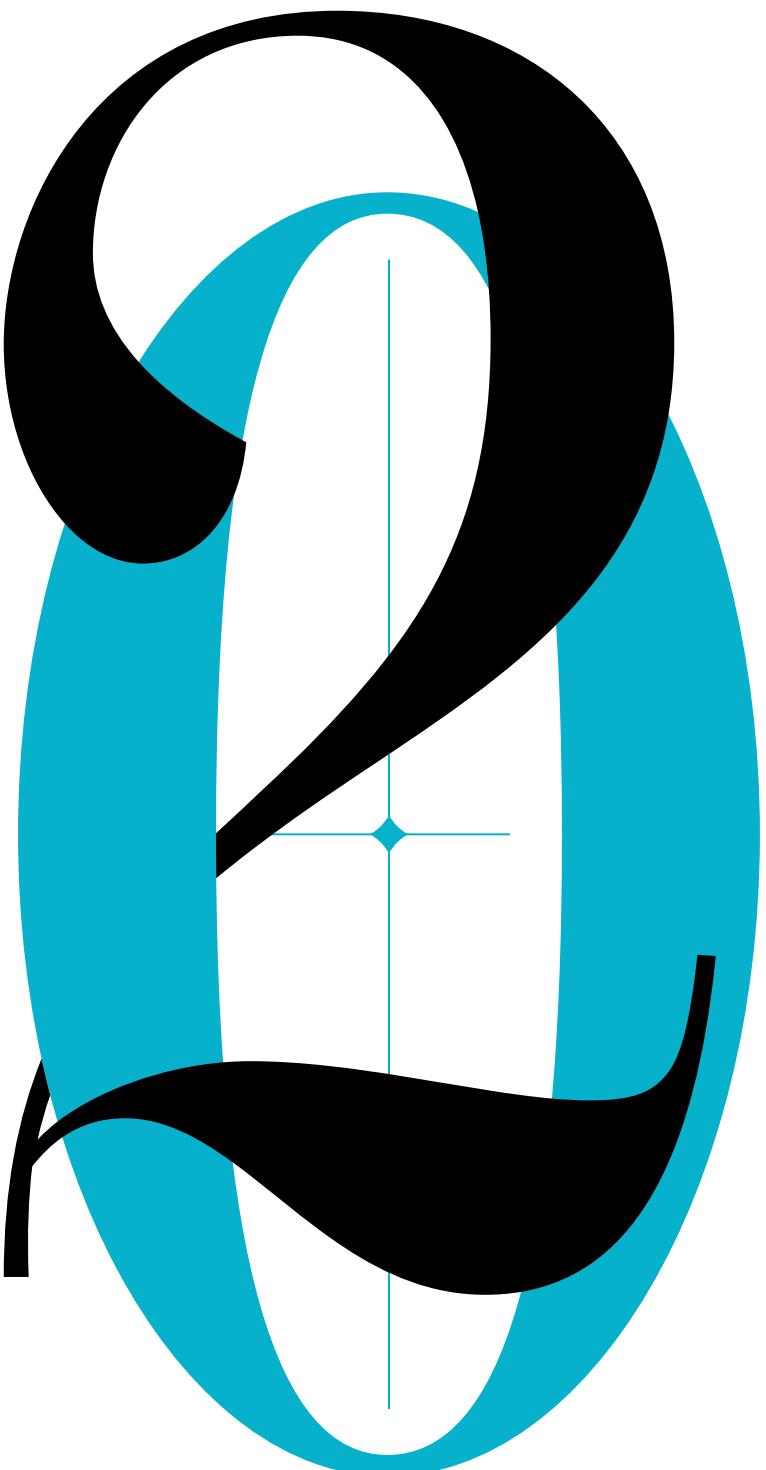




KOPRI
20th Anniversary

2024

KOPRI ABSTRACTS
Volume 16

KOPRI ABSTRACTS

Volume 16 | 2024

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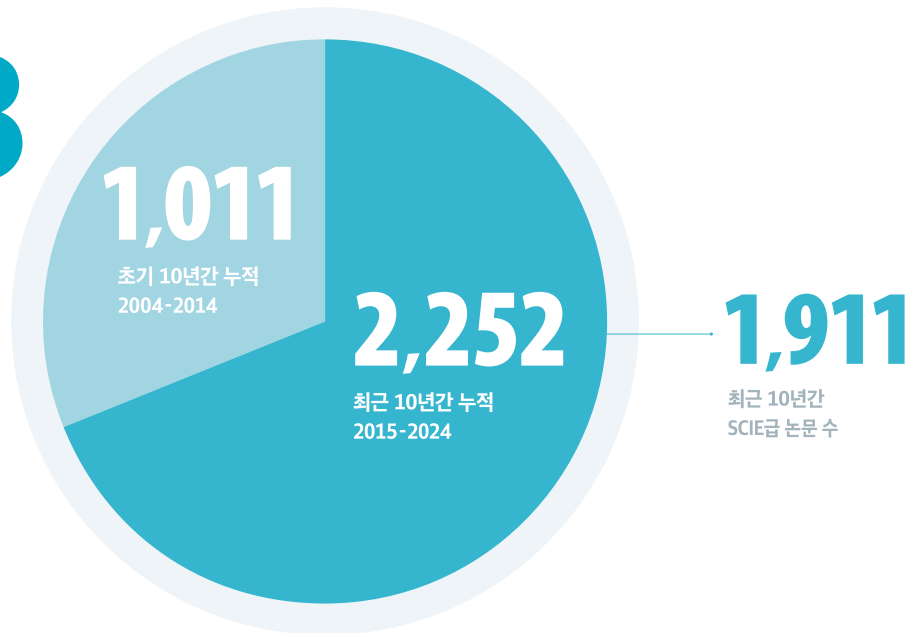
KOPRI 20th Anniversary

극지연구소 개소 20주년을 맞아 본 초록집에서는 지난 20년간 국제 학술지 게재 논문 3,263편을 종합 분석하여 인포그래픽으로 재구성하였다. (역대 KOPRI 초록집 수록 성과 기준) 생명과학과 기후과학의 비중이 가장 컸으며, 지구, 해양, 기술/정책 등 전 분야에서 균형있는 성장세를 확인할 수 있다. 연도별 추이와 분야별 분포를 통해 20년 연구의 흐름을 한눈에 볼 수 있도록 풀어냈다.

Marking KOPRI's 20th anniversary, this Abstracts volume presents an infographic based on a comprehensive analysis of 3,263 papers published in international journals over the past two decades (based on research outcomes included in past KOPRI Abstracts). Life science and Climate science account for the largest shares, and balanced growth is evident across all fields, including Geo science, Marine science, and Technology/Policy. By visualizing year-by-year trends and field-level distributions, the page offers a clear, at-a-glance view of KOPRI's 20-year research trajectory.

• 총 논문 수

3,263



• 연평균 논문 수

163

2004-2024

초기 5년
2004-2009

65

7.2% 연평균
증가율

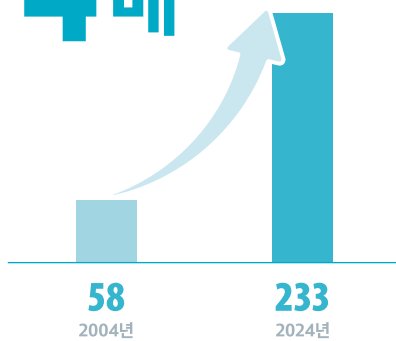


241

최근 5년
2020-2024

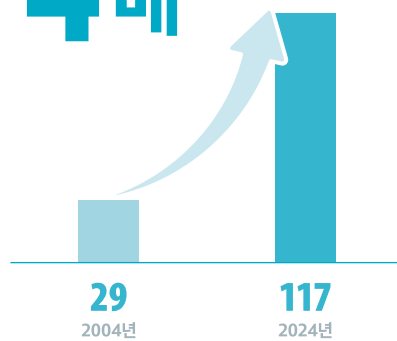
• 연간 논문 발간 수

4배



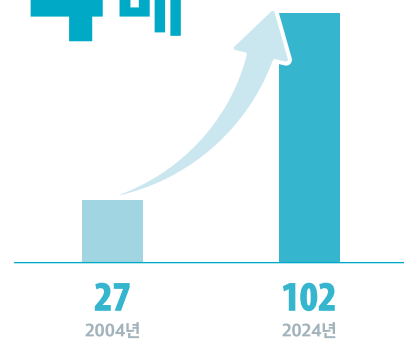
• 주저자 논문 수

4배



• 연구자 수

4배



1,168

36%

Life Sciences



929

28%

Climate Sciences



577

18%

Marine Sciences



541

17%

Geo Sciences



48

1%

Policy & Technology



분야별
누적 논문 수
2004-2024

분야별
비율



2009
아라온호
첫 출항

2014
장보고기지
준공



KOPRI
연간 논문 발간 수
2004-2024

250

200

150

100

50

140

2012
세 자릿수
기록

207

2016
200편
달성

Total
3,263

2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024

Summary of 2024 Research Paper Achievement

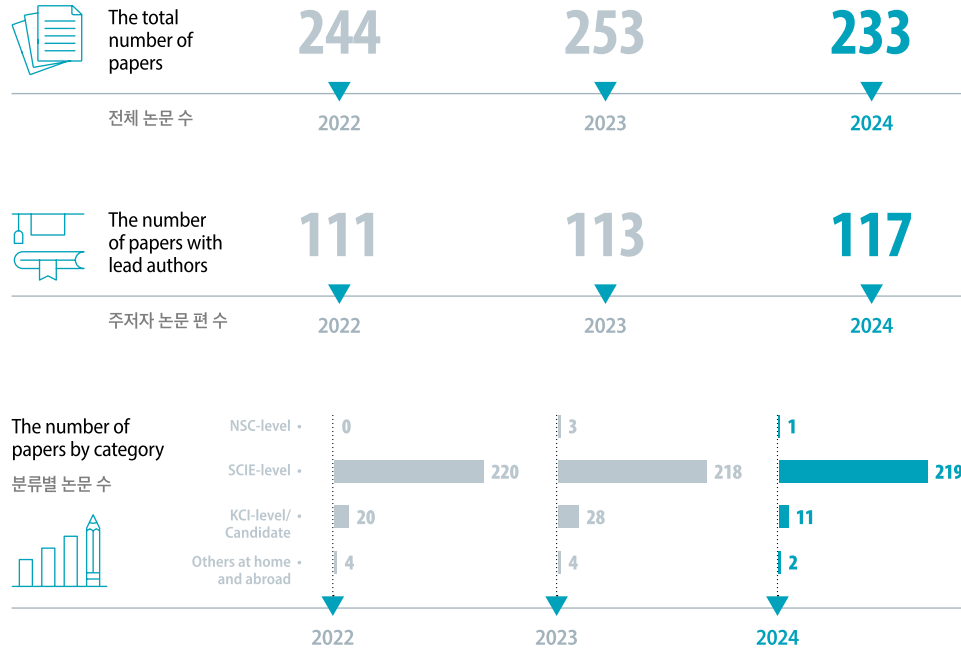
2024년 연구논문 성과 요약

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 of the Korea Polar Research Institute (KOPRI), including research paper publications, domestic and international collaborative research, 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

2024년 WoS에 등재된 SCIE/NSC 논문 209편의 분석 결과, 극지연구소는 국내외 513개 기관, 44개 국가와 공동연구를 수행하였다.

The analysis of papers(SCIE/NSC) published in 2024 found that KOPRI conducted collaborative research with individuals or institutions from a total of 513 institutes and 44 countries.

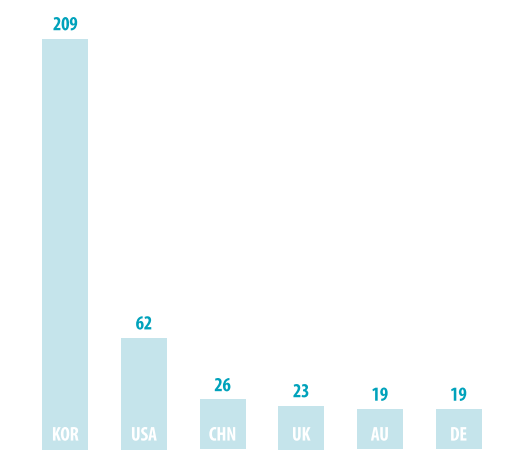
* Source: Web of Science, Clarivate Analytics



· Top 5 countries and number of research papers

공동연구 수행 국가 TOP 5 및 논문 수

Country	Number of records	% of 220
SOUTH KOREA 대한민국	209	95.0%
USA 미국	62	28.1%
CHINA 중국	26	11.8%
ENGLAND 영국	23	10.4%
AUSTRALIA 호주	19	8.6%
GERMANY 독일	19	8.6%



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

공동연구 수행기관(국내) TOP 5 및 논문 수

Institute	Number of records	% of 220
Korea Polar Research Institute (KOPRI) 극지연구소	200	90.9%
University of Science Technology (UST) 과학기술연합대학원대학교	54	24.4%
Seoul National University (SNU) 서울대학교	33	15.0%
Korea Institute of Ocean Science Technology (KIOST) 한국해양과학기술원	18	8.1%
KOREA UNIVERSITY 고려대학교	14	6.3%
YONSEI UNIVERSITY 연세대학교	13	5.9%

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

공동연구 수행기관(국외) TOP 5 및 논문 수

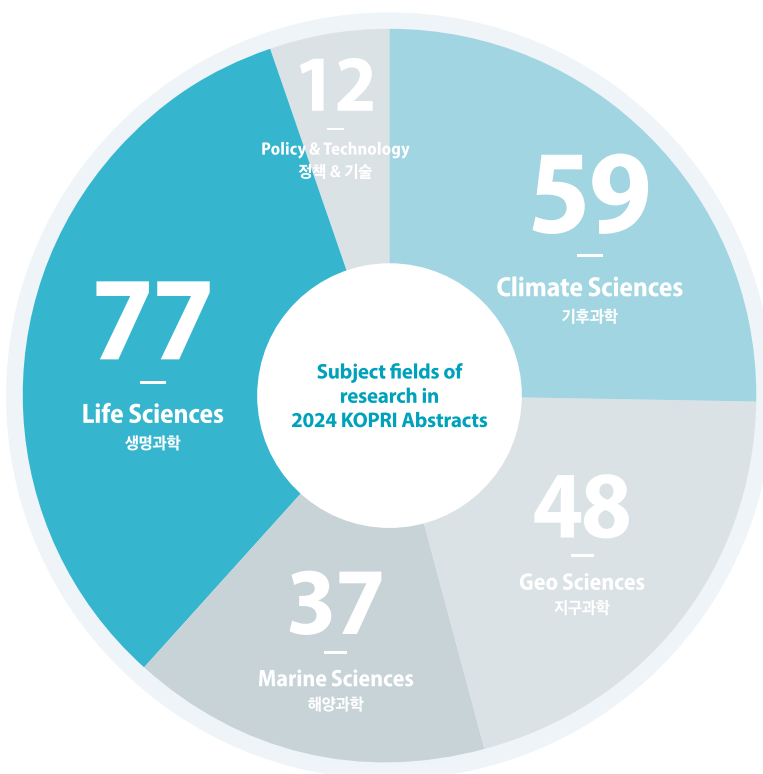
Institute	Number of records	% of 220
UNIVERSITY OF CALIFORNIA SYSTEM	16	7.2%
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE (CNRS)	13	5.9%
NATURAL ENVIRONMENT RESEARCH COUNCIL (NERC)	12	5.4%
SWISS FEDERAL INSTITUTES OF TECHNOLOGY DOMAIN	12	5.4%
UK RESEARCH INNOVATION (UKRI)	12	5.4%

03. Subject fields of research

연구 주제 분야

2024 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 등을, 지구과학은 지질, 지구물리, 수중음향 등을, 해양과학은 해양학(물리, 화학, 생물학, 지질학)뿐만 아니라 해양환경에 따른 생태학 및 기술개발 등의 주제를 포함하였다.

Research topics in 2024 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; **Geosciences** 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.



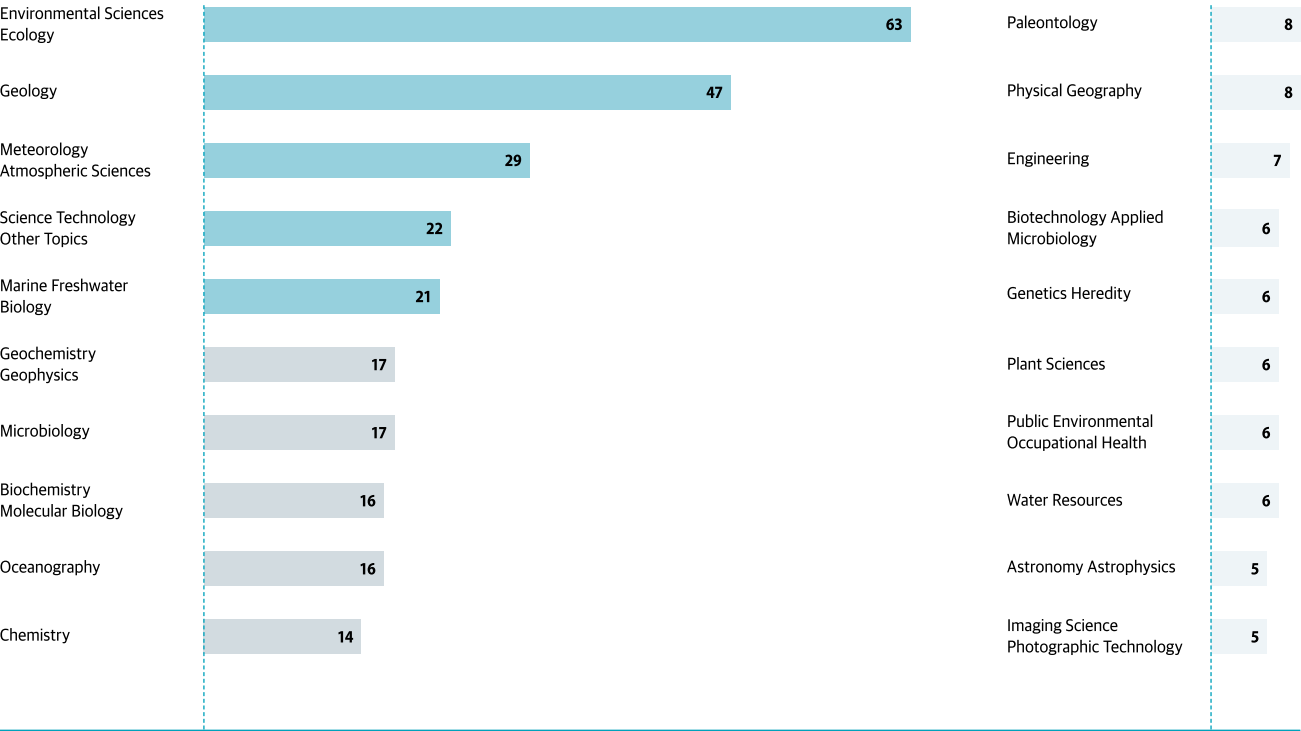
04. Web of Science Categories

WoS 연구 분야



· Top 20 Subject fields of research

Wos 연구 분야 Top 20



* Source: Web of Science, Clarivate Analytics

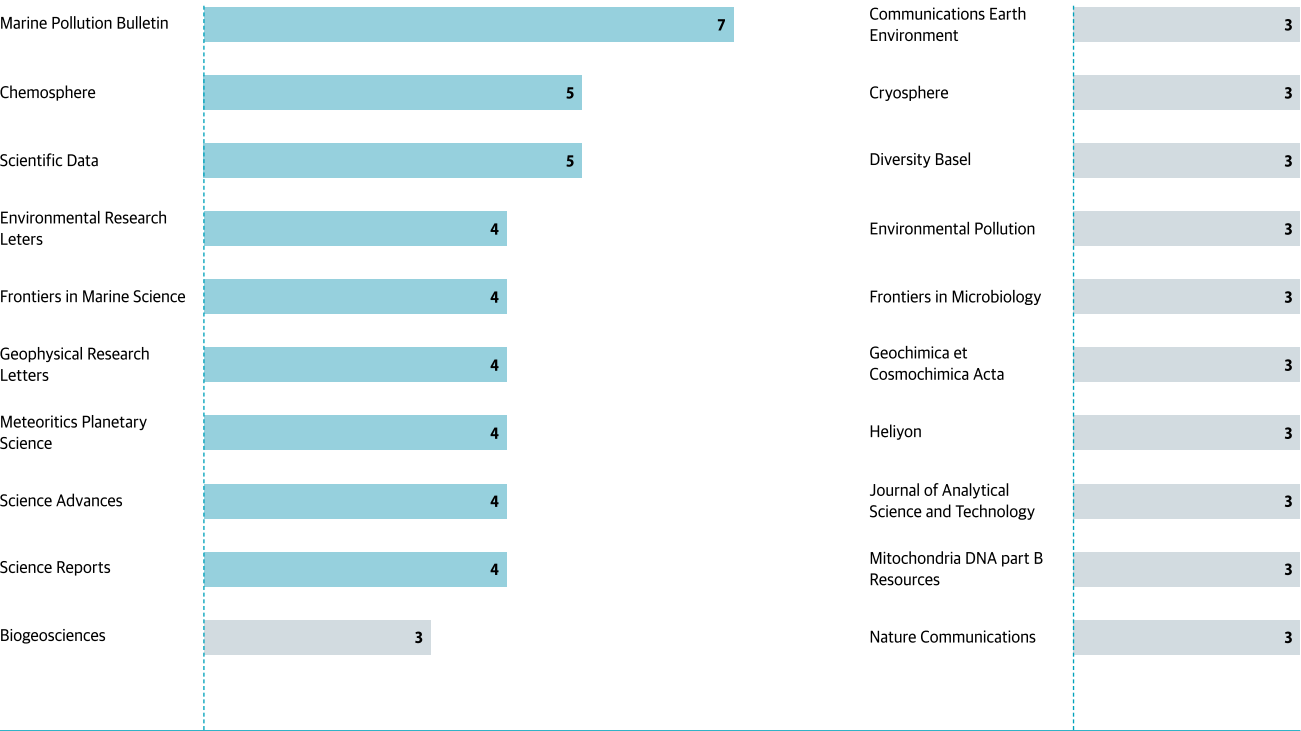
05. Major journals registered

주요 등재 저널



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

3편 이상 등재된 저널과 논문 수



* Source: Web of Science, Clarivate Analytics

1-7 *Environmental Sciences; Geosciences,
Multidisciplinary; Water Resources*

Characterizing coefficient of permeability based on response of groundwater level to river stage using regional database

Kim, Bokyung., Lee, Jiyeong., **Park, Keunbo.** and Lee, Junhwan.
Environmental Earth Sciences. 2024. 83(3).
doi: 10.1007/s12665-023-11379-z.

The coefficient of permeability (k) is an important soil property for various flow-related problems and site characterization. In this study, a new method for estimating k is proposed based on the time response of groundwater level (GWL) to river stage (RS) with changes in losing and gaining streams during normal and rainy periods, respectively. Focus was given on establishing a method that does not require costly experimental testing procedure while utilizing locally available hydrology and geologic database. For this purpose, the GWL–RS correlation model was introduced and adopted to develop the k correlation model based on the time response of GWL to RS. The proposed method was calibrated using measured datasets of GWL and RS collected from 17 different regions. Based on the compared results from the measured datasets, a modification factor (M_f) was established and adopted to further enhance the k correlation model. When the M_f was adopted, the R^2 value of the prediction was 0.8756, and the RMSE decreased to 0.00643. To check the applicability of the proposed method, additional datasets were collected and adopted into the comparison. It was confirmed that measured and predicted soil permeabilities were in close agreement.

keywords:

Coefficient of permeability; Correlation model; Groundwater level; River stage; Soil characterization; Regional database

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.

Cliamate Sciences

1-1 Meteorology & Atmospheric Sciences

A new understanding of the causes of future change in El Niño teleconnection

Lee, Hyun-Ju and Jin, Emilia Kyung.
Atmospheric Research. 2024. 307.
doi: 10.1016/j.atmosres.2024.107508.

Understanding and elucidating future changes in El Niño teleconnection is crucial because of the influence of El Niño on the globe via teleconnection. Existing climate models have consistently projected an eastward and poleward shift in El Niño teleconnection in the future, but the causes and dynamical processes of this shift have been poorly explained. Particularly, no study has examined the characteristic changes in the barotropic Rossby waves that form the teleconnection. This study investigates dynamic processes by analyzing the wavelength of the Rossby waves through spectral analysis, measuring the distance between circulation anomalies, and exploring the dispersion relationship of the barotropic Rossby waves. The results revealed that the wavelength of waves forming the teleconnection is expected to increase in warmer climate with an increase in the proportion of zonal-wavenumber-2 wave. Because changes in the mean state, including the strengthening of the westerly in the high-emission scenario, alter the frequencies of waves according to their zonal wavenumbers, this process is more notably manifested in the Southern Hemisphere, where the inter-model spread of the mean state is smaller, than in the Northern Hemisphere. Consequently, this will result in a shift in the position of El Niño's influence on the high latitudes of both Hemispheres. Specifically, in the Southern Hemisphere, it is anticipated that ocean warming in the seas in front of West Antarctica and moisture transport towards Antarctica, induced by El Niño, will shift eastward in the high-emission scenario compared to its conventional position.

keywords:

Future change; CMIP6 models; Barotropic Rossby wave; Impact on high latitudes

1-2 Meteorology & Atmospheric Sciences

Advances in Machine Learning Techniques Can Assist Across a Variety of Stages in Sea Ice Applications

Eayrs, Clare., Lee, Won Sang., Jin, Emilia Kyung., Lemieux, Jean-Francois., Massonnet, Francois., Vancoppenolle, Martin., Zampieri, Lorenzo., Bennetts, Luke G., Blockley, Ed., Chung, Eui-Seok., Fraser, Alexander D., Ham, Yoo-geun., Im, Jungho., Kim, Baek-min., Kim, Beong-Hoon., Kim, Jinsuk., Kim, Joo-Hong., Kim, Seong-Joong., Kim, Seung Hee., Korosov, Anton., Lee, Choon-Ki., Lee, Donghyuck., Lee, Hyun-Ju., Lee, Jeong-Gil., Lee, Jiyeon., Na, Jisung., Park, In woo., Park, Jikang., Wang, Xianwei., Xu, Shiming and Yun, Sukyoung.
Bulletin of the American Meteorological Society. 2024. 105(3): E527-E531.
doi: 10.1175/bams-d-23-0332.1.

keywords:
Antarctica; Arctic; Sea ice; Forecasting; Artificial intelligence; Machine learning

1-3 Environmental Sciences; Geosciences, Multidisciplinary; Remote Sensing; Imaging Science & Photographic Technology

Arctic Greening Trends: Change Points in Satellite-Derived Normalized Difference Vegetation Indexes and Their Correlation with Climate Variables over the Last Two Decades

Seo, Minji and Kim, Hyun-Cheol.
Remote Sensing. 2024. 16(7).
doi: 10.3390/rs16071160.

In this study, we utilized NDVI data from the moderate resolution imaging spectroradiometer (MODIS) alongside climatic variables obtained from a reanalyzed dataset to analyze Arctic greening during the summer months (June-September) of the last two decades. This investigation entailed a detailed analysis of these changes across various temporal scales. The data indicated a continuous trend of Arctic greening, evidenced by a 1.8% per decade increment

in the NDVI. Notably, significant change points were identified in June 2012 and September 2013. A comparative assessment of NDVI pre- and post-these inflection points revealed an elongation of the Arctic greening trend. Furthermore, an anomalous increase in NDVI of 2% per decade was observed, suggesting an acceleration in greening. A comprehensive analysis was conducted to decipher the correlation between NDVI, temperature, and energy budget parameters to elucidate the underlying causes of these change points. Although the correlation between these variables was relatively low throughout the summer months, a distinct pattern emerged when these periods were dissected and examined in the context of the identified change points. Preceding the change point, a strong correlation (approximately 0.6) was observed between all variables; however, this correlation significantly diminished after the change point, dropping to less than half. This shift implies an introduction of additional external factors influencing the Arctic greening trend after the change point. Our findings provide foundational data for estimating the tipping point in Arctic terrestrial ecosystems. This is achieved by integrating the observed NDVI change points with their relationship with climatic variables, which are essential in comprehensively understanding the dynamics of Arctic climate change, particularly with alterations in tundra vegetation.

keywords:

tundra vegetation; temperature; energy budget; MODIS; Bayesian model averaging time-series decomposition algorithm (BEAST)

PM₁₀ events during the midwinter in South Korea. This study investigated instances of extremely high (EH)-PM₁₀ in South Korea during mid-winter and examined the corresponding atmospheric teleconnection patterns to identify the factors contributing to EH-PM₁₀ events. *K*-means clustering analysis revealed that EH-PM₁₀ instances were associated with two large-scale teleconnection patterns. Cluster 1 exhibited a wave train pattern originating in the North Atlantic that developed from Eurasia to the Korean Peninsula. Cluster 2 was associated with a wave-like teleconnection pattern from the Barents-Kara Sea to the Korean Peninsula. The Rossby waves, triggered by the North Atlantic and the Arctic, propagated and weakened the surface pressure system. This led to a high-pressure anomaly over the Korean Peninsula, reducing atmospheric ventilation and causing a rapid increase in PM₁₀ concentration within a few days. Furthermore, an experiment involving a linear baroclinic model established that atmospheric forcing in upstream regions has the potential to induce large-scale atmospheric teleconnection patterns, resulting in EH-PM₁₀ cases in South Korea. These findings emphasize the ventilation effect and transport of PM₁₀ concentrations modulated by two large-scale teleconnection patterns originating from the Arctic and North Atlantic, leading to EH-PM₁₀ events in South Korea. Understanding this combined phenomenon may assist in the implementation of emission reduction measures based on the results of short-term forecasts of severe PM₁₀ events.

keywords:

Particulate matter; Teleconnection; Wave propagation; Severe PM₁₀ events; Ventilation effect; Atmospheric stagnant; PM₁₀ transport

1-4 Environmental Sciences

Arctic/North Atlantic atmospheric variability causes Severe PM₁₀ events in South Korea

Kim, Jeong-Hun., Kim, Maeng-Ki., Kim, Seong-Joong., Kim, Joo-Hong. and 3 others.

Science of the Total Environment. 2024. 914.

doi: 10.1016/j.scitotenv.2023.169714.

Severe PM₁₀ (particulate matter with a diameter of <10 μm) events in South Korea are known to be caused by stable atmospheric circulation conditions related to high-pressure anomalies in the upper troposphere. However, research on why these atmospheric circulation patterns occur is unknown. In this study, we propose new large-scale teleconnection pathways that cause severe

1-5 Astronomy & Astrophysics

Assessment of Polar Ionospheric Observations by VIPIR/Dynasonde at Jang Bogo Station, Antarctica: 2. Ionospheric Ion Drift Velocity

Kwon, Hyuck-Jin., Jee, Geonhwa., Ham, Young-Bae., Zaboltn, Nikolay., Lee, Changsup., Kim, Ensol. and Bullett, Terence W.

Journal of Geophysical Research-Space Physics. 2024. 129(5).

doi: 10.1029/2023ja032402.

Since the installation at the Antarctic Jang Bogo Station (JBS) in 2017, Korea Polar Research Institute (KOPRI) has been operating the Vertical Incidence Pulsed Ionospheric Radar (VIPIR) equipped with Dynasonde

analysis (JVD). The two-dimensional ion velocity is one of the key ionospheric parameters obtained from the JVD. The ionospheric ion velocities are compared with simultaneous, but independent, measurements of the Doppler velocity obtained from SuperDARN East radar at Dome C. The JVD ion velocity vector is projected to the line-of-sight direction of the SuperDARN observation over the JBS to be directly compared with each other. The result of comparison shows a reasonable agreement with the correlation coefficient of 0.72. The linear regression coefficient of about 0.5 represents that the JVD ion velocity is generally smaller than the SuperDARN observations by the regression coefficient, which may result from the different height ranges of the measurements. It is also found that the correlation coefficient increases with increasing magnetic activity (K_p), which suggests that the small-scale ionospheric density irregularities tend to move with large-scale plasma motion that is driven by enhanced plasma convection with increasing K_p .

keywords:

ion drift velocity; Dynasonde; polar ionosphere; Antarctica

1-6

Characterization of AhR-mediated potency in sediments from Kongsfjorden, Svalbard: Application of effect-directed analysis and nontarget screening

Gwak, Jiyun., Cha, Jihyun., Nam, Seung-Il., Kim, Jung-Hyun., and 4 others.

Chemosphere. 2024. 368: 143771-143771.

doi: 10.1016/j.chemosphere.2024.143771.

In this study, we aimed to identify the major aryl hydrocarbon receptor (AhR) agonists in surface sediments (S1-S10, $n=10$) from Kongsfjorden, Arctic Svalbard, using effect-directed analysis. High AhR-mediated potencies were observed in the mid-polar fractions and RP-HPLC subfractions (F2.6–F2.8; $\log K_{ow}$ 5–8) in the sediments of sites S2 and S3, which are located near abandoned coal mine areas, as assessed by the H4IIE-*luc* bioassay. The concentrations of traditional polycyclic aromatic hydrocarbon (t-PAHs), emerging PAHs, alkyl-PAHs, and styrene oligomers ranged from 6.1 to 2100 ngg^{-1} dry weight (dw), 0.5–1000 ngg^{-1} dw, 47 to 79,000 ngg^{-1} dw, and 4.2–130 ngg^{-1} dw, respectively, with elevated levels in S2 and S3. Principal component analysis coupled with multiple linear regression suggested that t-PAHs in sediments primarily originated from coal,

petroleum combustion, and coal combustion. Twenty-four target AhR agonists accounted for 3.2%–100% (mean = 47%) of the total AhR-mediated potencies in S2 and S3. Nontarget screening via GC-QTOFMS in the highly potent fractions identified 48 AhR agonist candidates through four-step selection criteria. Among these, 27 compounds were identified as coal-derived substances. VirtualToxLab in silico modeling predicted that most of the 48 tentative AhR agonist candidates could bind to AhR. Overall, our findings indicate significant contamination of the Kongsfjorden sediments by coal-derived substances, highlighting the need for further studies to assess the ecological risks associated with these contaminants.

keywords:

AhR-mediated potency; Coal; Effect-directed analysis; Kongsfjorden; Nontarget screening; Sediment

1-7 *Environmental Sciences; Geosciences, Multidisciplinary; Water Resources*

Characterizing coefficient of permeability based on response of groundwater level to river stage using regional database

Kim, Bokyoung., Lee, Jiyeong., Park, Keunbo. and Lee, Junhwan.

Environmental Earth Sciences. 2024. 83(3).

doi: 10.1007/s12665-023-11379-z.

The coefficient of permeability (k) is an important soil property for various flow-related problems and site characterization. In this study, a new method for estimating k is proposed based on the time response of groundwater level (GWL) to river stage (RS) with changes in losing and gaining streams during normal and rainy periods, respectively. Focus was given on establishing a method that does not require costly experimental testing procedure while utilizing locally available hydrology and geologic database. For this purpose, the GWL–RS correlation model was introduced and adopted to develop the k correlation model based on the time response of GWL to RS. The proposed method was calibrated using measured datasets of GWL and RS collected from 17 different regions. Based on the compared results from the measured datasets, a modification factor (M_f) was established and adopted to further enhance the k correlation model. When the M_f was adopted, the R^2 value of the prediction was 0.8756, and the RMSE decreased to 0.00643. To check the applicability of the proposed method, additional datasets were collected

and adopted into the comparison. It was confirmed that measured and predicted soil permeabilities were in close agreement.

keywords:

Coefficient of permeability; Correlation model; Groundwater level; River stage; Soil characterization; Regional database

1-8 Environmental Sciences

Climate-related variabilities in the Styx-M ice core record from northern Victoria Land, East Antarctica, during 1979–2014

Nyamgerel, Yalalt., Han, Yeongcheol., Hwang, Heejin., Han, Changhee., Hong, Sang-Bum., Hur, Soon Do. and Lee, Jeonghoon.

Science of the Total Environment. 2024. 935.

doi: 10.1016/j.scitotenv.2024.173319.

The historical climate variability in East Antarctica inferred from ice cores remains under debate owing to the vastness and complexity of the region. This study evaluates the potential climate variabilities in the Styx-M ice core records ($\delta^{18}\text{O}$, d -excess, and snow accumulation) from northern Victoria Land adjacent to the Ross Sea sector of East Antarctica during 1979–2014. Results show that the primary moisture source in this area is the Pacific Ocean sector. Although the annual mean $\delta^{18}\text{O}$ values was limited to directly indicate the temperature changes, a weak relevance between the average $\delta^{18}\text{O}$ values and the temperature signal during the austral summer season is detectable. $\delta^{18}\text{O}$, d -excess, and snow accumulation correlate with sea surface temperature and sea ice extent in the Ross Sea sector. A coupled influence of the SAM, ASL, and ENSO climate indices is expected, because the oceanic environment in this region is influenced by them. The pronounced intrusion of oceanic moisture coupled with atmospheric circulation patterns over the Ross Sea region makes the Styx-M ice core a promising record of the local oceanic conditions, with the snow accumulation rate being a direct proxy. Additionally, the analysis of trace elements from 1979 to 1999 revealed the presence of crustal dust sourced from the Transantarctic Mountains, as well as non-crustal sources, both intricately linked with atmospheric transport. These results demonstrate that the contributions of—and variations in—oceanic conditions associated with atmospheric circulation changes are detectable and dominant in the Styx-M ice core. This study serves as a basis for interpreting longer parts of the Styx-M ice core.

keywords:

Styx glacier; Snow accumulation; Water isotopes; Trace elements

1-9 Environmental Sciences; Marine & Freshwater Biology

Comparison of inorganic nitrogen concentrations in airborne particles at inshore and offshore sites in the Yellow Sea (2017–2019): Long-range transport and potential impact on marine productivity

Kim, Yewon., Mo, Ahra. and 9 others.

Marine Pollution Bulletin. 2024. 198.

doi: 10.1016/j.marpolbul.2023.115867.

Atmospheric deposition of nitrogen is one of the most important external nutrient sources. We investigated the concentrations of NO_3^- and NH_4^+ in airborne particles at both an offshore and an inshore site in the Yellow Sea. At the offshore site, devoid of local sources and located downwind from the highly developed areas of Korea and China, the concentrations of atmospheric particulate NO_3^- and NH_4^+ were $\sim 88 \pm 101 \text{ nmol m}^{-3}$ and $\sim 102 \pm 102 \text{ nmol m}^{-3}$, respectively, likely due to the transboundary long-range transport of pollutants. The inshore site showed a concentration ~ 2 times higher than the offshore site. Considering not only dry inorganic nitrogen deposition but also wet and organic material deposition, the total atmospheric nitrogen deposition was estimated to contribute roughly 10% to the new production in the Yellow Sea.

keywords:

Atmospheric deposition; Airborne total suspended particles; Yellow Sea; Anthropogenic nitrogen; Long-range transport

1-10 Environmental Sciences; Meteorology & Atmospheric Sciences

Comparison of new particle formation events in urban, agricultural, and arctic environments

Lee, Haebum., Cho, Hyungjin., Yoon, Young Jun., Kim, Joonwoo., Lee, Bang Yong. and Park, Kihong.

Atmospheric Environment. 2024. 333.

doi: 10.1016/j.atmosenv.2024.120634.

New particle formation (NPF) significantly contributes to the number-based aerosol population in the ambient atmosphere, thereby affecting cloud formation and human health. We compared NPF characteristics, including the occurrence frequency, occurrence criteria, particle formation rate (J), and growth rate (GR) obtained from continuous measurements of the number-size distribution of particles and various gases, among different atmospheric environments (urban, agricultural (livestock and cropland), and Arctic sites). The highest NPF occurrence frequency (55%) was observed at agricultural (livestock) site (vs. urban, 45%; agricultural (cropland), 26%; Arctic, 24%). Despite the increased evaporation rate of nucleating clusters in summer, the NH_3 -rich environment (79.6 ppb) of pig and chicken farms promoted NPF. The NPF frequency at the Arctic showed a distinct seasonal pattern (high in summer and low in winter) when compared with that at the urban site (high in spring and fall and low in summer and winter). The J varied more significantly than GR among different sites, suggesting that J is more sensitive to the environment than GR. The highest GR (7.94nmh^{-1}) and J ($2.72\text{cm}^{-3}\text{s}^{-1}$) were observed at the agricultural (livestock) site, whereas the Arctic site had the lowest GR (3.34nmh^{-1}) and J ($0.04\text{cm}^{-3}\text{s}^{-1}$). The contribution of H_2SO_4 vapor to NPF was the least in the Arctic and the highest in the urban environment. For NPF to occur, the ratio of the loss rate of condensable vapors to preexisting aerosols to their growth rate should be low, and this ratio was substantially lower in the Arctic than in the other environments. Our results underscore the complexity of NPF characteristics in different environments and highlight the interplay of various factors in governing NPF.

keywords:

New particle formation; Urban; Agricultural; Arctic

1-11 *Environmental Sciences; Remote Sensing; Imaging Science & Photographic Technology*

Contrasting response of regional spring Arctic Sea ice variations on Indian summer monsoon rainfall

Yadav, Juhi., Kumar, Avinash., Kim, Seong-Joong. and 3 others.

Remote Sensing of Environment. 2024. 311.

doi: 10.1016/j.rse.2024.114247.

Understanding the relationship between Arctic Sea

Ice Concentration (SIC) and Indian Summer Monsoon Rainfall (ISMR) is crucial for analysing regional climate change. Present study investigates this connection using satellite observations and simulations from Coupled Model Intercomparison Project Phase 5 (CMIP5) and CMIP6 coupled climate models, focusing on external forcing from 1979 to 2021. Rotated Empirical Orthogonal Function (REOF) analysis identified the dominant mode (PC1) of ISMR, explaining 31.7% of the variance with significant regional variability. Singular Value Decomposition (SVD) analysis revealed a maximum covariance of 41.1% during spring between Arctic SIC observations and ISMR. Leading SVD correlations for the multi-model ensemble mean (MEM) simulations of spring Arctic SIC were 30.6% (CMIP5) and 42.8% (CMIP6). Our results demonstrate a significant correlation between ISMR PC1 and observed Arctic spring SIC ($r = -0.25$, $p < 0.10$), particularly in the Central Arctic ($r = 0.51$, $p < 0.01$) and the Barents-Kara Sea ($r = -0.39$, $p < 0.01$). During the High Sea Ice Years (HSYs) in the Central Arctic, distinct pressure pattern centres developed extending from western Europe to the western Pacific Ocean and were linked to the circumglobal teleconnection (CGT) influence circulation. Anomalous highs over western central Asia and a strengthened easterly jet enhance rainfall in northwestern and peninsular India. Conversely, weakened jets and high-pressure systems during Low Sea Ice Years (LSYs) hinder the monsoon. This highlights the influence of upper atmospheric Rossby waves on circulation patterns. Similarly, during LSYs in the Barents-Kara Sea, the North Atlantic-Eurasia teleconnection wave train pattern and ridge formation over northwestern Europe affect the Indian monsoon's onset. North European geopotential height anomalies contribute to formation of these ridges and troughs, impacting wind patterns and thermodynamic instability, ultimately influencing rainfall distribution. This comprehensive study underscores the far-reaching impacts of seasonal Arctic changes on the ISMR, emphasising the critical role of climate teleconnections between Arctic SIC and the Indian monsoon. Our results suggest an improved understanding of regional Arctic SIC dynamics is vital for accurate ISMR predictions using future climate models.

keywords:

Circumglobal teleconnections; Sea ice concentration; Singular value decomposition; Ice-atmosphere interaction; Rossby wave

1-12 Meteorology & Atmospheric Sciences

Contribution Assessment of Northern Hemispheric Atmospheric Circulations to Korean Mid-Summer Surface Warming by the Atmospheric Nudging Experiment

Lee, Min-Hee., Noh, El., Kim, Joo-Hong., Kim, Joowan. and Jun, Sang-Yoon.

Asia-Pacific Journal of Atmospheric Sciences. 2024. 60(2): 119-130.

doi: 10.1007/s13143-023-00339-z.

Anomalous surface warming in Korea has been explained by the high-pressure anomaly accompanied by the vertical sinking motion and weakening of westerlies at the exit of the East Asian Jet. The large-scale circulations linked to this high pressure over East Asia are characterized by the low pressure over the Arctic (AC) and the high pressure over Western Europe (WE), East Asia, and the North Pacific (NP). To assess the contribution of these circulation anomalies to the hot summer in Korea, the four nudging experiments (AC, NP, AC + NP, and WE) are applied to the simulations with 50 different initial conditions in July. As a result, the most similar patterns on local and hemispheric scales are found in the AC + NP nudging experiment. However, the near-surface response in the AC + NP is still weak, and its center shifts to the north compared to the observed, which is induced by the weaker diabatic contribution for the downward motion in the nudging experiment. Using the quasi-geostrophic omega equation, we find that the simulated radiative feedback process is not sufficient to build up the large-scale subsidence with the short nudging period. Despite this limitation, AC + NP well simulates the coherent sinking motion and high-pressure system near Korea by the vorticity advection associated with the upper-level westerlies. It implies that the contribution of the North Pacific circulation (a downstream region) should also be considered to reasonably simulate the East Asia surface warming along with those in the upstream regions.

keywords:

Korean summer warming; Atmospheric nudging experiments; Heatwave; Atmospheric teleconnection

1-13 Geosciences, Multidisciplinary; Oceanography; Paleontology

Cryospheric and Oceanographic Evolution in the Arctic Makarov Basin Since the Early Pleistocene Revealed by Bulk Mineral Assemblages

Park, Kwangkyu., Nam, Seung-Il., Vogt, Christoph., Frederichs, Thomas., Kim, Jung-Hyun. and Khim, Boo-Keun.

Paleoceanography and Paleoclimatology. 2024. 39(5).

doi: 10.1029/2023pa004747.

We present the glacial history of the Makarov Basin (western Arctic Ocean) during the last similar to ~1.1 Myr, with sediment provenances using the newly refined chronostratigraphy of core ARA03B-41GC02. According to the principal component analysis of the bulk mineral assemblages, felsic minerals were dominant, and their ratios (K-feldspar/plagioclase and quartz/feldspars) indicated that sediment supply to the Makarov Basin was mainly from the Siberian margin and partly from northern North America, including the Canadian Arctic. However, their occurrence did not vary significantly between interglacials and glacials due to the mixed sources. In contrast, clinopyroxene and dolomite indicated specific sediment origins from the eastern Siberian margin and northern North America, respectively. The clinopyroxene content followed an eccentricity cycle (~100-Kyr) during the early to middle Pleistocene, suggesting that the eustatic sea level changes may have influenced its input from the eastern Siberian margin. The dolomite, transported primarily by icebergs from the Arctic sector of the Laurentide Ice Sheet (LIS) in northern North America, has also followed the same cycle since the early Pleistocene. Thus, the mineralogical signals highlight that sediment origins and transport processes in the Makarov Basin were related to ice sheet evolution at the eccentricity cycle. In addition, dolomite deposition in the Makarov Basin began by the early Pleistocene (~790 ka), ~150 ka earlier than in previous North Atlantic records (~640 ka), indicating the earlier LIS calving in the Arctic sector than in the Atlantic sector.

keywords:

stratigraphy; western Arctic Ocean; bulk mineral assemblage; eccentricity cycle; Laurentide Ice Sheet; paleoenvironmental change

1-14 Meteorology & Atmospheric Sciences

Data Assimilation Impact of GNSS RO Measurements from Cube Satellites on Arctic Weather Forecasts

Choi, Yonghan., Kim, Joowan., Kim, Joo-hong. and Cha, Dong-hyun.

Monthly Weather Review. 2024. 152(6): 1257-1275.

doi: 10.1175/mwr-d-23-0146.1.

In this study, the effects of assimilating Global Navigation Satellite System (GNSS) radio occultation (RO) observations from existing and recently added commercial cube satellites on analyses and forecasts over the Arctic region were investigated by conducting observing system experiments (OSEs). Profiles of refractivity were assimilated with a local observation operator using the three-dimensional variational method. The analyses and forecasts from the OSEs were verified against ERA5 reanalysis, radiosonde observations, and buoy observations. In addition to the averaged impact on forecast skill, the impact of GNSS RO observations was further examined for an individual Arctic cyclone case, focusing on the added value of the cube satellite data. The effects of GNSS RO observations from existing satellites on analyses and forecasts over the Arctic region are positive, and the assimilation of GNSS RO observations from cube satellites leads to additional improvements, particularly for temperature in the upper troposphere and lower stratosphere (UTLS). Temperature biases in the UTLS are significantly reduced in the analyses, and the improved analyses result in better forecasts of upperlevel potential vorticity and cyclone development when GNSS RO observations from cube satellites are assimilated. This result demonstrates the potential of GNSS RO data from cube satellites to enhance forecasts over the Arctic region.

keywords:

Arctic; Global positioning systems (GPS); Data assimilation; Numerical weather prediction/forecasting

Mauritz, Marguerite., Biasi, Christina., Bokhorst, Stef., Boike, Julia., Bret-Harte., M. Sydonia., Celis, Gerardo., Chae, Namyi., Christensen, Torben R., Murner, Sara June., Dengel, Sigrid., Dolman, Han., Edgar, Colin W., Elberling, Bo., Emmerton, Craig A., Euskirchen, Eugenie S., Goeckede, Mathias., Grelle, Achim., Heffernan, Liam., Helbig, Manuel., Holl, David., Humphreys, Elyn., Iwata, Hiroki., Jaerveoja, Jaervi., Kobayashi, Hideki., Kochendorfer, John., Kolari, Pasi., Kotani, Ayumi., Kutzbach, Lars., Kwon, Min Jung., Lathrop, Emma R., Lopez-Blanco, Efren., Mammarella, Ivan., Marushchak, Maija E., Mastepanov, Mikhail., Matsuura, Yojiro., Merbold, Lutz., Meyer, Gesa., Minions, Christina., Nilsson, Mats B., Nojeim, Julia., Oberbauer, Steven F., Olefeldt, David., Park, Sang-Jong, and 23 others.

Nature Climate Change. 2024.

doi: 10.1038/s41558-024-02057-4.

Tundra and boreal ecosystems encompass the northern circumpolar permafrost region and are experiencing rapid environmental change with important implications for the global carbon (C) budget. We analysed multi-decadal time series containing 302 annual estimates of carbon dioxide (CO₂) flux across 70 permafrost and non-permafrost ecosystems, and 672 estimates of summer CO₂ flux across 181 ecosystems. We find an increase in the annual CO₂ sink across non-permafrost ecosystems but not permafrost ecosystems, despite similar increases in summer uptake. Thus, recent non-growing-season CO₂ losses have substantially impacted the CO₂ balance of permafrost ecosystems. Furthermore, analysis of interannual variability reveals warmer summers amplify the C cycle (increase productivity and respiration) at putatively nitrogen-limited sites and at sites less reliant on summer precipitation for water use. Our findings suggest that water and nutrient availability will be important predictors of the C-cycle response of these ecosystems to future warming. The future of carbon dynamics in the northern high latitudes is uncertain yet represents an important potential feedback under climate change. This study uses a comprehensive observational dataset to show an increasing carbon sink in non-permafrost systems; in permafrost systems uptake was offset by loss.

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

Decadal increases in carbon uptake offset by respiratory losses across northern permafrost ecosystems

See, Craig R., Virkkala, Anna M., Natali, Susan M., Rogers, Brendan M.,

1-16 Meteorology & Atmospheric Sciences

Development of a monthly PM_{2.5} forecast model for Seoul, Korea, based on the dynamic climate forecast and a convolutional neural network algorithm

Park, Ingyu., Ho, Chang-Hoi., Kim, Jinwon., Kim, Joo-Hong. and Jun,

Sang-Yoon.

Atmospheric Research. 2024. 309.

doi: 10.1016/j.atmosres.2024.107576.

A convolutional neural network (CNN) model has been developed to predict monthly concentrations of particulate matter with a diameter $\leq 2.5 \mu\text{m}$ ($\text{PM}_{2.5}$) in Seoul, Republic of Korea, during winter months (November through February). Seven meteorological variables influencing $\text{PM}_{2.5}$ concentrations were selected as predictors: geopotential heights at 1000 and 500hPa, zonal and meridional winds, relative humidity and temperature at 850hPa, and boundary layer height. These predictors were obtained from the fifth generation of the European Centre for Medium-Range Weather Forecasts reanalysis (ERA5) for model construction and from the Korea Polar Prediction System (KPOPS) dynamic forecasts for operational predictions. From the 11-year ERA5 dataset for 2008–2020, one year was allocated for testing, while the remaining 10 years were randomly assigned for either training (80%) or validation (20%). This process was repeated until all 11 years were allocated for testing, resulting in 11 CNN models. The benchmark which used the ERA5 dataset as the predictors yielded a mean bias error (MBE) of $0.05 \mu\text{gm}^{-3}$, root mean square error (RMSE) of $2.41 \mu\text{gm}^{-3}$, Pearson correlation coefficient (R) of 0.85, and 71% hit rate in predicting the months of high $\text{PM}_{2.5}$ concentrations ($\geq 30 \mu\text{gm}^{-3}$) for the testing periods. The 11-CNN-model ensemble predictions using the KPOPS forecasts resulted in an MBE of $0.1 \mu\text{gm}^{-3}$, RMSE of $3.19 \mu\text{gm}^{-3}$, R of 0.74, and hit rate of 62.5% for the period 2008–2020. Considering that the average temporal correlation coefficients between the ERA5 and the KPOPS forecasts for the seven predictors ranged from 0.20 to 0.66, the CNN-based $\text{PM}_{2.5}$ prediction model has demonstrated good performance in overcoming the adverse effects of the KPOPS forecast errors on predicting $\text{PM}_{2.5}$ concentrations. The CNN model showed limitations for unusual period such as the COVID-19 period, November 2020 through February 2022, when the emissions in East Asia were substantially below their climatological normal levels. In conclusion, the CNN model developed in this study showed potential applicability to operational monthly $\text{PM}_{2.5}$ concentration predictions for the years of normal emissions using solely meteorological data. This can provide professionals in various fields, such as health care and environmental science, with valuable insights for long-term planning.

keywords:

Air pollution; $\text{PM}_{2.5}$ monthly forecast; Convolutional neural network (CNN); Korea Polar Prediction System (KPOPS); ECMWF reanalysis (ERA5); Dynamic climate forecast

1-17 Environmental Sciences

Differential responses of respiration and photosynthesis to air temperature over a moist tundra ecosystem of Alaska and its impact on changing carbon cycle

Lee, Ji-Yeon., Chae, Namyi., Kim, Yongwon., Yun, Juyeol., Jeong, Sujong., Choi, Taejin., Kim, Seong-Joong., Lee, Bang Yong. and Park, Sang-Jong.

Environmental Research Communications. 2024. 6(4).

doi: 10.1088/2515-7620/ad3c17.

This study analyzed the sensitivities of carbon cycle to surface air temperature using the CO_2 flux data collected from June to September for six years (2014–2019) over a moist tundra site in Council, Alaska. The tundra ecosystem was a strong sink of carbon in June and July, a weak sink in August with rapidly decreasing photosynthesis, and a carbon source in September. The ecosystem respiration (Re) and gross primary production (GPP) were obtained from the net ecosystem exchange (NEE) of eddy-covariance system. Both the Re and GPP increased with temperature, enhancing carbon emission and uptake during observation period. Notably, Re showed higher sensitivity to temperature than GPP did. This result means that as global warming continues, the increase in carbon release is greater than the increase in carbon uptake. In other words, the tundra ecosystem is expected to become a weaker carbon sink in June and July and a stronger source of carbon in September. Possible mechanism of different temperature sensitivities of Re and GPP as well as temporal variations of temperature sensitivities are suggested. Present results highlight the importance of understanding the temperature sensitivities of Re and GPP in various tundra ecosystems to accurately understand changes in the carbon cycle in the Arctic region.

keywords:

moist tundra ecosystem; carbon cycle; Global warming; temperature sensitivity; ecosystem respiration; GPP; NEE

1-18 Environmental Sciences; Meteorology & Atmospheric Sciences

Diverse sources and aging change the mixing state and ice nucleation properties of aerosol particles over the western Pacific and Southern Ocean

Xue, Jiao., Zhang, Tian., **Park, Keyhong.**, Yan, Jinpei., **Yoon, Young Jun.**, **Park, Jiyeon.** and Wang, Bingbing.

Atmospheric Chemistry and Physics. 2024. 24(13): 7731-7754.

doi: 10.5194/acp-24-7731-2024.

Atmospheric particles can impact cloud formation and play a critical role in regulating cloud properties. However, particle characteristics at the single-particle level and their ability to act as ice-nucleating particles (INPs) over the marine atmosphere are poorly understood. In this study, we present micro-spectroscopic characterizations and ice nucleation properties of particles collected during a cruise from South Korea to Antarctica in 2019. Most of the samples were dominated by fresh sea salt, aged sea salt, and sea salt mixed with sulfate particles, with total number percentages ranging from 48 % to 99 % over the western Pacific and the Southern Ocean. The mixing-state index of the particle population ranged from 50 % to 95 % over the Northern Hemisphere and Southern Hemisphere. Multiphase processes on sea salt particles resulted in chlorine deficiency. This selective aging process made the marine particle population more externally mixed. Ice nucleation onset conditions primarily for the deposition mode were measured and the investigated particles showed diverse ice nucleation abilities. The fresh sea salt particles with organic coatings exhibited the highest ice nucleation ability at a relative humidity with respect to ice as low as 121 %. The sea salt mixed sulfate particle was enriched in INPs by a factor of 1.9. Aging processes affected both the mixing state of the particles and their ice nucleation abilities. Our analysis shows that assuming an internally mixed particle population in the marine atmosphere can lead to errors of several orders of magnitude in predicting ice nucleation rates.

sedimentary strata, the smectite is derived from. Analyses of elemental composition of smectite minerals in marine sediments can help to differentiate the smectite sources and, thus, sediment provenance, with potentially far-reaching paleo-environmental implications. In this study, we investigated the smectite compositions of modern-latest Holocene seafloor surface sediments deposited offshore from the Amundsen Sea drainage sector, where the West Antarctic Ice Sheet is currently unstable and losing mass due to ocean-forced melting, to detect and understand the variabilities of their elemental composition and geographical distribution. The smectite composition in continental rise sediments was compared to that of potential source areas on the Amundsen Sea continental shelf and in the sub-Antarctic South Pacific basin. Furthermore, we analyzed the smectite composition of sediments in continental rise cores deposited during the last glacial and last interglacial periods to reconstruct source variations over glacialinterglacial cycles. In particular, high contents of Al-Fe-rich smectite indicate that the glacial sediments had been supplied from the coastal region around Pine Island Bay by the cross-shelf advance of the West Antarctic Ice Sheet during the last glacial period. This clearly contrasts with the smectite minerals in rise sediments deposited during the present and the last interglacial periods that are composed of two distinct smectite types (Mg-rich and Al-rich, respectively), indicating their supply from multiple sources. During interglacials, Mg-rich smectite is probably transported by Circumpolar Deep Water from the sub-Antarctic South Pacific basin to the continental rise, while Al-rich smectite is supplied as part of ice rafted debris and by marine currents from the coasts around the Amundsen Sea embayment. Our research demonstrates that analysis of the elemental composition of smectite minerals on the Amundsen Sea continental margin provides a valuable tool to trace variations in sources for detrital sediment components and their pathways throughout glacial-interglacial cycles.

1-19 Geochemistry & Geophysics

Elemental composition of smectite minerals in continental rise sediments from the Amundsen Sea, West Antarctica, as a tool to identify detrital input from various sources throughout late Quaternary glacial-interglacial cycles

Park, Young Kyu. and 6 others.

Chemical Geology. 2024. 657.

doi: 10.1016/j.chemgeo.2024.122116.

Detrital smectite is a ubiquitous clay mineral in marine sediments and has a variable total Fe, Al, and Mg composition depending on the source, i.e., bedrock or unconsolidated

keywords:

Editor: Christian France-Lanord; Amundsen Sea; Elemental composition of smectite; Glacial-interglacial cycle; Sediment provenance; West Antarctic Ice Sheet

1-20 Meteorology & Atmospheric Sciences

Evaluation of Four Cloud Microphysical Schemes Simulating Arctic Low-Level Clouds Observed During the ALOUD Experiment

Nam, Jihyun., Cho, Yeonsoo., Lim, Kyo-Sun., Jun, Sang-Yoon., Kim, Joo-Hong., Park, Sang-Jong. and Kim, Sang-Woo.
Asia-Pacific Journal of Atmospheric Sciences. 2024. 60(5): 727-740.
 doi: 10.1007/s13143-024-00378-0.

We investigated the microphysical characteristics of low-level Arctic clouds using four cloud microphysics parameterization schemes (Morrison, WDM6, NSSL, and P3) implemented in the Polar-optimized Weather Research and Forecasting (PWRP) model. Our assessment was based on a comparison with data collected during the Arctic Cloud Observations Using Airborne Measurements during the Polar Day (ACLOUD) experiment, which occurred near Svalbard between May and June 2017. During the ACLOUD campaign, a substantial number of clouds were observed, primarily influenced by adiabatic motions and sensible/latent heat fluxes that led to air masses warming up by 4°C as they traversed over the sea ice and ocean transition zone. Among the parameterization schemes tested, the Morrison and WDM6 schemes demonstrated superior performance overall, showing frequency bias (FB) values closer to 1 (1.07 and 1.13) and high log-odds ratios (0.50 and 0.48) in cloud occurrence predictions, indicating good agreement with observed data. In contrast, the NSSL and P3 schemes exhibited higher FB values (1.30 and 1.56) with lower log-odds ratios (0.17 and 0.16), indicating an overestimation of cloud occurrence. The WDM6 scheme produced higher ice-mixing ratios compared to Morrison and NSSL schemes, while the latter two tended to generate more snow and graupel. The NSSL scheme showed the least bias in simulating ice water content (IWC) in mixed-phase clouds; however, all schemes generally underestimated both liquid water content (LWC) and IWC. Notably, significant deviations in IWC were observed at an altitude of 1.2km compared to observations, attributed to differences in temperature thresholds for ice formation. This study emphasizes the importance of developing cloud parameterization in the Arctic based on observations to improve the accuracy of estimating cloud impacts on Arctic climate under rapid Arctic warming trends.

keywords:

Arctic clouds; ACLOUD; PWRP; Cloud microphysics scheme

1-21 *Environmental Sciences; Geosciences, Multidisciplinary; Meteorology & Atmospheric Sciences*

Extreme summer temperature anomalies over Greenland largely result from clear-sky

radiation and circulation anomalies

Blau, Manuel Tobias., Ha, Kyung-Ja. and Chung, Eui-Seok.
Communications Earth & Environment. 2024. 5(1).
 doi: 10.1038/s43247-024-01549-7.

The polar regions have been undergoing amplified warming in recent years. In particular, Greenland has experienced anomalously warm summers with intense melt rates. We employ a surface radiation budget framework to examine the causes for positive and negative summer temperature anomaly events over Greenland from 1979 to 2021. We found a dominant contribution of the clear-sky downwelling longwave radiation and the surface albedo feedback to temperature anomalies. Atmospheric temperature perturbations dominate the effect of anomalous emissivity on clear-sky downwelling longwave radiation. In warm years, enhanced turbulent heat exchange due to increased surface temperature and diabatic warming in the troposphere induces adiabatic heating of the atmosphere, enhanced moisture advection, and a high-pressure anomaly with a blocking-like anti-cyclonic circulation anomaly following peak temperature days. Different modes of natural climate variability, in particular, related to blocking over Greenland, can further amplify or dampen the ongoing warming trend, causing extreme temperature events. Extreme warm summers and high melt rates in Greenland since 1979 have been fueled by feedbacks between downwelling longwave radiation and a high-pressure blocking system, according to analyses of year-to-year perturbations of Greenland's surface energy budget.

1-22 *Geosciences, Multidisciplinary; Soil Science; Water Resources*

Ground surface temperature regimes are controlled by the topography and snow cover in the ice-free areas of Maritime Antarctica

Baptista, Joana., Vieira, Goncalo. and Lee, Hyungseok.
Catena. 2024. 240.
 doi: 10.1016/j.catena.2024.107947.

Ground Surface Temperature (GST) is especially relevant in permafrost regions, such as the ice-free areas of the Antarctic Peninsula, to the understanding of environmental changes, where a long-term warming trend has been detected since 1950. To better understand GST regimes and the topoclimatic controlling factors, 20

iButtons were installed at sites according to elevation, exposure, curvature, and proximity to permanent snow, recording temperatures at 3-hour intervals from March 2019 to February 2020. Multiple Factorial Analysis (MFA) was used to evaluate the influence of these factors on GST parameters and to group the sensors based on their similarities. An analysis of daily temperatures was conducted to classify types of daily ground temperature regimes for use in a spatial model, developed using Discriminant Analysis (DA). As was predicted elevation was identified as the main controlling factor, with a negative correlation to the Mean Annual Ground Surface Temperature, ranging from 0.6°C at 16m a.s.l. to -2°C at 254m a.s.l., and a positive correlation with Freezing Degree Days, ranging from 438 (at 16m a.s.l.) to 1042 (at 254m a.s.l.). Snow cover duration is the second control factor highlighted, determining the duration of the freezing season, which was prolonged where snow cover persisted longer, resulting in a more pronounced insulating effect. The diversity of conditions was reinforced with the identification of seven types of daily GST regimes (three frozen, two unfrozen, and two with freeze–thaw), leading to the categorization of four annual distribution types. These were spatialized for Barton Peninsula using the DA model (90% accuracy). The spatialization revealed a long frost season in proximity to snow patches, moderate frost season in areas above 160m a.s.l., a short frost season with slow warming in areas ranging from 90 to 160m a.s.l., and a short frost season with rapid warming in areas below 90m a.s.l.

keywords:

GST; Patterns of daily ground temperature regime; Topography; Microclimate; Barton Peninsula; Antarctica

using the Lomb-Scargle periodogram and wavelet analysis. In zonal winds and pressure, we estimated the height profiles for the amplitude ratio between annual oscillation (AO) and semi-annual oscillation (SAO) at both sites. Over KSS, the ratio indicates that SAO increases with altitude, whereas AO decreases, with SAO becoming the dominant oscillating component at around 90 km. However, the ratio mostly remains constant with an altitude due to the steady formation of a westward wind field throughout the height in summer. More intensive gravity wave activity over KSS drives meridional residual circulation in summer mesopause, creating a more powerful SAO signature above 90 km.

keywords:

mesospheric neutral winds/pressures; annual oscillation; semi-annual oscillation; hemispheric asymmetry; meteor radar

1-24 Astronomy & Astrophysics

HIWIND Balloon and Antarctica Jang Bogo FPI High Latitude Conjugate Thermospheric Wind Observations and Simulations

Wu, Qian., Lin, Dong., Wang, Wenbing., Qian, Liying., Jee, Geonhwa., Lee, Changsup. and Kim, Jeong-han.

Journal of Geophysical Research-Space Physics. 2024. 129(6).

doi: 10.1029/2023ja032400.

Using the *High* attitude Interferometer WIND observation balloon and Antarctic Jang Bogo station high latitude conjugate observations of the thermospheric winds we investigate the seasonal and hemispheric differences between the northern and southern hemispheres in June 2018. We found that the summer (northern) hemisphere dayside meridional winds have a double-hump feature, whereas in the winter (southern) hemisphere the dayside meridional winds have a single hump feature. We attribute that to stronger summer, perhaps, northern hemisphere cusp heating. We also compared the observation with NCAR Thermosphere Ionosphere Electrodynamics General Circulation Model (TIEGCM) model. The TIEGCM reproduced the double-hump feature because of added cusp heating. The summer hemisphere has stronger anti-sunward winds. This is the first time we have very high latitude conjugate thermospheric wind observations.

keywords:

thermospheric wind; balloon FPI; high latitude conjugate observation; Antarctica; cusp heating; MAGE and TIEGCM

1-23

Hemispheric Asymmetry of Annual/Semi-Annual Oscillations in Mesospheric Neutral Winds and Pressure Between Northern and Southern High Latitude Regions

Kam, Hosik., Kim, Jeong-Han., Lee, Changsup. and Kim, Yong Ha.

Journal of Astronomy and Space Sciences. 2024. 41(4): 225-2333.

doi: 10.5140/JASS.2024.41.4.225

We present oscillating features from long-term neutral wind (meteor radar) and pressure (microwave limb sounder) measurements at Esrange (67°N, 20°E, 2007-2018) in the northern hemisphere and King Sejong Station (KSS; 62°S, 58°W, 2007-2017) in the Southern Hemisphere

1-25 Geography, Physical; Geosciences, Multidisciplinary

Holocene paleoceanographic variability in Robertson Bay, Ross Sea, Antarctica: A marine record of ocean, ice sheet, and climate connectivity

Truax, Olivia J., Riesselman, Christina R., Wilson, Gary S., Stevens, Craig L., Parker, Rebecca L., Lee, Jae Il., McKay, Robert M., Rosenheim, Brad E., Ginnane, Catherine E., Turnbull, Jocelyn C., Moon, Heung Soo., Lee, Min Kyung., Dagg, Bob. and Yoo, Kyu-Cheul.
Quaternary Science Reviews. 2024. 332.
 doi: 10.1016/j.quascirev.2024.108635.

Accelerating ocean-driven basal melting of Antarctic ice shelves in recent decades has implications for sea level rise and global overturning circulation. Here, we reconstruct oceanographic conditions at the confluence of the Ross Sea and the Southern Ocean by analyzing a multi-proxy Holocene marine sedimentary record collected from Robertson Bay. A ramped pyrolysis oxidation radiocarbon age-depth model provides a timeline for glacial behavior and oceanographic changes over the last 6700 years. The diatom assemblage, magnetic susceptibility, grain size, total organic carbon and nitrogen, trace elements, and bulk $\delta^{13}\text{C}$ are used as proxies for changing ocean and glacial conditions, which we interpret in the context of modern oceanographic measurements. Our record shows evidence of persistent ice cover in the northwestern Ross Sea during the Antarctic midHolocene climate optimum (ca. 5 cal kyr BP). Based on this observation, we suggest that meltwater and iceberg discharge associated with ice sheet retreat in the Ross Sea region altered local oceanography during the mid-Holocene. The onset of modern style oceanographic conditions in Robertson Bay occurred at ca. 4 cal kyr BP. Stable late Holocene conditions in are punctuated by a period of enhanced polynya activity and upwelling of nutrient rich Circumpolar Deep Water ca. 0.8 cal kyr BP and an increase in the seasonal duration of sea ice after 0.7 cal kyr BP, during the Little Ice Age. The response of the marine environment in Robertson Bay to midHolocene ice sheet retreat and natural climate variability during the last millennium underscores the sensitivity of the Antarctic ice-ocean interface to projected changes in coming decades.

keywords:

Antarctica; Holocene; Ross Sea; Sea ice; Circumpolar Deep Water; Paleoceanography; Diatoms; Sedimentology

1-26 Geosciences, Multidisciplinary

Holocene paleoenvironmental change based on diatom records from the continental shelf of the Chukchi Sea in the Arctic Ocean

Bak, Young-Suk. and Nam, Seung-Il.
Geosciences Journal. 2024. 28(2): 213-225.
 doi: 10.1007/s12303-023-0040-7.

Diatom assemblages from ARA2B-1A taken in the Chukchi Sea shelf were analyzed to reconstruct paleoenvironmental changes during the last 10 ka BP. The main factors controlling the distribution of diatom in the Chukchi Sea are the relatively warm and nutrient-rich Pacific water inflow after the opening of the Bering Strait. Based on the selected diatoms, three diatom assemblage zones are identified. The diatom assemblage zone I shows a rare or very low abundance, which corresponds to the early Holocene (10–8 ka BP). The diatom assemblage zone II corresponds to the mid-to-late Holocene (8–2 ka BP). It is a seasonal sea-ice environment with relatively abundant diatom valves and *Chaetoceros* resting spores, as well as sea-ice species, cold-water species, coastal species, and upwelling species. The diatom assemblage zone III corresponds to the late Holocene (2–0 ka BP), and the sea-ice species generally decreased compared to zone II, while the coastal species *Paralia sulcata* occurred abundantly. In particular, the *Thalassiosira antarctica*, a cold-water species, increased distinctly during this time interval. After ~2 ka BP, *T. antarctica* rapidly increased while sea-ice species rarely appeared, indicating limited open-marine environments. In particular, after 1 ka BP, *T. antarctica* decreased while the sea-ice species increased, suggesting that the sea-ice increased again before the recent global warming of the Arctic, the late Holocene.

keywords:

Chukchi Sea; diatom assemblage; seasonal; sea-ice; Holocene

1-27 Environmental Sciences; Geosciences, Multidisciplinary; Meteorology & Atmospheric Sciences

How Does Plant CO₂ Physiological Forcing Amplify Amazon Warming in CMIP6 Earth System Models?

Kimm, Haechan, Park, So-Won, Jun, Sang-Yoon and Kug, Jong-Seong.
Earths Future. 2024. 12(6).

doi: 10.1029/2023ef004223.

The physiological response to increasing CO₂ concentrations will lead to land surface warming through a redistribution of the energy balance. As the Amazon is one of the most plant-rich regions, the increase in surface temperature, caused by plant CO₂ physiological forcing, is particularly large compared to other regions. In this study, we analyze the outputs of the 11 models in the Coupled Model Intercomparison Project Phase 6 to find out how CO₂ physiological forcing amplifies Amazonian warming under elevated CO₂ levels. With the CO₂ concentration increase from 285 to 823 ppm, the Amazon temperature increased by 0.48 ± 0.42 K as a result of plant physiological forcing. Moreover, we assess the contributions of each climate feedback to the surface warming due to physiological forcing by quantifying climate feedbacks based on radiative kernels. Lapse rate feedback and cloud feedback, analyzed as the primary contributors, accounted for 53% and 37% of Amazon warming, respectively. The warming contributions of these two feedbacks also exhibit a significant spread, which contributes to the predictive uncertainty. The surface warming due to reduced evapotranspiration is larger than the upper tropospheric warming in the Amazon, resulting in surface warming by lapse rate feedback. In addition, cloud cover in the Amazon region decreases due to the reduced evapotranspiration. Decreased cloud cover amplifies surface warming through the shortwave cloud feedback. Furthermore, differences in circulation and local convection caused by physiological effect contribute to the inter-model spread of the cloud feedback.

keywords:

physiological forcing; CMIP6; Amazon; climate feedback

current anthropogenic CH₄ emissions trajectory implies that large emissions reductions are needed to meet the target of the Paris Agreement (Nisbet et al., 2019). For effective regulation of CH₄, it is important to identify spatiotemporal emission sources, in particular those from East Asia – one of the largest CH₄ emitters. In this study, we present in-situ observations of atmospheric CH₄ concentrations (i.e., dry air mole fractions in part per billion (ppb)) and carbon isotopic compositions of CH₄ made during 2017–2020 at the Gosan station (GSN, 33.3°N, 126.2°E, 72 m a.s.l.) which is representative of regional background conditions in East Asia. The annual growth rate of the observed CH₄ baseline concentrations was 11 ± 1 ppb yr⁻¹. The enhanced pollution concentrations of CH₄ showed seasonally distinctive correlations with the corresponding $\delta^{13}\text{C-CH}_4$. The CH₄ source isotopic signature for winter derived based on both the Keeling and Miller-Tans approaches was -40.7 ± 3.4 ‰, suggesting dominant thermogenic sources (e.g., coal and/or gas combustion), whereas the source signature for summer was estimated as -54.1 ± 1.2 ‰, which seemed to represent both microbial sources (e.g., rice paddies) and fossil fuel sources of CH₄ emissions. Based on the $\delta^{13}\text{C-CH}_4$ source signatures, we were able to infer that the proportional contribution of microbial sources to CH₄ summer emissions was ranges from 45 to 79 %. The finding indicates that microbial sources account for a substantial portion of CH₄ summer emissions, consistent with estimates of 74–80 % derived from the observed correlation between CH₄ and C₂H₆, which serves as a complementary tracer for fossil fuel sources.

keywords:

Atmospheric methane; Methane isotopes; Isotopic signatures; Emission sources; East Asia

1-28 Environmental Sciences

Identifying emission sources of CH₄ in East Asia based on in-situ observations of atmospheric $\delta^{13}\text{C-CH}_4$ and C₂H₆

Geum, Sohyeon. and 8 others.

Science of the Total Environment. 2024. 908.

doi: 10.1016/j.scitotenv.2023.168433.

Methane (CH₄) is the second most important greenhouse gas influenced by human activity. The increase in atmospheric CH₄ concentrations contributed ~23 % to the anthropogenic radiative forcing (Saunio et al., 2020). The

1-29 Geography, Physical; Geosciences, Multidisciplinary

Impact of boundary conditions on the modeled thermal regime of the Antarctic ice sheet

Park, In-Woo., Jin, Emilia Kyung., Morlighem, Mathieu. and Lee, Kang-Kun.

Cryosphere. 2024. 18(3): 1139-1155.

doi: 10.5194/tc-18-1139-2024.

A realistic initialization of ice flow models is critical for predicting future changes in ice sheet mass balance and their associated contribution to sea level rise. The initial thermal

state of an ice sheet is particularly important, as it controls ice viscosity and basal conditions, thereby influencing the overall ice velocity. Englacial and subglacial conditions, however, remain poorly understood due to insufficient direct measurements, which complicate the initialization and validation of thermal models. Here, we investigate the impact of using different geothermal heat flux (GHF) datasets and vertical velocity profiles on the thermal state of the Antarctic ice sheet and compare our modeled temperatures to in situ measurements from 15 boreholes. We find that the temperature profile is more sensitive to vertical velocity than to GHF. The basal temperature of grounded ice and the amount of basal melting are influenced by both selection of GHF and vertical velocity. More importantly, we find that the standard approach, which consists of combining basal sliding speed and incompressibility to derive vertical velocities, provides reasonably good results in fast-flow regions (ice velocity $>50 \text{ m yr}^{-1}$) but performs poorly in slow-flow regions (ice velocity $<50 \text{ m yr}^{-1}$). Furthermore, the modeled temperature profiles in ice streams, where bed geometry is generated using a mass conservation approach, show better agreement with observed borehole temperatures compared to kriging-based bed geometry.

1-30 Meteorology & Atmospheric Sciences

Increased occurrence of two intrinsic atmospheric circulations in Asia during the boreal summer

Oh, Sae-Yoon., Yeh, Sang-Wook., Jeong, Yong-Cheol., Song, Hajoon. and Lee, Min-Hee.

International Journal of Climatology. 2024. 44(9): 2921-2933.

doi: 10.1002/joc.8488.

The k-means clustering of reanalysis datasets is used to classify the intrinsic atmospheric circulation in Asia based on the daily geopotential height of 500 hPa during the boreal summer (June, July and August) for 1958–2020. Among the total clusters of atmospheric circulation patterns in Asia, two distinct clusters of atmospheric circulation are characterized by a significant increasing trend in occurrence. They correspond to different zonal wave numbers (1–2 vs. 3–4) of atmospheric circulation in the mid-to-high latitudes of the Northern Hemisphere, and their associated sea surface temperature structures are not the same in the tropical Pacific and the North Atlantic. Further analysis indicates that two clusters of atmospheric circulation alter the amount of summer monsoon precipitation in East Asia, and an

increasing amount of precipitation in southern China in recent decades could be explained by the combined effect of an increasing trend in the frequency of occurrence of two clusters of atmospheric circulation. Finally, a long-term simulation of the Community Earth System Model version 2 suggests that anthropogenic forcing may be responsible for the increasing trend of occurrence of the two atmospheric circulations in Asia.

keywords:

anthropogenic forcing; atmospheric circulation; clusters; k-means clustering; linear trend

1-31 Geosciences, Multidisciplinary

Influence of Foehn-Like Winds on Near-Surface Temperature at Jang Bogo Station, Terra Nova Bay, East Antarctica

Ahn, Seohee., Seo, Won-Seok., Kwon, Hataek, Lee, Min-Hee., Kim, Seong-Joong., Lee, Bang Yong., Park, Sang-Jong. and Choi, Taejin.

Geophysical Research Letters. 2024. 51(22).

doi: 10.1029/2024gl110348.

The coast of Terra Nova Bay (TNB) is known as one of the intense katabatic wind confluence zones in Antarctica. Strong westerly winds with topography-specific foehn effects (foehn-like winds, FLWs) could have influenced surface temperatures in this area downwind of the Transantarctic Mountains, yet their impact remains unstudied. Jang Bogo Station (JBS) in TNB has weak winds year-round, with occasional strong winds causing significant winter temperature increases. This study aims to investigate the FLWs and their recent variability in occurrence at JBS in terms of surface temperature variability. During the strong wind events, the surface warms due to foehn effects such as adiabatic heating and vertical mixing. FLWs occur approximately 16% (10%) of the time in winter (annually). FLWs are caused by cyclones in the eastern Ross Sea. Meteorological records for 2015–2022 revealed an increased FLW frequency, particularly in winter, which has increased temperatures in recent years.

keywords:

foehn effects; Antarctica; Terra Nova Bay; surface temperature rise; Ross sea atmospheric circulation

Influence of high-latitude blocking and the northern stratospheric polar vortex on cold-air outbreaks under Arctic amplification of global warming

Hanna, Edward., Francis, Jennifer., Wang, Muyin., Overland, James E., Cohen, Judah., Luo, Dehai., Vihma, Timo., Fu, Qiang., Hall, Richard J., Jaiser, Ralf., **Kim, Seong-Joong.**, Köhler, Raphael., Luu, Linh., Shen, Xiaocen., Erner, Irene., Ukita, Jinro., Yao, Yao., Ye, Kunhui., **Choi, Hyesun.** and Skific, Natasa.

Environmental Research: Climate. 2024. 3(4): 042004.

doi: 10.1088/2752-5295/ad93f3.

It is widely accepted that Arctic amplification (AA)—enhanced Arctic warming relative to global warming—will increasingly moderate cold-air outbreaks (CAOs) to the midlatitudes. Yet, some recent studies also argue that AA over the last three decades to the rest of the present century may contribute to more frequent severe winter weather including disruptive cold spells. To prepare society for future extremes, it is necessary to resolve whether AA and severe midlatitude winter weather are coincidental or physically linked. Severe winter weather events in the northern continents are often related to a range of stratospheric polar vortex (SPV) configurations and atmospheric blocking, but these dynamical drivers are complex and still not fully understood. Here we review recent research advances and paradigms including a nonlinear theory of atmospheric blocking that helps to explain the location, timing and duration of AA/midlatitude weather connections, studies of the polar vortex's zonal asymmetric and intra-seasonal variations, its southward migration over continents, and its surface impacts. We highlight novel understanding of SPV variability—polar vortex stretching and a stratosphere–troposphere oscillation—that have remained mostly hidden in the predominant research focus on sudden stratospheric warmings. A physical explanation of the two-way vertical coupling process between the polar vortex and blocking highs, taking into account local surface conditions, remains elusive. We conclude that evidence exists for tropical preconditioning of Arctic-midlatitude climate linkages. Recent research using very large-ensemble climate modelling provides an emerging opportunity to robustly quantify internal atmospheric variability when studying the potential response of midlatitude CAOs to AA and sea-ice loss.

Keywords:

blocking; Arctic amplification; polar vortex; global warming; cold air outbreaks

Inorganic iodine and bromine speciation in Arctic snow at picogram-per-grams levels by IC-ICP-MS

Frassati, Stefano., Barbaro, Elena., Rossetti, Claudia., Cozzi, Giulio., Turetta, Clara., Scoto, Federico., Roman, Marco., Feltracco, Matteo., **Kim, Kitae.**, and 3 others.

Journal of Analytical Science and Technology. 2024. 15(1).

doi: 10.1186/s40543-024-00462-0.

Iodine and bromine play central roles in polar atmospheric chemistry: iodine influences the atmospheric oxidative capacity and can generate cloud condensation nuclei, while bromine participates in ozone depletion reactions, known as bromine explosions. Here we present a very sensitive analytical method for Br and I speciation by coupling the ion chromatography system (IC) with an inductively coupled plasma sector field mass spectrometer (ICP-SFMS). We achieved sub-picogram-per gram (pg g^{-1}) as limits of detection (LODs) ranging from 0.4 pg g^{-1} for I^- , 0.8 pg g^{-1} for IO_3^- , 4 pg g^{-1} for Br^- , and 1 pg g^{-1} for BrO_3^- , respectively. These values represent a decrease of up to 30 times compared to the LODs reported in other studies. The method was validated using deep snow samples from the Svalbard Islands, collected at the end of the polar night to quantify various oxidized compounds during their seasonal minimum. In the future, this method could prove useful in the paleoclimatic study of ice cores and snow, as well as in ice chemistry research.

keywords:

Halogen speciation; Arctic snow; Ion chromatography; ICP-MS

Integrating the controlled evaporation mixer with cavity ring-down spectroscopy for enhanced water vapor isotope calibration

Moon, Jangil., Han, Yeongcheol., Kim, Songyi., Lee, Jeonghoon., and Do Hur, Soon.

Journal of Analytical Science and Technology. 2024. 15(1).

doi: 10.1186/s40543-024-00455-z.

Accurate measurement of water vapor isotopes ($\delta^{18}\text{O}$ and $\delta^2\text{H}$) is fundamental for advancing our understanding of the hydrological cycle and improving hydrological model

accuracy. This study introduces an innovative calibration methodology using a controlled evaporation mixer (CEM) for determining stable isotopic ratios in atmospheric water vapor via cavity ring-down spectroscopy. The CEM technique reliably produces a stable water vapor stream, crucial for enhancing the precision and accuracy of isotopic measurements. Its rapid adaptation to changes in water vapor concentration and compatibility with different water standards enhance calibration reliability. Demonstrated reproducibility in generating water vapor across a broad concentration range from 900 to over 25,000 ppmv, coupled with a substantial reduction in memory effects, makes this approach highly effective in both laboratory and field settings. This calibration advancement greatly enhances research capabilities for continuous atmospheric water vapor analysis, providing deeper insights into hydrological processes and atmospheric dynamics.

keywords:

Isotope calibration; Water vapor isotopes; Stable isotopes; CRDS; Vaporization

1-35 *Geosciences, Multidisciplinary; Soil Science; Water Resources*

Isotopic evolution of snowmelt and its hydrometeorological importance in snow-covered regions

Nyamgerel, Yalalt., **Han, Yeongcheol.** and Lee, Jeonghoon.
Catena. 2024. 234.
doi: 10.1016/j.catena.2023.107543.

Snowmelt, a component of the hydrological cycle, is influenced by changing climate and meteorological events. In the context of hydrometeorological studies, the water isotopic composition of snowmelt has been commonly used. This study examined temporal variations in the isotopic composition of snowmelt from an isotopically heterogeneous snowpack to the context of accurate quantification of isotope-based hydrograph separation. In this study, a one-dimensional model was used to simulate the isotopic variations of the meltwater by varying the initial isotopic compositions of the snow layers and parameters such as effectiveness of exchange (ψ), ice-to-liquid ratio of the exchange system (f), and water saturation (S). Isotopic evolution is sensitive to the initial layer sequence of isotopically enriched or depleted snow in the snowpack and the extent of isotopic differences between the layers. More

varied patterns are observed in the isotopic evolution as the ψ and f values are increased; particularly, a significant modification is observed in the bottom layer that is altered by the enriched top layer, thereby further affecting the pattern of isotopic evolution. The isotopic heterogeneity has been suggested to be a significant factor in the isotopic evolution of snowmelt, even though various other influencing factors have been considered under natural conditions. Because of the close dependence of snow and glacial conditions upon climate change, this study is expected to support further hydrometeorological studies, particularly in snow-dominated regions.

keywords:

Snowmelt; Snowpack; Isotopic evolution; Snow cover; Hydrograph separation

1-36 *Environmental Sciences; Remote Sensing; Imaging Science & Photographic Technology*

Long-term prediction of Arctic sea ice concentrations using deep learning: Effects of surface temperature, radiation, and wind conditions

Kim, Young Jun., **Kim, Hyun-cheol.** and 3 others.
Remote Sensing of Environment. 2025. 318.
doi: 10.1016/j.rse.2024.114568.

Over the last five decades, Arctic sea ice has been shrinking in area and thickness. As a result, increased marine traffic has created a need for improved sea ice forecasting on seasonal to annual time-scales. In this study, we introduce a novel UNET-based deep learning model to forecast sea ice concentration up to 12 months. Based on yearly hindcast validation, the UNET 3-, 6-, 9-, and 12-month predictions provided more accurate and stable predictions than did the four baseline models: the Copernicus Climate Change Service (C3S), the damped anomaly persistence (DP) forecast, and two deep learning approach, the Convolutional Neural Network (CNN) models and Convolutional Long Short-Term Memory (ConvLSTM). During years with large departures from the long-term trend, the proposed UNET model exhibited promising SIC prediction results with root-mean-square errors (RMSEs), which were reduced from 17.35 to 7.07 % compared to the four baseline models. Our findings also confirmed the relative importance of each predictor variable (temperature, incoming solar radiation, wind speed and direction) in long-term prediction. Past SIC conditions,

together with surface temperature emerged as the most important factors for SIC prediction, especially in the marginal ice zone. Incoming solar radiation and wind speed and direction showed greater sensitivity in predicting SICs in areas with thin ice. This model offers the potential to shape Arctic development and management plans and strategies, ensuring extended forecasting periods and enhanced prediction accuracy.

keywords:

SIC prediction; UNet

1-37 *Astronomy & Astrophysics; Geosciences, Multidisciplinary*

Millennial-Scale Changes in Atmospheric Nitrous Oxide During the Holocene

Azharuddin, Syed., Ahn, Jinho., Ryu, Yeongjun., Brook, Ed. and Salehnia, Nasrin.

Earth and Space Science. 2024. 11(1).

doi: 10.1029/2023ea002840.

Nitrous oxide (N₂O) is an important greenhouse gas which destroys the ozone in the stratosphere. Primary sources of atmospheric N₂O are nitrification and denitrification in terrestrial soils and the ocean, and the main sink is photolysis in the stratosphere. Studies have mostly focused on the climate-related response of N₂O during glacial-interglacial periods. However, its mechanism of variation during the Holocene remains unclear. We present a high-resolution N₂O record from the South Pole Ice (SPICE) core covering the Holocene epoch. The millennial-scale N₂O trend agrees with existing records. We constructed a Holocene composite consisting of the new N₂O measurements in SPICE and existing records from other ice core sites. The N₂O composite reveals four distinct periods of N₂O variation during 11.5–10.0 ka, 10.0–6.2 ka, 6.2–2.2 ka, and 2.2–1.4 ka, including two maxima in 11.0–10.0 ka and 3.0–2.2 ka and minima in 8.8–6.2 ka and approximately 1.4 ka. Apart from these, our new high-resolution record from SPICE shows a short-term N₂O decrease around 2.8 ka which is not observed in other records possibly due to lower sample resolution and/or higher age smoothing. Comparison of our new Holocene N₂O composite with the paleo-proxy records suggests the plausible linkage of major monsoon (Asian, North African, South and North American, and Australian-Indonesian monsoon) and upwelling (Arabian Sea and Eastern Tropical South Pacific) regions in regulating

the atmospheric N₂O during the Holocene.

keywords:

ice cores; south pole; nitrous oxide; Holocene; paleoclimate

1-38 *Multidisciplinary Sciences*

Millennial-scale variability of Greenland dust provenance during the last glacial maximum as determined by single particle analysis

Ro, Seokhyun., Park, Jonghyeon., Yoo, Hanjin., Han, Changhee., Lee, Ahhyung., Lee, Yoojin., Kim, Minjeong., Han, Yeongcheol., Svensson, Anders., Shin, Jinhwa., Ro, Chul-Un. and Hong, Sungmin.

Scientific Reports. 2024. 14(1).

doi: 10.1038/s41598-024-52546-x.

Greenland ice core records exhibited 100-fold higher dust concentrations during the Last Glacial Maximum (LGM) than during the Holocene, and dust input temporal variability corresponded to different climate states in the LGM. While East Asian deserts, the Sahara, and European loess have been suggested as the potential source areas (PSAs) for Greenland LGM dust, millennial-scale variability in their relative contributions within the LGM remains poorly constrained. Here, we present the morphological, mineralogical, and geochemical characteristics of insoluble microparticles to constrain the provenance of dust in Greenland NEEM ice core samples covering cold Greenland Stadials (GS)-2.1a to GS-3 (~14.7 to 27.1 kyr ago) in the LGM. The analysis was conducted on individual particles in microdroplet samples by scanning electron microscopy with energy dispersive X-ray spectroscopy and Raman microspectroscopy. We found that the kaolinite-to-chlorite (K/C) ratios and chemical index of alteration (CIA) values were substantially higher (K/C: 1.4 ± 0.7 , CIA: 74.7 ± 2.9) during GS-2.1a to 2.1c than during GS-3 (K/C: 0.5 ± 0.1 , CIA: 65.8 ± 2.8). Our records revealed a significant increase in Saharan dust contributions from GS-2.1a to GS-2.1c and that the Gobi Desert and/or European loess were potential source(s) during GS-3. This conclusion is further supported by distinctly different carbon contents in particles corresponding to GS-2.1 and GS-3. These results are consistent with previous estimates of proportional dust source contributions obtained using a mixing model based on Pb and Sr isotopic compositions in NEEM LGM ice and indicate millennial-scale changes in Greenland dust provenance that are probably linked to large-scale atmospheric circulation variabilities during the LGM.

1-39 Paleontology

Miocene Climatic Optimum and Middle Miocene Climate Transition: a foraminiferal record from the central Ross Sea, Antarctica

Bombard, Samantha E., Leckie, R. Mark., Browne, Imogen M., Shevenell, Amelia E., McKay, Robert M., Harwood, David M., Kim, Sunghan., and Iodp Expedit 373 Scientists.

Journal of Micropalaeontology. 2024. 43(2): 383-421.

doi: 10.5194/jm-43-383-2024.

The Ross Sea record of the Miocene Climatic Optimum (MCO; ~16.9–14.7 Ma) and the Middle Miocene Climate Transition (MMCT; ~14.7–13.8 Ma) provides critical insights into Antarctic ocean–cryosphere interactions during a time of extreme warmth and subsequent cooling. Here we report on Lower to Middle Miocene foraminiferal assemblages from the International Ocean Discovery Program (IODP) Site U1521 on the outer shelf of the central Ross Sea to identify regional shifts in environmental and water mass conditions and trace continental shelf evolution. We identified seven benthic biofacies clusters, dominated by abundant *Globocassidulina subglobosa* (a proposed indicator of proto-Circumpolar Deep Water, pCDW), *Uvigerina* cf. *U. fueguina* (high productivity and enhanced bottom-water currents), *Nonionella* spp. (high productivity), or *Melonis* spp. (high productivity) using a Q-mode cluster analysis to develop preliminary regional paleoenvironmental interpretations. Four unique assemblages, including *Globobulimina* cf. *G. auriculata* (high productivity and low oxygen), are also identified. Unit IV (representing the early MCO event) is a short-lived (~80 ka), progradational, clast-poor sandy diamictite, likely deposited during deglaciation; the upper part of Unit IV is transitional with overlying Unit III. Unit IV sediments contain the most persistently abundant and diverse foraminiferal assemblages recovered at U1521 because they are mud-rich and diatom-poor, despite very high sedimentation rates. The benthic assemblages shift between *Globocassidulina* and *Uvigerina* dominance, suggesting changes in the pCDW influence relative to productivity and/or current activity. We suggest the abundance of *Uvigerina* (a shelf-edge proxy) in Unit IV records the northward progradation of the Ross continental shelf at this location during the late Early to Middle Miocene. Unit III (MCO) was deposited in an open-marine setting, evident by the ice-rafted detritus or debris (IRD) clast-free, diatom-rich/diatom-bearing muds. The sporadic nature of foraminiferal abundances in Unit III is likely due to intervals of terrigenous mud alternating with more diatom-rich/diatom-bearing muds. As in Unit IV, the muddier lithologies (higher natural gamma ray (NGR) values) are more likely

to preserve calcareous foraminifera, whereas the most diatom-rich sediments (lower NGR values) are more corrosive to carbonate. We interpret the muddier intervals as interglacials with incursions of pCDW, as indicated by increased *Globocassidulina subglobosa*, and sporadic occurrences of rare warmer-water planktic foraminifera. Collectively, these multiple incursions of warmer-water planktic foraminifera provide evidence for polar amplification in the Ross Sea during the MCO and MMCT. The diatom-rich muds are interpreted as glacials during the MCO with open-marine conditions and higher productivity. The dominance of *Globobulimina* in the upper part of Unit III corresponds with the carbon maximum of Carbon Maxima 2 (CM2) and low-oxygen conditions in the sediments at ~16.1 Ma. Subsequent glaciation (including Mi2, Miocene Isotope event 2), marine-based ice sheet grounding, and erosion on the shallow shelf are recorded by the widespread Ross Sea Unconformity 4 (RSU4; ~15.95–14.2 Ma) at Site U1521. Unit II (MMCT) likely represents sedimentation in the interval between the RSU4 and the Mi3 (Miocene Isotope event 3) glaciation at ~13.9–13.8 Ma. The benthic biofacies composition of Unit II shows a further increase in neritic taxa, including *Elphidium magellanicum* and *Epistominella vitrea*, suggesting continued shoaling of the continental shelf, which facilitated the growth of marine-based ice sheets during the Middle Miocene. Our initial correlation between Site U1521 and the Antarctic geological DRILLing Project (ANDRILL) site, AND-2A, yields similar environmental interpretations, including peak warm events 3 and 4 during the MCO, supported by the foraminifera and unit lithologies. Suspected glacial intervals during the MCO, including Mi2 at the top of Unit III, correlate well with the reconstructed deep-sea estimates of ice volume changes (seawater $\delta^{18}\text{O}_{\text{sw}}$ record) from the Ocean Drilling Program (ODP) Site 1171 on the South Tasman Rise.

1-40 Environmental Sciences; Geosciences, Multidisciplinary; Meteorology & Atmospheric Sciences

Multi-decadal climate variability and satellite biases have amplified model-observation discrepancies in tropical troposphere warming estimates

Chung, Eui-Seok., Kim, Seong-Joong., Sohn, Byung-Ju., Noh, Young-Chan. and John, Viju O.

Communications Earth & Environment. 2024. 5(1).

doi: 10.1038/s43247-024-01510-8.

Most coupled model simulations substantially overestimate tropical tropospheric warming trends over the satellite era, undermining the reliability of model-projected future climate change. Here we show that the model-observation discrepancy over the satellite era has arisen in large part from multi-decadal climate variability and residual biases in the satellite record. Analyses indicate that although the discrepancy is closely linked to multi-decadal variability in the tropical Pacific sea surface temperatures, the overestimation remains over the satellite era in model simulations forced by observed time-varying sea surface temperatures with a La Niña-like pattern. Regarding moist thermodynamic processes governing tropical tropospheric warming, however, we find a broad model-observation consistency over a post-war period, suggesting that residual biases in the satellite record may contribute to model-observation discrepancy. These results underscore the importance of sustaining an accurate long-term observing system as well as constraining the model representation of tropical Pacific sea surface temperature change and variability.

1-41 *Geosciences, Multidisciplinary; Meteorology & Atmospheric Sciences*

Multi-year assessment of the impact of ship-borne radiosonde observations on polar WRF forecasts in the Arctic

Choi, Yonghan., Kim, Joo-Hong., Jun, Sang-Yoon., Choi, Taejin. and Zhang, Xiangdong.

Geoscience Letters. 2024. 11(1).

doi: 10.1186/s40562-024-00326-w.

To compensate for the lack of conventional observations over the Arctic Ocean, ship-borne radiosonde observations have been regularly carried out during summer Arctic expeditions and the observed data have been broadcast via the global telecommunication system since 2017. With these data obtained over the data-sparse Arctic Ocean, observing system experiments were carried out using a polar-optimized version of the Weather Research and Forecasting (WRF) model and the WRF Data Assimilation (WRFDA) system to investigate their effects on analyses and forecasts over the Arctic. The results of verification against reanalysis data reveal: (1) DA effects on analyses and forecasts; (2) the reason for the year-to-year variability of DA effects; and (3) the possible role of upper-level potential vorticity in delayed DA effects. The overall assimilation

effects of the extra data on the analyses and forecasts over the Arctic are positive. Initially, the DA effects are the most apparent in the temperature variables in the middle/lower troposphere, which spread to the wind variables in the upper troposphere. The effects decrease with time but reappear after approximately 120 h, even in the 240-h forecasts. The effects on forecasts vary depending on the proximity of the radiosonde observation locations to the high synoptic variability. The upper-level potential vorticity is known to play an important role in the development of Arctic cyclones, and it is suggested as a possible explanation for the delayed DA effects after about 120 h.

keywords:

Ship-borne radiosonde observations; Data assimilation; Arctic forecasts; Year-to-year variability; Delayed effect

1-42 *Multidisciplinary Sciences*

Partitioning the drivers of Antarctic glacier mass balance (2003–2020) using satellite observations and a regional climate model

Kim, Byeong-Hoon., Seo, Ki-Weon., Lee, Choon-Ki., Kim, Jae-Seung., Lee, Won Sang., Jin, Emilia Kyung. and van den Broeke, Michiel.

Proceedings of the National Academy of Sciences of the United States of America. 2024. 121(41).

doi: 10.1073/pnas.2322622121.

We investigate the mass changes of Antarctic glaciers from 2003 to 2020, partitioning them into the contributions of surface mass balance (SMB) and ice discharge, using high-resolution ice mass change estimates derived from the combination of two different types of satellite observations (gravimetry and altimetry) and outputs from a regional climate model. Our analysis indicates that changes in ice discharge have played a dominant role in ongoing ice mass trends and their accelerations, especially in glaciers near the Amundsen and Bellingshausen Seas in West Antarctica. In particular, mass losses of the Thwaites and Pine Island Glaciers have been mostly (>90%) controlled by ice discharge, while the contribution of SMB has been relatively minor. In East Antarctica, SMB accounts for significant portions (>50%) of ice mass imbalances of glaciers in e.g., Dronning Maud Land and Wilkes Land. Ice discharge has also played a notable role in overall mass gain in the region. While our ice discharge estimates agree well with previous estimates from satellite imagery in West Antarctica, notable differences are found in glaciers of East Antarctica and

the Antarctic Peninsula. This highlights the need for more observations and improved numerical models to refine these estimates.

keywords:

Antarctica; ice mass change; surface mass balance; ice discharge

1-43 *Geosciences, Multidisciplinary*

Pleistocene glaciomarine laminated muds in the Central Basin of the northwestern Ross Sea and their palaeoceanographic records

Khim, Boo-Keun., Sohn, Young Kwan., Lee, Min Kyung., Kim, Sunghan., Lee, Jae Il. and Yoo, Kyu Cheul.

Terra Nova. 2024. 36(1): 37-44.

doi: 10.1111/ter.12688.

Glaciomarine laminated muds around the Antarctic continental margin are important in the marine geological record related to ice sheet dynamics. Microscopic observation and backscattered electron imagery of Pleistocene laminated muds in the Central Basin (Ross Sea) reveal that the light laminae comprise terrigenous angular to subangular silt-sized particles, scattered diatom fragments, and eroded sand-sized lumps of fossil-bearing mud. In contrast, the dark laminae are clayey and biogenic with very tiny pieces of fossils. These laminated muds are interpreted to have been deposited by subglacial meltwater plumes underneath the advancing glaciers that torn off the earlier-deposited and semi-consolidated diatom-rich sediments. Thus, most biogenic components of these laminated muds were recycled from older deposits, indicating that they are not related to enhanced biological production during the mud deposition. Our study suggests that the recycling of biogenic particles should be considered when interpreting the palaeoclimatic and palaeoceanographic implications of Antarctic environmental system.

keywords:

antarctic continental margin; glaciomarine laminated muds; paleoceanography

1-44 *Paleontology*

Pliocene-Pleistocene warm-water incursions and water mass changes on the Ross Sea continental shelf (Antarctica) based on foraminifera from IODP Expedition 374

Seidenstein, Julia L., Leckie, R. Mark., McKay, Robert., De Santis, Laura., Harwood, David., Kim, Sunghan., and Iodp Expedit 373 Scientists.

Journal of Micropalaeontology. 2024. 43(2): 211-238.

doi: 10.5194/jm-43-211-2024.

International Ocean Discovery Program (IODP) Expedition 374 sailed to the Ross Sea in 2018 to reconstruct paleoenvironments, track the history of key water masses, and assess model simulations that show warm-water incursions from the Southern Ocean led to the loss of marine-based Antarctic ice sheets during past interglacials. IODP Site U1523 (water depth 828 m) is located at the continental shelf break, northeast of Pennell Bank on the southeastern flank of Iselin Bank, where it lies beneath the Antarctic Slope Current (ASC). This site is sensitive to warm-water incursions from the Ross Sea Gyre and modified Circumpolar Deep Water (mCDW) today and during times of past warming climate. Multiple incursions of subpolar or temperate planktic foraminifera taxa occurred at Site U1523 after 3.8 Ma and prior to ~1.82 Ma. Many of these warm-water taxa incursions likely represent interglacials of the latest Early Pliocene and Early Pleistocene, including Marine Isotope Stage (MIS) Gi7 to Gi3 (~3.72–3.65 Ma), and Early Pleistocene MIS 91 or 90 (~2.34–2.32 Ma) and MIS 77–67 (~2.03–1.83 Ma) and suggest warmer-than-present conditions and less ice cover in the Ross Sea. However, a moderately resolved age model based on four key events prohibits us from precisely correlating with Marine Isotope Stages established by the LR04 Stack; therefore, these correlations are best estimates. Diatom-rich intervals during the latest Pliocene at Site U1523 include evidence of anomalously warm conditions based on the presence of subtropical and temperate planktic foraminiferal species in what likely correlates with interglacial MIS G17 (~2.95 Ma), and a second interval that likely correlates with MIS KM3 (~3.16 Ma) of the mid-Piacenzian Warm Period. Collectively, these multiple incursions of warmer-water planktic foraminifera provide evidence for polar amplification during super-interglacials of the Pliocene and Early Pleistocene. Higher abundances of planktic and benthic foraminifera during the Mid- to Late Pleistocene associated with interglacials of the MIS 37–31 interval (~1.23–1.07 Ma), MIS 25 (~0.95 Ma), MIS 15 (~0.60 Ma), and MIS 6–5e transition (~0.133–0.126 Ma) also indicate a reduced ice shelf and relatively warm conditions, including multiple

warmer interglacials during the Mid-Pleistocene Transition (MPT). A decrease in sedimentation rate after ~1.78 Ma is followed by a major change in benthic foraminiferal biofacies marked by a decrease in *Globocassidulina subglobosa* and a decrease in mud (<63 µm) after ~1.5 Ma. Subsequent dominance of *Trifarina earlandi* biofacies beginning during MIS 15 (~600 ka) indicate progressive strengthening of the Antarctic Slope Current along the shelf edge of the Ross Sea during the mid to Late Pleistocene. A sharp increase in foraminiferal fragmentation after the MPT (~900 ka) and variable abundances of *T. earlandi* indicate higher productivity, a stronger but variable ASC during interglacials, and/or corrosive waters, suggesting changes in water masses entering (mCDW) and exiting (High Salinity Shelf Water or Dense Shelf Water) the Ross Sea since the MPT.

1-45 Ecology; Geosciences, Multidisciplinary; Oceanography

Polar vortex weakening and its impact on surface temperature in recent decades

Kim, Seong-Joong. and Choi, Hyesun.

Polar Research. 2024. 43.

doi: 10.33265/polar.v43.9723.

The stratospheric polar vortex (SPV) weakening is linked to surface circulation changes. This study employs statistical analysis using reanalysis data to compare the anomalous SPV behaviour in the Northern (NH) and Southern (SH) hemispheres and its downward impacts on surface climate. The onset of annual SPV weakening occurs in mid-January and late September in the NH and SH hemispheres, respectively. Following the onset of SPV weakening, stratospheric polar cap height (PCH) anomalies were strongly correlated with tropospheric PCH anomalies. Significant cold anomalies were observed over Eurasia within 30 days after SPV weakening onset in the NH, whereas warming responses occurred in the SH 30–60 days after onset over Antarctica, except in the Antarctic Peninsula. These contrasting surface temperature responses to SPV weakening events in both hemispheres are the results of changes in the geopotential height in the troposphere, reminiscent of the change in geopotential height in the lower stratosphere, with a trough over Eurasia in the NH, and a higher height anomaly over East Antarctica in the SH. SPV changes have played a role in modulating surface climate via a downward influence on tropospheric circulation in recent decades. Even though they show a weakening trend in both hemispheres, SPV

changes cannot fully explain long-term temperature trends. This is partially because SPV trends observed during the analysis period are relatively weak. This study enhances our understanding of the characteristics of the SPV coupled with troposphere circulation and can contribute to improved surface weather forecasting.

keywords:

Stratospheric polar vortex; vortex weakening events; polar cap height; surface temperature, climate change; stratosphere- troposphere coupling

1-46 Geosciences, Multidisciplinary; Oceanography

Post-glaciation depositional changes in Wijdefjorden, northern Svalbard, using grain-size end-member modelling

Ahn, Youngkyu., Joe, Young Jin., Jang, Kwangchul., Kim, Jung-Hyun., Son, Yeong Ju., Forwick, Matthias., Hong, Sungmin. and Nam, Seung-Il.

Marine Geology. 2024. 472.

doi: 10.1016/j.margeo.2024.107306.

Grain-size end-member (EM) modelling is a robust statistical approach for identifying and quantifying dominant grain-size distributions. This approach provides a novel perspective for understanding the impact of interactions between depositional processes in complex sedimentary environments. This study examines grain-size distributions of six glacialmarine sediment cores collected along an N–S transect from the continental shelf to the Wijdefjorden system in northern Svalbard. In addition, we integrate grain-size EMs with lithologic and acoustic facies, allowing us to identify three distinct groups of EMs (EM1–3), each closely associated with specific depositional processes: turbid meltwater discharge (EM1), sediment winnowing by bottom currents (EM2), and the deposition of ice-rafted debris in glacialmarine conditions and subglacial till (EM3). An analysis of the three EM groups reveals that the glacial retreat during the last deglaciation and the Atlantic Water inflow significantly impacted depositional changes within the Wijdefjorden system. In contrast, a decrease in the Atlantic Water inflow during the late Holocene corresponds to glacial re-advance, resulting in shifts in the depositional environment. This study demonstrates the utility of EM modelling in deciphering complex grain-size distributions and reconstructing different climate-driven depositional processes in glacialmarine sediments in Svalbard fjords. This

integrated approach enhances our understanding of the intricate interplay among climate change, glacier dynamics, and oceanic forcing in polar fjord environments.

keywords:

Svalbard; Fjord; Tidewater glacier; Grain-size end-member modelling; Depositional process

1-47 Meteorology & Atmospheric Sciences

Seasonal and Local Time Variation in the Observed Peak of the Meteor Altitude Distributions by Meteor Radars

Dawkins, ECM., Janches, D., Stober, G., Carrillo-Sanchez, JD., Lieberman, RS., Jacobi, C., Moffat-Griffin, T., Mitchell, NJ., Cobbett, N., Batista, PP., Andrioli, VF., Buriti, RA., Murphy, DJ., Kero, J., Gulbrandsen, N., Tsutsumi, M., Kozlovsky, A., Lester, M., Kim, Jeong-Han., Lee, Changsup. and 7 others.

Journal of Geophysical Research-Atmospheres. 2024. 129(21).

doi: 10.1029/2024jd040978.

Meteoroids of sub-milligram sizes burn up high in the Earth's atmosphere and cause streaks of plasma trails detectable by meteor radars. The altitude at which these trails, or meteors, form depends on a number of factors including atmospheric density and the astronomical source populations from which these meteoroids originate. A previous study has shown that the altitude of these meteors is affected by long-term linear trends and the 11-year solar cycle related to changes in our atmosphere. In this work, we examine how shorter diurnal and seasonal variations in the altitude distribution of meteors are dependent on the geographical location at which the measurements are performed. We use meteoroid altitude data from 18 independent meteor radar stations at a broad range of latitudes and investigate whether there are local time (LT) and seasonal variations in the altitude of the peak meteor height, defined as the majority detection altitude of all meteors within a certain period, which differ from those expected purely from the variation in the visibility of their astronomical source. We find a consistent LT and seasonal response for the Northern Hemisphere locations regardless of latitude. However, the Southern Hemisphere locations exhibit much greater LT and seasonal variation. In particular, we find a complex response in the four stations located within the Southern Andes region, which indicates that the strong dynamical atmospheric activity, such as the gravity waves prevalent here, disrupts, and masks the seasonality

and dependence on the astronomical sources.

keywords:

meteor; altitude; mesosphere; meteor radar; gravity waves

1-48 Green & Sustainable Science & Technology; Environmental Sciences

Seasonal dynamics of airborne biomolecules influence the size distribution of Arctic aerosols

Jang, Eunho., Park, Ki-Tae., Yoon, Young Jun., Jang, Kyoung-Soon., Kim, Min Sung., Kim, Kitae., Chung, Hyun Young., Mazzola, Mauro., Cappelletti, David. and Lee, Bang Yong.

Environmental Science and Ecotechnology. 2024. 22.

doi: 10.1016/j.esec.2024.100458.

Organic matter is crucial in aerosol-climate interactions, yet the physicochemical properties and origins of organic aerosols remain poorly understood. Here we show the seasonal characteristics of submicron organic aerosols in Arctic Svalbard during spring and summer, emphasizing their connection to transport patterns and particle size distribution. Microbial-derived organic matter (MOM) and terrestrial-derived organic matter (TOM) accounted for over 90% of the total organic mass in Arctic aerosols during these seasons, comprising carbohydrate/protein-like and lignin/tannin-like compounds, respectively. In spring, aerosols showed high TOM and low MOM intensities due to biomass-burning influx in the central Arctic. In contrast, summer exhibited elevated MOM intensity, attributed to the shift in predominant atmospheric transport from the central Arctic to the biologically active Greenland Sea. MOM and TOM were associated with Aitken mode particles (<100 nm diameter) and accumulation mode particles (>100 nm diameter), respectively. This association is linked to the molecular size of biomolecules, impacting the number concentrations of corresponding aerosol classes. These findings highlight the importance of considering seasonal atmospheric transport patterns and organic source-dependent particle size distributions in assessing aerosol properties in the changing Arctic.

keywords:

Organic aerosol; FT-ICR MS; Particle size distribution; Atmospheric transport pattern; Biomolecule

1-49 Environmental Sciences/Meteorology & Atmospheric Sciences

Shipborne observations of black carbon aerosols in the western Arctic Ocean during summer and autumn 2016–2020: impact of boreal fires

Deng, Yange., Tanimoto, Hiroshi., Ikeda, Kohei., Kameyama, Sohiko., Okamoto, Sachiko., Jung, Jinyoung., Yoon, Young Jun., Yang, Eun Jin. and Kang, Sung-Ho.

Atmospheric Chemistry and Physics. 2024. 24(10): 6339–6357.

doi: 10.5194/acp-24-6339-2024.

Black carbon (BC) aerosol is considered one of the most important contributors to rapid climate warming as well as snow and sea ice melting in the Arctic, yet the observations of BC aerosols in the Arctic Ocean have been limited due to infrastructural and logistical difficulties. We observed BC mass concentrations (m_{BC}) using light absorption methods on board the icebreaker R/V Araon in the Arctic Ocean ($< 80^\circ N$ and $166^\circ E$ to $156^\circ W$) as well as the North Pacific Ocean in summer and early autumn of 2016–2020. The levels, interannual variations, and pollution episodes of m_{BC} in the Arctic were examined, and the emission sources responsible for the high-BC episodes were analyzed with global chemistry-transport-model simulations. The average m_{BC} in the surface air over the Arctic Ocean (72° – $80^\circ N$) observed by the 2019 cruise exceeded 70 ng m^{-3} , which was substantially higher than that observed by cruises in other years (approximately 10 ng m^{-3}). The much higher m_{BC} observed in 2019 was perhaps due to more frequent wildfires occurring in the Arctic region than in other years. The model suggested that biomass burning contributed most to the observed BC by mass in the western Arctic Ocean and the marginal seas. For these 5 years, we identified 10 high-BC episodes north of $65^\circ N$, including one in 2018 that was associated with co-enhancements of CO and CH₄ but not CO₂ and O₃. The model analysis indicated that certain episodes were attributed to BC-containing air masses transported from boreal fire regions to the Arctic Ocean, with some transport occurring near the surface and others in the mid-troposphere. This study provides crucial datasets on BC mass concentrations and the mixing ratios of O₃, CH₄, CO, and CO₂ in the western Arctic Ocean regions, and it highlights the significant impact of boreal fires on the observed Arctic BC during the summer and early autumn months.

1-50 Environmental Sciences; Meteorology & Atmospheric Sciences

Statistical seasonal prediction of Arctic sea ice concentration based on spatiotemporal anomaly persistent method

Lee, Gyu-Ri., Woo, Sung-Ho., Baek, Eun-Hyuk., Kim, Joo-Hong., Kim, Baek-Min. and Jeong, Jee-Hoon.

Environmental Research Letters. 2024. 19(11).

doi: 10.1088/1748-9326/ad7d1f.

Accurate prediction of Arctic sea ice is crucial for high-latitude and even mid-latitude climate prediction. It significantly affects atmospheric circulation, the environment, ecology, and maritime transport. This study developed a statistical prediction model to predict monthly Arctic sea ice concentration (SIC) for up to one year based on the season-reliant empirical orthogonal functions (SEOFs) technique. Its prediction skill was compared with that of a dynamical prediction model. The spatiotemporal pattern of sea ice anomalies, which exhibit strong seasonality and are maintained for a significant period above the seasonal time scale by atmosphere-ocean interactions, was extracted using SEOFs. A prediction model was constructed by extrapolating from the recent anomalous state of sea ice to predict the future. Experimental retrospective predictions with monthly time resolution for 1982–2021 were performed to validate the prediction skill of Arctic SIC and areal extent. Statistically significant prediction skills were achieved over several months, even up to six months, exceeding the skill of the dynamical model.

keywords:

Arctic sea ice; statistical prediction; season-reliant EOF; prediction skill; atmospheric circulation

1-51 Geosciences, Multidisciplinary

The dominant influence of indian ocean dipole-like ocean warming on decreased precipitation over eastern East Antarctica

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

Frontiers in Earth Science. 2024. 12.

doi: 10.3389/feart.2024.1387809.

East Antarctica is undergoing a noticeable decrease in precipitation, significantly impacting ice mass loss.

However, there is a lack of research on the underlying factors behind this change. This study highlights that on an interannual timescale, the precipitation variations in Eastern East Antarctica (EEA) are predominantly influenced by the Indian Ocean Dipole mode (IOD) compared to other climate variabilities like the Southern Annular Mode (SAM), El Niño–Southern Oscillation (ENSO), and north Atlantic variability. Through trend analysis of each climate variability, we confirmed that the observed decrease in EEA precipitation can be attributed to positive IOD-like ocean warming. A positive SAM trend also contributed to specific Wilkes Land and Queen Mary Land regions. Despite these influence on long-term trend, the relationship between IOD and EEA precipitation exhibits sporadic changes on interdecadal timescales. Notably, the apparent negative correlation between the two declined to insignificance in the early 2000s, only to re-establish a significant negative correlation by the early 2010s. The primary driver of this change is the inconsistent propagation of waves originating from the Indian Ocean. During periods of high correlation, these waves propagate southeastward, inducing a robust low-pressure anomaly near Victoria Land, ultimately leading to decreased EEA precipitation. However, during periods of low correlation, the waves move eastward and fail to alter the circulation anomalies near East Antarctica.

keywords:

eastern east Antarctica (EEA); decreased precipitation trend in EEA; positive IOD-like ocean warming; interdecadal change in the relationship between IOD and EEA precipitation; changes in teleconnections

1-52 *Meteorology & Atmospheric Sciences*

The Extraordinary March 2022 East Antarctica "Heat" Wave. Part I: Observations and Meteorological Drivers

Wille, Jonathan D., Alexander, Simon P., Amory, Charles., Baiman, Rebecca., Barthelemy, Leonard., Bergstrom, Dana M., Berne, Alexis., Binder, Hanin., Blanchet, Juliette., Bozkurt, Deniz., Bracegirdle, Thomas J., Casado, Mathieu., **Choi, Taejin.**, Clem, Kyle R., Codron, Francis., Datta, Rajashree., Di Battista, Stefano., Favier, Vincent., Francis, Diana., Fraser, Alexander D., Fourre, Elise., Garreaud, Rene D., Genthon, Christophe., Gorodetskaya, Irina V., Gonzalez-Herrero, Sergi., Heinrich, Victoria J., Hubert, Guillaume., Joos, Hanna., **Kim, Seong-Joong.** and 21 others.

Journal of Climate. 2024. 37(3).

doi: 10.1175/jcli-d-23-0175.1.

Between 15 and 19 March 2022, East Antarctica experienced an exceptional heat wave with widespread 30°–40°C temperature anomalies across the ice sheet. This record-shattering event saw numerous monthly temperature records being broken including a new all-time temperature record of −9.4°C on 18 March at Concordia Station despite March typically being a transition month to the Antarctic coreless winter. The driver for these temperature extremes was an intense atmospheric river advecting subtropical/midlatitude heat and moisture deep into the Antarctic interior. The scope of the temperature records spurred a large, diverse collaborative effort to study the heat wave's meteorological drivers, impacts, and historical climate context. Here we focus on describing those temperature records along with the intricate meteorological drivers that led to the most intense atmospheric river observed over East Antarctica. These efforts describe the Rossby wave activity forced from intense tropical convection over the Indian Ocean. This led to an atmospheric river and warm conveyor belt intensification near the coastline, which reinforced atmospheric blocking deep into East Antarctica. The resulting moisture flux and upper-level warm-air advection eroded the typical surface temperature inversions over the ice sheet. At the peak of the heat wave, an area of 3.3 million km² in East Antarctica exceeded previous March monthly temperature records. Despite a temperature anomaly return time of about 100 years, a closer recurrence of such an event is possible under future climate projections. In Part II we describe the various impacts this extreme event had on the East Antarctic cryosphere.

SIGNIFICANCE STATEMENT: In March 2022, a heat wave and atmospheric river caused some of the highest temperature anomalies ever observed globally and captured the attention of the Antarctic science community. Using our diverse collective expertise, we explored the causes of the event and have placed it within a historical climate context. One key takeaway is that Antarctic climate extremes are highly sensitive to perturbations in the midlatitudes and subtropics. This heat wave redefined our expectations of the Antarctic climate. Despite the rare chance of occurrence based on past climate, a future temperature extreme event of similar magnitude is possible, especially given anthropogenic climate change.

keywords:

Antarctica; Atmospheric river; Extreme events; Automatic weather stations; Climate records

The Extraordinary March 2022 East Antarctica "Heat" Wave. Part II: Impacts on the Antarctic Ice Sheet

Wille, Jonathan D., Alexander, Simon P., Amory, Charles., Baiman, Rebecca., Barthelemy, Leonard., Bergstrom, Dana M., Berne, Alexis., Binder, Hanin., Blanchet, Juliette., Bozkurt, Deniz., Bracegirdle, Thomas J., Casado, Mathieu., **Choi, Taejin.**, Clem, Kyle R., Codron, Francis., Datta, Rajashree., Di Battista, Stefano., Favier, Vincent., Francis, Diana., Fraser, Alexander D., Fourre, Elise., Garreaud, Rene D., Genthon, Christophe., Gorodetskaya, Irina V., Gonzalez-Herrero, Sergi., Heinrich, Victoria J., Hubert, Guillaume., Joos, Hanna., **Kim, Seong-Joong**, and 25 others.

Journal of Climate. 2024. 37(3): 779-799.

doi: 10.1175/jcli-d-23-0176.1.

Between 15 and 19 March 2022, East Antarctica experienced an exceptional heat wave with widespread 30°–40°C temperature anomalies across the ice sheet. In Part I, we assessed the meteorological drivers that generated an intense atmospheric river (AR) that caused these record-shattering temperature anomalies. Here, we continue our large collaborative study by analyzing the widespread and diverse impacts driven by the AR landfall. These impacts included widespread rain and surface melt that was recorded along coastal areas, but this was outweighed by widespread high snowfall accumulations resulting in a largely positive surface mass balance contribution to the East Antarctic region. An analysis of the surface energy budget indicated that widespread downward longwave radiation anomalies caused by large cloudliquid water contents along with some scattered solar radiation produced intense surface warming. Isotope measurements of the moisture were highly elevated, likely imprinting a strong signal for past climate reconstructions. The AR event attenuated cosmic ray measurements at Concordia, something previously never observed. Last, an extratropical cyclone west of the AR landfall likely triggered the final collapse of the critically unstable Conger Ice Shelf while further reducing an already record low sea ice extent.

SIGNIFICANCE STATEMENT: Using our diverse collective expertise, we explored the impacts from the March 2022 heat wave and atmospheric river across East Antarctica. One key takeaway is that the Antarctic cryosphere is highly sensitive to meteorological extremes originating from the midlatitudes and subtropics. Despite the large positive temperature anomalies driven from strong downward longwave radiation, this event led to huge amounts of snowfall across the Antarctic interior desert. The isotopes in this snow of warm airmass origin will likely be detectable

in future ice cores and potentially distort past climate reconstructions. Even measurements of space activity were affected. Also, the swells generated from this storm helped to trigger the final collapse of an already critically unstable Conger Ice Shelf while further degrading sea ice coverage.

keywords:

Antarctica; Ice shelves; Snow; Energy budget/balance; Paleoclimate

The Impact of Lower Atmosphere Forecast Uncertainties on WACCM-X Prediction of Ionosphere-Thermosphere System During Geomagnetic Storms

Lee, Wonseok., Song, In-Sun., Shim, Ja Soon., Liu, Guiping. and **Jee, Geonhwa.**

Space Weather-the International Journal of Research and Applications. 2024. 22(12).

doi: 10.1029/2024sw004137.

Impacts of lower atmosphere forecast uncertainties on the Ionosphere-Thermosphere (IT) system are investigated using the Whole Atmosphere Community Climate Model with Thermosphere and Ionosphere eXtension (WACCM-X) for April 2010 and March 2013 geomagnetic storms. For each storm, a specified-dynamics simulation (analysis run) is carried out by constraining the model dynamics using reanalysis data. Results of the analysis runs are used as initial conditions for forecast runs initialized on 20, 10, 5, 2, and 1 day before the storm onset time. The forecast runs show that errors in TEC compared to the analysis run appear in the equatorial region within 1-2 days after forecast starts with differences of about 10%. These discrepancies gradually expand to high-latitudes after 10 days. These errors in TECs could be due to the deviations in the semidiurnal (SW2) and non-migrating (DE3) tides that also occur within 1–2 days after forecast starts. SW2 and DE3 tides could modify the E-region wind driven dynamo at low latitudes, affecting the vertical plasma drift in the F-region, leading to the forecast errors in TEC. The TEC forecast errors at high-latitudes could be due to the change in the column integrated O/N₂, associated with tidal wind variations and resultant delayed change in vertical motions. The SW2 and DE3 tides can be affected by uncertainties in winds in the mesosphere and lower thermosphere (MLT) in the mid-to-high latitudes. The

MLT wind uncertainties are correlated with gravity wave drag (GWD), suggesting that the uncertainties in GWD can be one of the major sources of IT forecast errors.

1-55 Meteorology & Atmospheric Sciences

Tropical eastern Pacific cooling trend reinforced by human activity

Chung, Eui-Seok., Kim, Seong-Joong., Lee, Sang-Ki., Ha, Kyung-Ja., Yeh, Sang-Wook., Kim, Yong Sun., Jun, Sang-Yoon., Kim, Joo-Hong. and Kim, Dongmin.

Npj Climate and Atmospheric Science. 2024. 7(1).

doi: 10.1038/s41612-024-00713-2.

It remains unresolved whether the La Niña-like sea surface temperature (SST) trend pattern during the satellite era, featuring a distinct warming in the northwest/southwest Pacific but cooling in the tropical eastern Pacific, is driven by either external forcing or internal variability. Here, by conducting a comprehensive analysis of observations and a series of climate model simulations for the historical period, we show that a combination of internal variability and human activity may have shaped the observed La Niña-like SST trend pattern. As in observations, SSTs in each model ensemble member show a distinct multi-decadal swing between El Niño-like and La Niña-like trend patterns due to internal variability. The ensemble-mean trends for some models are, however, found to exhibit an enhanced zonal SST gradient along the equatorial Pacific over periods such as 1979–2010, suggesting a role of external forcing. In line with this hypothesis, single-forcing large ensemble model simulations show that human-induced stratospheric ozone depletion and/or aerosol changes have acted to enhance the zonal SST gradient via strengthening of Pacific trade winds, although the effect is model dependent. Our finding suggests that the La Niña-like SST trend is unlikely to persist under sustained global warming because both the ozone and aerosol impacts will eventually weaken.

1-56 Environmental Sciences; Meteorology & Atmospheric Sciences

Unveiling the role of tropical Pacific on the emergence of ice-free Arctic projections

Jahfer, Sharif., Ha, Kyung-Ja., Chung, Eui-Seok., Franzke, Christian L. E. and Sharma, Sahil.

Environmental Research Letters. 2024. 19(4).

doi: 10.1088/1748-9326/ad3141.

The observed sea ice concentration (SIC) over the Arctic has receded substantially in recent decades, and future model projections predict a seasonally ice-free Arctic in the second half of this century. Nevertheless, the impact of the Pacific on Arctic sea ice projections has yet to receive much attention. Observations show that summertime Arctic SIC growth events are related to the weakening of the Aleutian low and cooling events over the equatorial Pacific, and vice versa. We demonstrate that under various Coupled Model Intercomparison Project Phase 6 projections, the models in which the impact of El Niño-driven SIC loss is significantly higher than the La Niña-related SIC growth tend to turn seasonally ice-free by about 10–20 years ahead of the ensemble mean under high-emission future scenarios. We show how the non-linear impact of the El Niño Southern Oscillation (ENSO) on Arctic SIC resulted in a faster decline of summertime sea ice. The ENSO-related SIC changes in the multi-model ensemble mean of Arctic SIC are considerably lower than the internal variability and anthropogenic-driven changes. However, the asymmetric interannual ENSO effects over several decades and the resultant changes in surface heat fluxes over the Arctic lead to significant differences in the timing of sea ice extinction. Our results suggest that climate models must capture the realistic tropical Pacific–Arctic teleconnection to better predict the long-term evolution of the Arctic climate.

keywords:

Arctic sea ice; ENSO; North Pacific Index; ice-free Arctic; tropical Pacific; CMIP6 projection; evolution of Arctic sea ice

1-57 Geosciences, Multidisciplinary

Vertical Wind Profiles in the Mesosphere and Lower Thermosphere Driven by Meteor Radar and Ionospheric Connection Explorer Observations Over the Korean Peninsula

Lee, Jaewook., Kwak, Young-Sil., Kam, Hosik., Kil, Hyosub., Park, Jaeheung., Kim, Jeongheon., Yang, Tae-Yong. and Lee, Changsup.

Geophysical Research Letters. 2024. 51(4).

doi: 10.1029/2023gl106450.

Meteor radar observations provide wind data

ranging from 80 to 100 km altitude, while the Michaelson Interferometer for Global High-resolution Thermospheric Imaging (MIGHTI) onboard the Ionospheric Connection Explorer satellite offers wind data above 90 km altitude. This study aims to generate wind profiles in the mesosphere and lower thermosphere by combining the winds derived from meteor radar and MIGHTI observations over the Korean Peninsula from January 2020 to December 2021. The wind profiles derived from the two instruments are continuous at night, but they show discrepancies during the day. The atomic oxygen 557.7 nm (green line) emission intensity measured by MIGHTI peaks at approximately 100 km during the day and 94 km at night. The vertical gradient of the airglow volume emission rate is more pronounced during the day. These differences can cause day-night differences in the MIGHTI wind retrieval accuracy, potentially leading to discrepancies during the day.

keywords:

neutral winds; mesosphere and lower thermosphere; ICON-MIGHTI; meteor radar

1-58 *Environmental Sciences; Geosciences, Multidisciplinary; Meteorology & Atmospheric Sciences*

Warmer Antarctic summers in recent decades linked to earlier stratospheric final warming occurrences

Choi, Hyesun., Kwon, Hataek., **Kim, Seong-Joong.** and Kim, Baek-Min.

Communications Earth & Environment. 2024. 5(1).

doi: 10.1038/s43247-024-01221-0.

Since the 2000s, the pause of the strong Antarctic cooling and later stratospheric final warming onset trends has been identified. Here we employ composite and congruence analysis using reanalysis and in-situ data to propose a linkage between pivotal changes in the surface temperature trends and the timing of stratospheric final warming events. In early stratospheric final warming events, the positive polar cap height anomaly developed in the stratosphere in early October, descending to the troposphere and surface in late spring and summer, resulting in high-pressure anomalies, which led to warmer surfaces in most of Antarctica. In late stratospheric final warming occurrences, opposing or weaker behaviors were observed. The trend toward earlier stratospheric final warming appears to play a considerable role in warmer summers over parts of interior

Antarctica through the strengthening of the anti-cyclonic surface pressure anomaly. This could influence the regional sea-ice modulation over the Southern Ocean.

Earlier occurrence of the stratospheric final warming in the Southern Hemisphere vortex over the past two decades is linked to warmer surface temperatures over interior Antarctica, according to an investigation using reanalysis data.

1-59 *Meteorology & Atmospheric Sciences*

Winter Targeted Observing Periods during the Year of Polar Prediction in the Southern Hemisphere (YOPP-SH)

Bromwich, David H., Gorodetskaya, Irina V., Carpentier, Scott., Alexander, Simon., Bazile, Eric., Heinrich, Victoria J., Massonnet, Francois., Powers, Jordan G., Carrasco, Jorge F., Cayette, Arthur., **Choi, Taejin.**, Chyhareva, Anastasiia., Colwell, Steven R., Cordeira, Jason M., Cordero, Raul R., Doerenbecher, Alexis., Duran-Alarcon, Claudio., French, W. John R., Gonzalez-Herrero, Sergi., Guyot, Adrien., Haiden, Thomas., Hirasawa, Naohiko., Imazio, Paola Rodriguez., Kawzenuk, Brian., Krakovska, Svitlana., Lazzara, Matthew A., Litell, Mariana Fontolan., Manning, Kevin W., Norris, Kimberley., **Park, Sang-Jong.** and 7 others.

Bulletin of the American Meteorological Society. 2024. 105(9):

E1662-E1684.

doi: 10.1175/bams-d-22-0249.1.

The Year of Polar Prediction in the Southern Hemisphere (YOPP-SH) held seven targeted observing periods (TOPs) during the 2022 austral winter to enhance atmospheric predictability over the Southern Ocean and Antarctica. The TOPs of 5–10-day duration each featured the release of additional radiosonde balloons, more than doubling the routine sounding program at the 24 participating stations run by 14 nations, together with process-oriented observations at selected sites. These extra sounding data are evaluated for their impact on forecast skill via data denial experiments with the goal of refining the observing system to improve numerical weather prediction for winter conditions. Extensive observations focusing on clouds and precipitation primarily during atmospheric river (AR) events are being applied to refine model microphysical parameterizations for the ubiquitous mixed-phase clouds that frequently impact coastal Antarctica. Process studies are being facilitated by high-time-resolution series of observations and forecast model output via the YOPP Model Intercomparison and Improvement Project (YOPPsiteMIIP).

Parallel investigations are broadening the scope and impact of the YOPP-SH winter TOPs. Studies of the Antarctic tourist industry's use of weather services show the scope for much greater awareness of the availability of forecast products and the skill they exhibit. The Sea Ice Prediction Network South (SIPN South) analysis of predictions of the sea ice growth period reveals that the forecast skill is superior to the sea ice retreat phase.

keywords:

Antarctica; Southern Ocean; Numerical weather prediction/forecasting; Cloud microphysics; Numerical analysis/modeling

Part 2.

Geo Sciences

2-1 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.,** Sakamoto, Naoya. and Yurimoto, Hisayoshi.

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 ²⁶Al/²⁷Al ratios, (²⁶Al/²⁷Al)₀, for individual Ca-Al-rich inclusions (CAIs) in meteorites. We find that the relative sensitivity factors of ²⁷Al/²⁴Mg 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 ²⁷Al/²⁴Mg of ~30, ~100, and ~400. The obtained mineral isochron of hibonite in the FGI yields (²⁶Al/²⁷Al)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 (²⁶Al/²⁷Al)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 ¹⁶O-rich to ¹⁶O-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.

2-2 Geochemistry & Geophysics

A distinctive rare earth element signature for pyrite oxidation and glacial weathering

Jang, Kwangchul., Bayon, Germain., Pourret, Olivier., **Joe, Young Jin., Kim, Jung-Hyun.,** Byun, Eunji., Forwick, Matthias., Leon, Rafael. and **Nam, Seung-Il.**

Chemical Geology. 2024. 660.

doi: 10.1016/j.chemgeo.2024.122167.

The application of rare earth elements (REE) and neodymium (Nd) isotopes to authigenic Fe-(oxyhydr) oxide phases leached from marine sediments can be used for reconstructing past ocean circulation and chemical weathering patterns on nearby continental landmasses. To explore the behaviour of REE during chemical weathering in glacial environments, we analyzed the authigenic fraction of glaciomarine sediments from the continental shelf off northern Svalbard (Arctic Ocean), where the evolution of ice sheet dynamics since the last deglaciation is well constrained. Our results show that leached authigenic fractions in Svalbard sediments exhibit shale-normalized REE patterns characterized by anomalously high mid-REE enrichment relative to both light- and heavy-REE, as expressed by concavity index values (CI > 2.5) that significantly depart from typical REE signatures for leached fractions in marine and river sediments worldwide. Using a compilation of literature data, we provide compelling evidence that the occurrence of pronounced mid-REE enrichment in authigenic fractions of Svalbard marine sediments links to terrestrial oxidation of pyrite following glacial weathering. While future investigation will be required to further understand the detailed mechanism accounting for the observed REE decoupling and its link to pyrite oxidation, we propose that preferential dissolution of mid-REE-enriched rock-bearing minerals such as apatite following glacial erosion, sulfide weathering and subsequent release of sulfuric acid could release a distinctive REE signature in glacial surface environments. Our findings suggest that the use of authigenic REE in the sedimentary record could provide a means for tracing glacial weathering and associated biogeochemical sulfur and iron cycling across geological times.

keywords:

Rare earth elements; Iron oxyhydroxides; Sulfide weathering; Sulfur cycle; Arctic coastal environments; Glacier retreat

2-3 Multidisciplinary Sciences

A giant stem-group chaetognath

Park, Tae-Yoon S., Nielsen, Morten Lunde., Parry, Luke A., Sorensen, Martin Vinther., Lee, Mirinae., Kihm, Ji-Hoon., Ahn, Inhye., Park, Changkun. and 5 others.

Science Advances. 2024. 10(1).

doi: 10.1126/sciadv.adi6678.

Chaetognaths, with their characteristic grasping spines, are the oldest known pelagic predators, found in the lowest Cambrian (Terreneuvian). Here, we describe a large stem chaetognath, *Timorebestia koprii* gen. et sp. nov., from the lower Cambrian Sirius Passet Lagerstätte, which exhibits lateral and caudal fins, a distinct head region with long antennae and a jaw apparatus similar to *Amiskwia sagittiformis*. *Amiskwia* has previously been interpreted as a total-group chaetognathiferan, as either a stem-chaetognath or gnathostomulid. We show that *T. koprii* shares a ventral ganglion with chaetognaths to the exclusion of other animal groups, firmly placing these fossils on the chaetognath stem. The large size (up to 30 cm) and gut contents in *T. koprii* suggest that early chaetognaths occupied a higher trophic position in pelagic food chains than today.

Beacon Supergroup, showing shifting clastic provenance from different source rocks. Results obtained from this integrated study support a source for the Permian Weller Coal Measures from the local basement, made up of very low- to high grade metamorphic rocks. A compositional shift is recorded with the Lower Triassic Feather Conglomerate, mainly linked with changes in the fluvial style, likely associated with tectonic activity. The Middle to Upper Triassic Lashly Formation shows the main provenance change, supporting a distal source region: the fluvial system received a volcanoclastic input derived from the Permian-Triassic arc located to the east of the basin. The compositional and provenance variations, together with paleocurrent indicators, compared to the coeval units in the central Transantarctic Mountains, allow the reconstruction of the basin evolution and of the changing clastic drainage patterns. Data support the occurrence of articulated sub-basins where alluvial sedimentation settled, in which a morphological-structural divide was represented by the Ross High, separating during the Permian up to the Early Triassic the Victoria Land sub-basin from the main Transantarctic Basin. According to the changed composition of the Lashly Formation sandstones, it appears that in the Middle/Late Triassic, the Ross High was not more a morphological barrier, and that the Victoria Land sub-basin was joined with the Transantarctic foreland Basin.

keywords:

Provenance; Allan Hills; Gondwana; Detrital UPb geochronology; Sandstone petrography

2-4 Geography, Physical; Geosciences, Multidisciplinary; Paleontology

A multi-proxy detrital study from Permian-Triassic fluvial sequences of Victoria Land (Antarctica): Implications for the Gondwanan basin evolution

Zurli, Luca., Liberato, Giovanni Pio., Perotti, Matteo., Woo, Jusun., Lee, Mi Jung. and Cornamusini, Gianluca.

Palaeogeography Palaeoclimatology Palaeoecology. 2024. 641.

doi: 10.1016/j.palaeo.2024.112113.

One of the most complete Permian-Triassic fluvial sequences of the Beacon Supergroup, characterizing the infilling of the Transantarctic Basin, is recorded in the Allan Hills in Victoria Land (Antarctica). The multidisciplinary provenance approach carried out in this study includes UPb analysis on detrital zircons, chemistry on detrital mineral phases (garnet and white mica), and sandstone petrography. These, coupled with the data regarding the stratigraphic/sedimentological framework, provide a reconstruction of the geological history of the Permian-Triassic portion of the

2-5 Geosciences, Multidisciplinary

A new helcionelloid mollusc from the Cambrian of Greenland and Idaho (Laurentia)

Oh, Yeongju. and Peel, John S.

Bulletin of the Geological Society of Denmark. 2024. 73: 199-208.

doi: 10.37570/bgisd-2024-73-12.

Ressericonella gen. nov., a new genus of helcionelloid mollusc, characterized by a narrow shell with a shallowly convex dorsal surface and flat to shallowly concave lateral areas, is described from the Cambrian of Greenland and Idaho. The type species is *Helcionella aequa* Resser, 1939 from the Langston Formation (Naomi Peak Limestone Member) of early middle Cambrian age (Miaolingian Series, Wuliuan Stage, Albertella Biozone). *Ressericonella pipalukae* gen. et sp. nov. occurs in the latest early Cambrian (Cambrian Series 2, Stage 4, Bonnia-Pagetides elegans Biozone)

of southern Freuchen Land, North Greenland. Silicified specimens of *Ressericonella pipalukae* from North Greenland preserve two-layered shell structure in which an inner layer with a transverse fibrous pattern similar to lamello-fibrillar structure is overlain by an outer layer with fine threads radiating from the apex.

keywords:

Mollusca; Helcionelloida; Cambrian; Idaho; North Greenland

interpretations of radiocarbon measurements in the context of environmental reconstruction.

keywords:

Antarctica; instrumentation; radiocarbon AMS dating; ramped pyrolysis; sediments

2-6 Geochemistry & Geophysics

ADVANCING ANTARCTIC SEDIMENT CHRONOLOGY THROUGH COMBINED RAMPED PYROLYSIS OXIDATION AND PYROLYSIS-GC-MS

Ginnane, Catherine E., Turnbull, Jocelyn C., Naeher, Sebastian., Rosenheim, Brad E., Venturelli, Ryan A., Phillips, Andy M., Reeve, Simon., Parry-Thompson, Jeremy., Zondervan, Albert., Levy, Richard H., Yoo, Kyu-Cheul. and 4 others.

Radiocarbon. 2024. 66(5): 1120-1139.

doi: 10.1017/rdc.2023.116.

Radiocarbon (^{14}C) dating of sediment deposition around Antarctica is often challenging due to heterogeneity in sources and ages of organic carbon in the sediment. Chemical and thermochemical techniques have been used to separate organic carbon when microfossils are not present. These techniques generally improve on bulk sediment dates, but they necessitate assumptions about the age spectra of specific molecules or compound classes and about the chemical heterogeneity of thermochemical separations. To address this, the Rafter Radiocarbon Laboratory has established parallel ramped pyrolysis oxidation (RPO) and ramped pyrolysis-gas chromatography-mass spectrometry (Py-GC-MS) systems to thermochemically separate distinct carbon fractions, diagnose the chemical composition of each fraction, and target suitable RPO fractions for radiocarbon dating. Three case studies of sediment taken from locations around Antarctica are presented to demonstrate the implementation of combined RPO-AMS and Py-GC-MS to provide more robust age determination in detrital sediment stratigraphy. These three depositional environments are good examples of analytical and interpretive challenges related to oceanographic conditions, carbon sources, and other factors. Using parallel RPO-AMS and Py-GC-MS analyses, we reduce the number of radiocarbon measurements required, minimize run times, provide context for unexpected ^{14}C ages, and better support

2-7 Chemistry, Analytical

Analysis of Cation Composition in Dolomites on the Intact Particles Sampled from Asteroid Ryugu

Morita, Mayu., Yui, Hiroharu., Urashima, Shu-hei., Onose, Morihiko., Komatani, Shintaro., Nakai, Izumi., Abe, Yoshinari., Terada, Yasuko., Homma, Hisashi., Motomura, Kazuko., Ichida, Kiyohiro., Yokoyama, Tetsuya., Nagashima, Kazuhide., 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., Fujiya, Wataru., Fukai, Ryota., Gautam, Ikshu., Haba, Makiko K., Hibiya, Yuki., Hidaka, Hiroshi., Hoppe, Peter., Huss, Gary R., Iizuka, Tsuyoshi., Ireland, Trevor R., Ishikawa, Akira., Itoh, Shoichi., Kawasaki, Noriyuki., Kita, Noriko T., Kitajima, Kouki., Kleine, Thorsten., Krot, Sasha., Liu, Ming-Chang., Masuda, Yuki., Moynier, Frederic., Nguyen, Ann., Nittler, Larry., Pack, Andreas., Park, Changkun. and 40 others.

Analytical Chemistry. 2023. 96(1): 170-178.

doi: 10.1021/acs.analchem.3c03463.

Characterization of the elemental distribution of samples with rough surfaces has been strongly desired for the analysis of various natural and artificial materials. Particularly for pristine and rare analytes with micrometer sizes embedded on specimen surfaces, non-invasive and matrix effect-free analysis is required without surface polishing treatment. To satisfy these requirements, we proposed a new method employing the sequential combination of two imaging modalities, i.e., microenergy-dispersive X-ray fluorescence (micro-XRF) and Raman micro-spectroscopy. The applicability of the developed method is tested by the quantitative analysis of cation composition in micrometer-sized carbonate grains on the surfaces of intact particles sampled directly from the asteroid Ryugu. The first step of micro-XRF imaging enabled a quick search for the sparsely scattered and micrometer-sized carbonates by the codistributions of Ca^{2+} and Mn^{2+} on the Mg^{2+} - and Fe^{2+} -rich phyllosilicate matrix. The following step of Raman micro-spectroscopy probed the carbonate grains and analyzed their cation composition (Ca^{2+} , Mg^{2+} , and $\text{Fe}^{2+} + \text{Mn}^{2+}$) in a

matrix effect-free manner via the systematic Raman shifts of the lattice modes. The carbonates were basically assigned to ferroan dolomite bearing a considerable amount of $\text{Fe}^{2+} + \text{Mn}^{2+}$ at around 10 atom %. These results are in good accordance with the assignments reported by scanning electron microscopy–energy-dispersive X-ray spectroscopy, where the thin-sectioned and surface-polished Ryugu particles were applicable. The proposed method requires neither sectioning nor surface polishing; hence, it can be applied to the remote sensing apparatus on spacecrafts and planetary rovers. Furthermore, the non-invasive and matrix effect-free characterization will provide a reliable analytical tool for quantitative analysis of the elemental distribution on the samples with surface roughness and chemical heterogeneity at a micrometer scale, such as art paintings, traditional crafts with decorated shapes, as well as sands and rocks with complex morphologies in nature.

2-8

Anisotropy of magnetic susceptibility of sediments in the Ross Sea continental rise, antarctica: Evaluation of paleocurrent variability reconstruction

Shin, Jiyoung., Lee, Min Kyung., Kang, Myung-Il. and Joo, Young Ji.
Journal of the Geological Society of Korea. 2024. 60(4): 349-360.
doi: 10.14770/jgsk.2024.036.

The Antarctic continental margins exhibit unique sedimentary characteristics influenced by climatic changes in glacial environments and oceanic circulation. This study aims to trace the variability of bottom current and associated paleoenvironmental conditions in the Ross Sea continental rise through comprehensive interpretation of sedimentary facies, grain size distribution, and anisotropy of magnetic susceptibility (AMS). The sedimentary facies of the studied core are divided into two, diamictite with abundant ice-rafted debris (IRD) and laminated silt lacking IRD. Silty sediments with well-developed wavy contact and cross laminae indicate the influence of sustained bottom currents. The diamictite layers display faint or absent sedimentary structures and abundant bioturbation, but occasionally contain gravel and sand-rich layers formed by bottom-current winnowing. AMS results show that the degree of magnetic anisotropy (P') has no consistent relationship with sedimentary facies and grain size variations, probably due to disturbances from secondary magnetic fabrics, and is not regarded as a direct proxy for current intensity. However,

enhanced oblate fabrics align with the laminated silts and gravel-rich layers, contourite deposition by geostrophic currents flowing around the Ross Sea. These results imply that magnetic fabrics may sensitively reflect sedimentary processes that vary with bottom current systems in the Ross Sea (e.g., lamination and winnowing), highlighting the need for future magnetic studies in various polar environmental settings.

keywords:

Antarctica; Ross Sea; paleocurrent variability; anisotropy of magnetic susceptibility; sortable silt

2-9 Other Natural Science

Assessment of Antarctic Ice Tongue Areas Using Sentinel-1 SAR on Google Earth Engine

Lee, Na-Mi., Kim, Seung Hee. and Kim, Hyun-Cheol.
Korean Journal of Remote Sensing. 2024. 40(3): 285-293.
doi: 10.7780/kjrs.2024.40.3.5.

This study explores the use of Sentinel-1 Synthetic Aperture Radar (SAR), processed through Google Earth Engine (GEE), to monitor changes in the areas of Antarctic ice shelves. Focusing on the Campbell Glacier Tongue (CGT) and Drygalski Ice Tongue (DIT), the research utilizes GEE's cloud computing capabilities to handle and analyze large datasets. The study employs Otsu's method for image binarization to distinguish ice shelves from the ocean and mitigates detection errors by averaging monthly images and extracting main regions. Results indicate that the CGT area decreased by approximately 26% from January 2016 to January 2024, primarily due to calving events, while DIT showed a slight increase overall, with notable reduction in recent years. Validation against Sentinel-2 optical images demonstrates high accuracy, underscoring the effectiveness of SAR and GEE for continuous, long-term monitoring of Antarctic ice shelves.

keywords:

Antarctic ice shelves; Sentinel-1; Synthetic aperture radar; Google Earth Engine; Campbell Glacier Tongue; Drygalski Ice Tongue; Calving

2-10 Geochemistry & GeophysicsGeology

Changes in Vegetation Distribution around the King Sejong Station in Antarctica: A Comprehensive Analysis of Time-Lapse Electrical Resistivity Data, Meteorological Data, and Vegetation Data

Kim, Kwansoo., Lee, Eungsang., Ju, Hyeontae., Lee, Joohan. and Kim, Won-Ki.

Lithosphere. 2024. 2024(4).

doi: 10.2113/2024/lithosphere_2024_200.

The impact of buildings around the King Sejong Station (KSS), South Korea's first scientific station in Antarctica, has locally altered snowfall accumulation and vegetation distribution. Areas with high snowfall accumulation exhibited sparse vegetation, whereas areas with low snowfall showed distinct vegetation. This study conducted a comprehensive analysis using various data sources to understand the causes of changes in vegetation distribution. Meteorological data, including air temperature, soil temperature, soil moisture, and wind, were analyzed to determine the impact of station buildings on snow cover changes. The changes in vegetation distribution were more clearly visible through results of measured Normalized Difference Vegetation Index. Additionally, time-lapse electrical resistivity data were collected throughout 2020 to analyze variations in the subsurface electrical resistivity distribution. Electrical resistivity surveys utilized both dipole-dipole and Wenner arrays to gather data, with subsurface electrical resistivity information obtained through inversion process. The active layer, which is characterized by low electrical resistivity and is conducive to vegetation growth, is distributed in the upper layers and changes over time, only in vegetated area. In contrast, the development of the active layer was not observed in nonvegetated area. In conclusion, the time-lapse electrical resistivity data effectively reveal the temporal changes in the distribution of the active layer in the study area. When the electrical resistivity data were interpreted in conjunction with meteorological data, it provided a good understanding of the causes of changes in the distribution of vegetation around the KSS.

Pierce, Chris., Gerekos, Christopher., Skidmore, Mark., Beem, Lucas., Blankenship, Don., Lee, Won Sang., Adams, Ed., Lee, Choon-Ki. and Stutz, Jamey.

Cryosphere. 2024. 18(4): 1495-1515.

doi: 10.5194/tc-18-1495-2024.

The structure and distribution of sub-glacial water directly influences Antarctic ice mass loss by reducing or enhancing basal shear stress and accelerating grounding line retreat. A common technique for detecting sub-glacial water involves analyzing the spatial variation in reflectivity from an airborne radar echo sounding (RES) survey. Basic RES analysis exploits the high dielectric contrast between water and most other substrate materials, where a reflectivity increase ≥ 15 dB is frequently correlated with the presence of sub-glacial water. There are surprisingly few additional tools to further characterize the size, shape, or extent of hydrological systems beneath large ice masses.

We adapted an existing radar backscattering simulator to model RES reflections from sub-glacial water structures using the University of Texas Institute for Geophysics (UTIG) Multifrequency Airborne Radar Sounder with Full-phase Assessment (MARFA) instrument. Our series of hypothetical simulation cases modeled water structures from 5 to 50 m wide, surrounded by bed materials of varying roughness. We compared the relative reflectivity from rounded R  thlisberger channels and specular flat canals, showing both types of channels exhibit a positive correlation between size and reflectivity. Large (> 20 m), flat canals can increase reflectivity by more than 20 dB, while equivalent R  thlisberger channels show only modest reflectivity gains of 8–13 dB. Changes in substrate roughness may also alter observed reflectivity by 3–6 dB. All of these results indicate that a sophisticated approach to RES interpretation can be useful in constraining the size and shape of sub-glacial water features. However, a highly nuanced treatment of the geometric context is necessary.

Finally, we compared simulated outputs to actual reflectivity from a single RES flight line collected over Thwaites Glacier in 2022. The flight line crosses a previously proposed R  thlisberger channel route, with an obvious bright bed reflection in the radargram. Through multiple simulations comparing various water system geometries, such as canals and sub-glacial lakes, we demonstrated the important role that topography and water geometry can play in observed RES reflectivity. From the scenarios that we tested, we concluded the bright reflector from our RES flight line cannot be a R  thlisberger channel but could be consistent with a series of flat canals or a sub-glacial lake. However, we note our simulations were not exhaustive of all possible sub-glacial water configurations.

The approach outlined here has broad applicability for

2-11 Geography, Physical; Geosciences, Multidisciplinary

Characterizing sub-glacial hydrology using radar simulations

studying the basal environment of large glaciers. We expect to apply this technique when constraining the geometry and extent of many sub-glacial hydrologic structures in the future. Further research may also include comprehensive investigations of the impact of sub-glacial roughness, substrate heterogeneity, and computational efficiencies enabling more complex and complete simulations.

2-12 Environmental Sciences

Chronological distribution and potential sources of persistent toxic substances in soils from the glacier foreland of Midtre Lovénbreen, Svalbard

Cha, Jihyun., Kim, Jung-Hyun., Jung, Ji Young., Nam, Seung-Il. and Hong, Seongjin.

Environmental Pollution. 2024. 357.

doi: 10.1016/j.envpol.2024.124387.

Despite its reputation as one of the cleanest regions globally, recent studies have identified the presence of various persistent toxic substances (PTSs) in the environmental matrices collected from Svalbard. This study investigated the chronological distribution and potential sources of 81 PTSs in soils from the glacier foreland of Midtre Lovénbreen. Soil samples ($n=45$) were categorized by age based on exposure to the atmosphere due to glacier retreat in July 2014 into five age groups: 80–100 years ($n=7$), 60–80 years ($n=12$), 40–60 years ($n=16$), 20–40 years ($n=7$), and <20 years ($n=3$). Concentrations of polychlorinated biphenyls (PCBs, $n=32$) in soils varied with age, ranging from 0.29 to 0.74 ngg^{-1} dw. In addition, the concentrations of polycyclic aromatic hydrocarbons (PAHs, $n=28$), perylene, and alkyl-PAHs ($n=20$) in soils ranged from 21 to 80 ngg^{-1} dw, 2.9–62 ngg^{-1} dw, and 73–420 ngg^{-1} dw, respectively. The concentrations of PTSs were observed to be greater in older soils. Principal component analysis revealed that PCBs in soils originated from various product sources. Positive matrix factorization modeling estimated the association of PAHs in soils with potential origins, such as diesel emissions, petroleum and coal combustion, and coal. Potential sources of PAHs were mainly coal in younger soils and diesel emissions and petroleum combustion in older soils. Alkyl-PAH compositions in the soil were similar to those of bituminous coal, with a noteworthy degree of weathering observed in older soils. The accumulation rate and flux of PTSs in soils exhibited compound-specific patterns, reflecting factors such as long-range transport, fate, origin,

and recent inputs. These findings can serve as baseline data for protecting and preserving polar environments.

keywords:

Svalbard; Glacier foreland; Soil; Persistent toxic substances

2-13 Multidisciplinary Sciences

Contribution of carbonate-derived dissolved inorganic carbon into autochthonous particulate organic carbon in two small temperate Korean rivers (Geum and Seomjin)

Kang, Sujin., Kim, Jung-Hyun. And 3 others.

Heliyon. 2024. 10(10).

doi: 10.1016/j.heliyon.2024.e31154.

In this study, we estimated the contributions of carbonate mineral weathering to dissolved inorganic carbon (DIC) and carbonate-derived DIC to autochthonous particulate organic carbon (POC) in two temperate Korean rivers. We combined stoichiometric and stable carbon isotopic approaches to calculate the contribution of autochthonous POC, considering diverse riverine DIC sources. We collected surface water samples from May 2016 to May 2018 and analyzed the major ion composition of rivers along with the concentrations and stable carbon isotopes of DIC. Our estimates showed that the relative abundances of carbonate mineral weathering (0.41 ± 0.11 in the Geum River and 0.43 ± 0.07 in the Seomjin River) were only slightly lower than those of silicate mineral weathering (0.59 ± 0.1 in the Geum River and 0.57 ± 0.07 in the Seomjin River). The resulting percentage contributions of DIC derived from the carbonate mineral weathering to riverine autochthonous POC, if we consider the additional DIC sources of atmospheric and soil-derived CO_2 , were $10 \pm 3\%$ in the Geum River and $2 \pm 1\%$ in the Seomjin River. The calculated annual fluxes of carbonate-derived DIC for 2016–2018 were $23.2 \pm 0.3 \text{ Gg C yr}^{-1}$ in the Geum River and $1.1 \pm 0.4 \text{ Gg C yr}^{-1}$ in the Seomjin River. Moreover, the calculated annual fluxes of carbonate-derived POC were $3.6 \pm 0.5 \text{ Gg C yr}^{-1}$ in the Geum River and $0.1 \pm 0.7 \text{ Gg C yr}^{-1}$ in the Seomjin River. Accordingly, our study provides the first insight into the contribution of carbonate-derived DIC to riverine autochthonous POC in small temperate Korean river systems, dominated by silicate rocks.

2-14 *Geochemistry & Geophysics***Disequilibrium oxygen isotope distribution among aqueously altered minerals in Ryugu asteroid returned samples**

Kita, Noriko T., Kitajima, Kouki., Nagashima, Kazuhide., Kawasaki, Noriyuki., Sakamoto, Naoya., Fujiya, Wataru., 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., 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.

Meteoritics & Planetary Science. 2024. 59(8): 2097-2116.

doi: 10.1111/maps.14163.

Oxygen 3-isotope ratios of magnetite and carbonates in aqueously altered carbonaceous chondrites provide important clues to understanding the evolution of the fluid in the asteroidal parent bodies. We conducted oxygen 3-isotope analyses of magnetite, dolomite, and breunnerite in two sections of asteroid Ryugu returned samples, A0058 and C0002, using a secondary ion mass spectrometer (SIMS). Magnetite was analyzed by using a lower primary ion energy that reduced instrumental biases due to the crystal orientation effect. We found two groups of magnetite data identified from the SIMS pit morphologies: (1) higher $\delta^{18}\text{O}$ (from 3‰ to 7‰) and $\Delta^{17}\text{O}$ (~2‰) with porous SIMS pits mostly from spherulitic magnetite, and (2) lower $\delta^{18}\text{O}$ (~-3‰) and variable $\Delta^{17}\text{O}$ (0‰-2‰) mostly from euhedral magnetite. Dolomite and breunnerite analyses were conducted using multi-collection Faraday cup detectors with precisions $\leq 0.3\text{‰}$. The instrumental bias correction was applied based on carbonate compositions in two ways, using Fe and (Fe + Mn) contents, respectively, because Ryugu dolomite contains higher amounts of Mn than the terrestrial standard. Results of dolomite and breunnerite analyses show a narrow range of $\Delta^{17}\text{O}$; 0.0‰-0.3‰ for dolomite in A0058 and 0.2‰-0.8‰ for dolomite and breunnerite in C0002. The majority of breunnerite, including large $\geq 100\text{ }\mu\text{m}$ grains, show systematically lower $\delta^{18}\text{O}$ (~21‰) than dolomite (25‰-30‰ and 23‰-27‰ depending on the instrumental bias corrections). The equilibrium temperatures between magnetite and dolomite from the coarse-grained lithology in A0058 are calculated to be $51 \pm 11^\circ\text{C}$ and $78 \pm 14^\circ\text{C}$, depending on the instrumental bias correction scheme for

dolomite; a reliable temperature estimate would require a Mn-bearing dolomite standard to evaluate the instrumental bias corrections, which is not currently available. These results indicate that the oxygen isotope ratios of aqueous fluids in the Ryugu parent asteroid were isotopically heterogeneous, either spatially, or temporary. Initial water ice accreted to the Ryugu parent body might have $\Delta^{17}\text{O} > 2\text{‰}$ that was melted and interacted with anhydrous solids with the initial $\Delta^{17}\text{O} < 0\text{‰}$. In the early stage of aqueous alteration, spherulitic magnetite and calcite formed from aqueous fluid with $\Delta^{17}\text{O} \sim 2\text{‰}$ that was produced by isotope exchange between water ($\Delta^{17}\text{O} > 2\text{‰}$) and anhydrous solids ($\Delta^{17}\text{O} < 0\text{‰}$). Dolomite and breunnerite, along with some magnetite, formed at the later stage of aqueous alteration under higher water-to-rock ratios where the oxygen isotope ratios were nearly at equilibrium between fluid and solid phases. Including literature data, $\delta^{18}\text{O}$ of carbonates decreased in the order calcite, dolomite, and breunnerite, suggesting that the temperature of alteration might have increased with the degree of aqueous alteration.

2-15 *Geochemistry & Geophysics; Engineering, Electrical & Electronic; Remote Sensing; Imaging Science & Photographic Technology***Efficient Direct Envelope Inversion With Excitation Amplitude for Strong Velocity Contrast Model**

Lee, Dawoon., **Kang, Seung-Goo., Kim, Sumin.,** Kim, Young Seo. and Chung, Wookeon.

IEEE Transactions on Geoscience and Remote Sensing. 2024. 62.

doi: 10.1109/tgrs.2024.3422978.

Full waveform inversion (FWI) is a notable technique that provides high-resolution physical parameters of subsurface media. Although FWI is frequently employed to recover velocity models for relatively weak parameter perturbations, its effectiveness is limited by the lack of low-frequency information in the presence of strong parameter perturbations. To address this limitation, we propose to utilize direct envelope inversion (DEI), which highlights the low-frequency information contained within the seismic envelope data to successfully construct velocity models for strong parameter perturbations. However, conventional DEI requires envelope computation for the source wavefield, which limits the application of memory cost-reduction methods and significantly increases the computational time needed for the envelope. To mitigate these computational

challenges, we introduce excitation amplitude (ExA) as a means to reduce the computational cost associated with DEI. By utilizing only the most energetic amplitude and its arrival time at each grid point of the direct envelope virtual source field, this method can reduce the computational time and memory requirement while maintaining the accuracy of the DEI. In the numerical examples, we demonstrate that the proposed method overcomes the computational cost limitations of conventional DEI. Additionally, applying our method to field data acquired in the Arctic helped reconstruct strong scattering models for the subsea permafrost.

keywords:

Mathematical models; Data models; Computational modeling; Scattering; Imaging; Perturbation methods; Computational efficiency; Direct envelope inversion (DEI); excitation amplitude (ExA); scattering wavefield; subsea permafrost; velocity modeling

2-16 Geochemistry & Geophysics

Efficient extended least-squares reverse time migration based on an excitation amplitude imaging condition

Kim, Sumin., Kang, Seung-Goo., Choi, Yeonjin. and Chung, Wookeun.

Geophysics. 2024. 89(1): S31-S45.

doi: 10.1190/geo2023-0216.1.

In least-squares reverse time migration (LSRTM), which is typically an overdetermined linear inverse problem, the kinematic traveltime error from an inaccurate migration velocity leads to migration image degradation and slow convergence speed. Extended LSRTM (ELSRTM), with an extended imaging condition along the subsurface offset in LSRTM, can effectively mitigate sensitivity to the migration velocity accuracy by adding an extra dimension to the model space. However, for assembling migration images, large imaging condition operations that are proportional to the number of subsurface-offset bins hinder the practical application of ELSRTM. To address this computational problem in ELSRTM, we develop an efficient ELSRTM method based on a modified excitation amplitude (ExA) imaging condition. Furthermore, our ELSRTM method can correctly represent the forward source wavefield by convolving the source wavelet with the ExA. With the forward source wavefield represented this way, Born -modeled data can

be simulated efficiently. Thus, wavefield simulation for generating the forward source wavefield is implemented only once at the first iteration. Based on these computational advantages, our ELSRTM method becomes highly efficient. Synthetic data examples on a modified Marmousi2 velocity model demonstrate that our ELSRTM method produces an accurate migration image efficiently even if an inaccurate migration velocity is used. Field data acquired from the Chukchi Sea of the Arctic Ocean also are used to verify the practicality of our ELSRTM method.

2-17 Chemistry, Analytical

Electron microprobe dating of lunar zirconolite

Park, Changkun. and Kim, Hwayoung.

Journal of Analytical Science and Technology. 2024. 15(1).

doi: 10.1186/s40543-024-00431-7.

Zirconolite is an accessory mineral occurred in the lunar basaltic and granitic rocks and contains relatively high contents of U, Th, and Pb, which is attractive for age dating. However, very few studies have reported the crystallization ages of lunar zirconolites because of the challenge of dating lunar zirconolites due to their fine-grained size and irregular shape. In this study, we analyzed zirconolites in a granitic clast of the lunar meteorite DEW 12007 using an electron microprobe. MAN (mean atomic number) background, peak interference, and blank corrections were applied to 31 elements including U, Th, and Pb, and REEs, to obtain high-precision and high-accuracy chemical data of the zirconolites. The electron microprobe age of the zirconolites is determined to be 4332 ± 14 Ma (2σ , $n=20$), which is consistent with the U–Pb age (4340.9 ± 7.5 Ma; 2σ) of zircon grains from the same clast measured by an ion microprobe. The precision and accuracy achieved in this study represents a notable advance compared to previously reported electron microprobe ages of lunar zirconolites. This suggests that electron microprobe dating may be applicable to extraterrestrial materials, especially for microscopic U-Th-Pb-containing minerals in the samples returned from the Moon and Mars.

keywords:

Lunar zirconolite; U-Th-Pb dating; Electron microprobe; MAN background

2-18 *Geology*

Exploring electron backscatter diffraction analysis as a tool for understanding stromatolite: Quantitative description of Cretaceous lacustrine stromatolite reveals formative processes and high-resolution climatic cycles

Roda, Mar Simonet., **Kim, Daeyeong.** and 3 others.

Sedimentology. 2024. 71(7): 2448-2469.

doi: 10.1111/sed.13222.

Lacustrine stromatolites serve as important archives for recording environmental changes, and the detailed examination of their microfabrics is essential for understanding their formative processes and the environmental changes embedded within them. This study explored the application of Electron Backscatter Diffraction combined with Energy-Dispersive X-ray Spectroscopy to investigate a well-preserved middle Cretaceous lacustrine stromatolite from south-eastern Korea, unveiling ultra-high-resolution sedimentary processes that are often challenging to observe using conventional methods. Two types of microsparitic layers and one type of crystalline layer are distinguished based on their texture, crystal morphology and elemental composition. Both microsparitic layers are micrometre-thick and are characterized by poorly co-oriented calcite grains, but differ in their composition. Type 1 is depleted in magnesium but enriched in detrital elements such as silicon and aluminium, likely originating from the trapping and binding of detrital sediments on microbial mats during rainy seasons. In contrast, type 2 is enriched in magnesium but devoid of detrital elements, interpreted to have formed by the precipitation of calcium carbonate during dry seasons. The crystalline layers comprise fan-shaped calcite crystals (*ca* 500 μm in length) with radiating internal structures, with their *c*-axes oriented perpendicular to the stromatolite layers. These structures resemble those observed in some modern freshwater stromatolites, which are interpreted as imprints of cyanobacterial fascicles. While the cyclic occurrence of types 1 and 2 microsparitic layers might imply annual seasonal cycles, the less frequent crystalline layers are interpreted as a result of environmental changes occurring every 27 to 30 years. This is the first study to apply Electron Backscatter Diffraction to stromatolites, showcasing its potential in unravelling both the formative and diagenetic processes of ancient stromatolites.

keywords:

Cretaceous; EBSD; EDS; Korea; lacustrine carbonate; microbial carbonate; microbialite

2-19 *Engineering, Civil; Geosciences, Multidisciplinary; Water Resources*

Export of aged dissolved organic carbon to the Geum and Seomjin estuaries in South Korea

Kang, Sujin., **Kim, Jung-Hyun.**, Ryu, Jong-Sik. and Shin, Kyung-Hoon.

Journal of Hydrology. 2024. 632.

doi: 10.1016/j.jhydrol.2024.130659.

We investigated the source and reactivity of dissolved organic carbon (DOC) in two contrasting Korean estuaries: the Geum, a closed system with a dammed river mouth, and the Seomjin, an open estuary system. The average $\Delta^{14}\text{C}_{\text{DOC}}$ value in the Geum estuary ($-101.8 \pm 38.0 \text{ ‰}$) was higher than that in the Seomjin estuary ($-176.4 \pm 101.9 \text{ ‰}$). The depleted ^{14}C signal in the Seomjin estuary appears to be associated with a high average monthly Q90/Q50 ratio, which is an indicator of base water flow, and a low DOC:SB + ratio, which is an indicator of groundwater flow. This suggests that groundwater in the Seomjin watershed passed through a deeper soil column compared with the Geum watershed, transferring older DOC to the river during the base flow season and into the estuary. In contrast, the Geum estuary dam appears to be associated with higher $\Delta^{14}\text{C}_{\text{DOC}}$ and the export of younger DOC to the estuary due to enhanced primary productivity in the dam reservoir. Our results suggest that input of aged DOC derived from a deeper soil column influenced the estuarine DOC pool in the open Seomjin estuary, and this effect could be dampened by riverine DOC produced in the dam reservoir of the closed Geum estuary.

keywords:

Dissolved organic carbon; Estuary dam; Carbon isotopes; Closed estuary; Open estuary; Aged carbon export; Estuarine DOC

2-20 *Geosciences, Multidisciplinary; Meteorology & Atmospheric Sciences*

Fallacy of paleoproductivity signals by the recycled biogenic components: case study in the Central Basin of the northwestern Ross Sea

Khim, Boo-Keun., **Kim, Sunghan.**, Lee, Min Kyung., Sohn, Young Kwan., **Lee, Jae Il.** and **Yoo, Kyu-Cheul.**

Geoscience Letters. 2024. 11(1).

doi: 10.1186/s40562-024-00365-3.

Core LC42, retrieved from the Central Basin of the northwestern Ross Sea, contains three distinct sediment facies (IRD (ice-rafted debris)-poor bioturbated sandy mud, IRD-rich massive sandy mud, and laminated mud) that are interleaved with each other and deposited over the last 1 Ma. The biogenic components (biogenic opal, total organic carbon, and total nitrogen) of the laminated mud layers are consistently higher than the other two facies throughout the core. Based on the depositional succession of sediment facies and IRD-related depositional processes in the Antarctic continental margin, the laminated mud layers without IRD have been deposited during the glacial periods, but the enhanced paleoproductivity in terms of biogenic components during the mud deposition is unexpected. Backscattered electron imagery substantiates distinctly different componentry of the alternating light and dark laminae in the laminated mud. In particular, the light laminae contain scattered diatom fragments and eroded sand-sized lumps of fossil-bearing mud, whereas the dark laminae are clayey and diatomaceous. Both laminae thus are characterized by the high biogenic components, but they are interpreted to have been principally recycled from older deposits because diatom fragments are mostly reworked and old and their archives are poorly preserved. During the glacial periods, these laminated muds were deposited downward by milky plumes of meltwater discharged underneath the advancing glaciers that scoured the earlier-deposited and semi-consolidated diatom-rich sediments. Our study thus highlights that the recycling of biogenic particles should be pre-cautious to avoid the fallacy of paleoclimatic interpretation in formulating climate-productivity models in the Antarctic continental margin.

keywords:

Climate-productivity model; Antarctic continental margin; Biogenic components; Recycled diatoms; Ross Sea

2-21 Geosciences, Multidisciplinary

First multi-proxy chronostratigraphy of the lower Cambrian Byrd Group, Transantarctic Mountains and correlation within East Gondwana

Betts, Marissa J., Claybourn, Thomas M., Holmer, Lars E., Skovsted, Christian B., Myrow, Paul M., Stemmerik, Lars., Topper, Timothy P., Park, Tae-Yoon S., and 4 others.

Gondwana Research. 2024. 136: 126-141.

doi: 10.1016/j.gr.2024.07.022.

Antarctica and Australia were sutured together at the equator during the major pulse of animal biodiversification associated with the Cambrian radiation. However, the lack of detailed systematic chemostratigraphic and biostratigraphic sampling of lower Cambrian sedimentary successions from Antarctica has significantly impeded precise age determination and correlation with Cambrian strata on other palaeocontinents. This study is the first to present integrated, simultaneously sampled biostratigraphic and chemostratigraphic ($\delta^{13}\text{C}$ isotopes) data from the same measured stratigraphic sections through the lower Cambrian Byrd Group in the Transantarctic Mountains. Shelly fossil assemblages (brachiopods, tomotiids, molluscs, bradoriids, trilobites) from the Holyoake Range and Churchill Mountains facilitate direct correlation with the *Dailyatia odyssei* Zone of South Australia (Cambrian Stages 3–4), and trilobites provide strong correlation between the Starshot Formation and the Cymbric Vale Formation in western New South Wales. A new ID-TIMS radiometric date of 514.96 ± 0.16 Ma from a tuff in the lower Cymbric Vale Formation is similar to dates from tuff beds in the Third Plain Creek Member of the Mernmerna Formation in the Flinders Ranges, providing an important absolute-age tie point between these lower Cambrian successions. Chemostratigraphic data from the upper Shackleton Limestone in the Holyoake Range capture a negative $\delta^{13}\text{C}$ excursion that can be correlated to negative values within the multi-peaked MICE (cycles V–VIII in Siberia). Integrated faunal and chemostratigraphic data indicate a Cambrian Stages 3–4 age, giving robust chronostratigraphic context for the upper Shackleton Limestone–Holyoake Formation–Starshot Formation succession for the first time, permitting reconstruction of the depositional history of the lower Cambrian of Antarctica and global correlation of Byrd Group strata.

keywords:

Cambrian; Chronostratigraphy; Small shelly fossils; Correlation; Biostratigraphy; Isotope

2-22 Geochemistry & Geophysics

Grossite-bearing refractory inclusions from reduced CV chondrites: Mineralogical and oxygen isotopic constraints on the parent body alteration history

Han, Jangmi., Nagashima, Kazuhide., Park, Changkun., Krot, Alexander N. and Keller, Lindsay P.

Geochimica Et Cosmochimica Acta. 2024. 385: 100-117.

doi: 10.1016/j.gca.2024.09.001.

We report the results of coordinated mineralogical, microstructural, and oxygen isotopic analyses of grossite-bearing refractory inclusions from reduced CV (Vigarano type) chondrites to obtain a more complete picture of secondary parent body alteration processes and conditions. Grossite (CaAl_2O_7) occurs in cores of nodules in fine-grained Ca,Al-rich inclusions (CAIs) that likely represent aggregates of nebular condensates. In many occurrences, grossite has been partially replaced by hercynite $[(\text{Fe,Mg,Zn})\text{Al}_2\text{O}_4]$, which displays complex microstructures and compositions, and magnetite nanoparticles. The alteration of grossite was a crystallographically-controlled, fluid-driven process that occurred via partial dissolution of grossite and subsequent precipitation of hercynite and magnetite during short-lived and low-temperature metasomatic alteration on the CV chondrite parent body. The constituent phases of grossite-bearing CAIs show heterogeneous oxygen isotopic compositions, with grossite and perovskite displaying systematically ^{16}O -depleted compositions ($\Delta^{17}\text{O} = -12\text{‰}$ to -1‰) relative to uniformly ^{16}O -rich hibonite and spinel ($\Delta^{17}\text{O} = -25\text{‰}$ to -21‰). Melilite is variably ^{16}O -depleted ($\Delta^{17}\text{O} = -25\text{‰}$ to -2‰). The observed oxygen isotopic distribution is interpreted as a result of mineralogically controlled oxygen isotopic exchange with an ^{16}O -poor fluid on the CV chondrite parent body. Collectively, the presence of limited fluids played an important role in preferential alteration of grossite to hercynite and magnetite and various degrees of ^{16}O depletion in grossite, perovskite, and melilite during thermal metamorphism. We conclude that, among refractory phases in the inclusions, grossite was the most susceptible to metasomatic reactions with Fe-rich fluids and the second most susceptible, after perovskite, to oxygen isotopic exchange with an ^{16}O -poor fluid during the thermal history of the CV chondrite parent asteroid.

keywords:

Calcium-aluminum-rich inclusions; Grossite; Hercynite; Transmission electron microscopy; Oxygen isotopes

2-23 Environmental Sciences; Limnology; Water Resources

High-Resolution Terrestrial Water Storage Estimates From GRACE and Land Surface Models

Kim, Jae-Seung., Seo, Ki-Weon., Kim, Byeong-Hoon. and 3 others.
Water Resources Research. 2024. 60(2).
 doi: 10.1029/2023wr035483.

Terrestrial Water Storage (TWS) changes have been estimated at basin to continental scales from gravity variations using data from the Gravity Recovery and Climate Experiment (GRACE) satellites since 2002. The relatively low spatial resolution (~ 300 km) of GRACE observations has been a main limitation in such studies. Various data processing strategies, including mascons, forward modeling, and constrained linear deconvolution (CLD), have been employed to address this limitation. Here we develop a revised CLD method to obtain a TWS estimate that combines GRACE observations with much higher spatial resolution land surface models. The revised CLD constrains model estimates to agree with GRACE TWS when smoothed. As an example, we apply the method to obtain a high spatial resolution TWS estimate in Australia. We assess the accuracy of the approach using synthetic GRACE data.

keywords:

GRACE; land surface model; terrestrial water storage; high-resolution TWS

2-24 Geochemistry & Geophysics

Hydrogen in magnetite from asteroid Ryugu

Aleon, J., Mostefaoui, S., Bureau, H., Vangu, D., Khodja, H., Nagashima, K., Kawasaki, N., Abe, Y., Alexander, C. M. O'D., Amari, S., Amelin, Y., Bajo, K., 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., Ishikawa, A., Itoh, S., 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., Nguyen, A., Nittler, L. R., Onose, M., Pack, A., Park, Changkun. and 42 others.
Meteoritics & Planetary Science. 2024. 59(8): 2058-2072.
 doi: 10.1111/maps.14139.

In order to gain insights on the conditions of aqueous alteration on asteroid Ryugu and the origin of water in the outer solar system, we developed the measurement of water content in magnetite at the micrometer scale by secondary ion mass spectrometry (NanoSIMS) and determined the H and Si content of coarse-grained euhedral magnetite grains (polyhedral magnetite) and coarse-grained fibrous (spherulitic) magnetite from the Ryugu polished section A0058-C1001. The hydrogen content in magnetite ranges between ~ 900 and ~ 3300 wt ppm equivalent water and is correlated with the Si content. Polyhedral magnetite has low and homogenous silicon and water content, whereas

fibrous magnetite shows correlated Si and water excesses. These excesses can be explained by the presence of hydrous Si-rich amorphous nanoinclusions trapped during the precipitation of fibrous magnetite away from equilibrium and testify that fibrous magnetite formed from a hydrous gel with possibly more than 20 wt% water. An attempt to determine the water content in sub- μm framboids indicates that additional calibration and contamination issues must be addressed before a safe conclusion can be drawn, but hints at elevated water content as well. The high water content in fibrous magnetite, expected to be among the first minerals to crystallize at low water–rock ratio, points to the control of water content by local conditions of magnetite precipitation rather than large-scale alteration conditions. Systematic lithological variations associated with water-rich and water-poor magnetite suggest that the global context of alteration may be better understood if local water concentrations are compared with millimeter-scale distribution of the various morphologies of magnetite. Finally, the high water content in the magnetite precursor gel indicates that the initial O isotopic composition in alteration water must not have been very different from that of the earliest magnetite crystals.

2-25 Environmental Sciences; Marine & Freshwater Biology

Identifying the external N and Hg inputs to the estuary ecosystem based on the triple isotopic information ($\delta^{15}\text{N}_{\text{NO}_3}$, $\Delta^{17}\text{O}_{\text{NO}_3}$ and $\delta^{18}\text{O}_{\text{NO}_3}$)

Kim, Haryun., Kim, Hye Seon., Kim, Jihee., Yang, Dongwoo., Lee, Kitack., **Kim, Kitae.** and 12 others.

Marine Pollution Bulletin. 2024. 200.

doi: 10.1016/j.marpolbul.2024.116035.

The supply and sources of N and Hg in the Geum estuary of the western coast of Korea were evaluated. Triple isotope proxies ($\delta^{15}\text{N}_{\text{NO}_3}$, $\Delta^{17}\text{O}_{\text{NO}_3}$ and $\delta^{18}\text{O}_{\text{NO}_3}$) of NO_3^- combined with conservative mixing between river and ocean waters were used to improve isotope finger-printing methods. The N pool in the Geum estuary was primarily influenced by the Yellow Sea water, followed by riverine discharge ($821 \times 10^6 \text{ mol yr}^{-1}$) and atmospheric deposition ($51 \times 10^6 \text{ mol yr}^{-1}$). The influence of the river was found to be greater for Hg than that of the atmosphere. The triple isotope proxies revealed that the riverine and atmospheric inputs of N have been affected by septic wastes and fossil fuel burning, respectively. From the inner estuary towards offshore region, the influence of the river diminishes, thus increasing the relative impact of the atmosphere. Moreover,

the isotope proxies showed a significant influence of N assimilation in February and nitrification in May.

keywords:

Triple nitrogen isotope; Nitrogen; Mercury; Estuary

2-26 Geosciences, Multidisciplinary; Oceanography; Paleontology

Incorporation of Multi-Elements Into Diatom Frustules in the Scotia Sea, Antarctica, Since the Last Glacial Maximum

Kim, Sunghan., Kim, Bo Kyung., Yoo, Kyu-Cheul., Lee, Min Kyung., Lee, Jae Il., Kim, Sookwan. and Bak, Young-Suk.

Paleoceanography and Paleoclimatology. 2024. 39(7).

doi: 10.1029/2023pa004790.

The glacial-interglacial cycle of elements and the linkage with biological production is very important. Nonetheless, records on incorporation of elements into diatom frustules are very poor in the Southern Ocean where diatom productivity is very high. As a result, there is a big gap in our understanding of elemental cycles in association with biological production and the controlling mechanisms. Here, we documented concentrations of major, trace, and rare earth elements of diatom frustules in two cores collected from the Southern Ocean since the Last Glacial Maximum to understand changes of incorporation of these elements into diatom frustules and to investigate mechanisms for changing incorporation. We found that there are three types of glacial-interglacial variation patterns. Most elements showed increased (decreased) concentrations during the glacial period (interglacial) with decreased (increased) diatom production in the surface water following the variation pattern of magnetic susceptibility, whereas P, Ge, and Sb showed the opposite trend following the variation pattern of biogenic opal. Li, Ni, Ag, W, U, and I showed no clear glacial-interglacial variation pattern. These different variation patterns imply that elemental incorporation into diatom frustules are also different according to elements. Our results revealed that biologically mediated removal of most elements from surface water to deep-sea is comparable between glacial (low diatom production with high elements assimilation) and interglacial (high diatom production with low elements assimilation) periods in the Southern Ocean. However, more removal of P, Sb, and Ge in the surface water by diatoms occurs during interglacial periods in the Southern Ocean.

Concentrations of multi-elements within diatom frustules were documented from the Southern Ocean since the Last Glacial Maximum (LGM). Most elements were assimilated/incorporated into diatoms synchronously: high (low) during glacial (interglacial) periods. P, Ge, and Sb showed low incorporation into diatom frustules during the LGM but increased during the Holocene.

keywords:

Scotia Sea; diatom frustule; incorporation; element cycle; glacial-interglacial

2-27 *Geochemistry & Geophysics*

Maskelynite- as seen in shocked Lonar target basalt, India, and martian and lunar meteorites

Ray, Dwijesh., Misra, Saumitra., **Park, Changkun.**, Newsom, Horton E. and Peterson, Eric J.

Geochemistry. 2024. 84(2).

doi: 10.1016/j.chemer.2024.126127.

In this study, we investigate the mineralogical and petrochemical characteristics of maskelynite occurring in a shocked basalt boulder from a terrestrial impact crater on a basaltic target – the Lonar impact crater in India, and the martian and lunar meteorites. The majority of Lonar maskelynite experienced solid-state transformation and maintained almost a uniform chemical composition, consistent with the unshocked feldspar. The locally flow-like texture and marginal vesiculation in feldspathic glass are needed in interaction with the impact-melt. The vesiculated melt occasionally occurring at the margins of maskelynite is characterised by Na-loss due to the shock-induced volatility. A shock pressure of ≤ 42 GPa and at a temperature of ≤ 1000 °C appear consistent for the formation of Lonar vesiculated melt/ feldspathic glass. Under the impact-induced shock metamorphism, maskelynite samples from the moon retain both the crystalline and amorphous domains with a distinct chemical heterogeneity attributed to different shock metamorphism effects of the plagioclase. In contrast, the martian maskelynites exhibit a smooth, homogeneous composition. The estimated shock pressure is relatively higher at ~ 42 – 45 GPa based on experiments and models. The difference in Si/Al ratio in lunar (1–1.3) and martian maskelynite (1.5–1.9) suggests its inherent difference in composition of the crust, whereas the Lonar maskelynite shows overlapping composition with the martian maskelynite contending Lonar basalt as a potential

terrestrial analogue to the martian crust.

keywords:

Feldspar; Maskelynite; Lonar crater; Martian meteorite; Lunar meteorite

2-28 *Geosciences, Multidisciplinary*

Massive Ice Outcrops and Thermokarst Along the Arctic Shelf Edge: By-Products of Ongoing Groundwater Freezing and Thawing in the Sub-Surface

Paull, Charles K., **Hong, Jong Kuk.**, Caress, David W., Gwiazda, Roberto., Kim, Ji-Hoon., Lundsten, Eve., Paduan, Jennifer B., **Jin, Young Keun.**, Duchesne, Mathieu J., **Rhee, Tae Siek.**, and 3 others. *Journal of Geophysical Research-Earth Surface*. 2024. 129(10).

doi: 10.1029/2024jf007719.

Substantial seafloor morphological changes are rapidly occurring along the Canadian Arctic shelf edge. Five multibeam bathymetric mapping surveys, each partially covering a 15 km² study area between 120- and 200-m water depth, were conducted over a 12-year time period. These surveys reveal that 65 new craters have developed between 2010 and 2022, averaging 6.5 m and reaching up to 30 m deep. Remotely operated vehicle investigations revealed massive ice outcrops exposed on two newly formed crater flanks. This ice is not relict subaerially formed Pleistocene permafrost because it is hosted in sediments which were deposited in a submarine setting post-deglaciation. Low salinity porewater and sediment core ice samples with depleted oxygen isotopic compositions indicate waters with a meteoric signature are discharging and freezing in this area. These ascending brackish groundwaters are likely derived in part from thawed relict permafrost hundreds of meters under the continental shelf. They refreeze as they approach the -1.4 °C seafloor, leading to the development of widespread, near seafloor, sub-bottom ice layers. Conditions appropriate for ice melting also exist nearby where ice is exposed to seawater or warmed by ascending groundwater. Small variations in temperature and salinity lead to shifts between freezing of ascending brackish groundwater or melting of near seafloor ice layers. These conditions have produced a dramatic submarine thermokarst morphology riddled with multi-aged depressions. Thermokarst geohazards may exist, unmapped, on other Arctic margins with groundwater channeled toward the shelf edge by a relict permafrost cap, and sufficiently cold shelf edge bottom

water temperatures.

keywords:

submarine permafrost; repeat mapping; Arctic seafloor; submarine thermokarst; geohazards; Beaufort shelf

2-29 Geochemistry & Geophysics

Melt-Rock Reaction in the Lower Oceanic Crust and the Influence on the Evolution of Mid-Ocean Ridge Basalts at the Central Indian Ridge (7°50'–8°30'S)

Choi, Sarang., Park, Jung-Woo., Kim, Jonguk., Oh, Jihye., **Park, Changkun.** and **Han, Seunghee.**

Journal of Petrology. 2024. 65(6).

doi: 10.1093/petrology/egae057.

Various crustal processes shape both the lower oceanic crust and mid-ocean ridge basalts (MORBs). To better understand how these crustal processes influence MORB compositions, we conducted comprehensive petrographic and geochemical investigations on gabbroic rocks and erupted lavas dredged from a segment of the Central Indian Ridge (CIR) spanning from 7°50'S to 8°30'S. The petrographic and geochemical analyses of the gabbroic rocks revealed evidence of melt-rock reaction through reactive porous flow in olivine gabbro and gabbro. This process resulted in distinctive features in clinopyroxene, including disequilibrium textures with a troctolite/anorthosite matrix, complex variations in Mg#–Cr–Ti [Mg# = molar Mg/(Mg + Fe²⁺)] relationships, and considerable enrichment and fractionation of incompatible trace elements. A significant finding of our study is the close resemblance of trace element ratios in MORB and olivine-hosted melt inclusions to those of melts in equilibrium with clinopyroxene from olivine gabbro and gabbro with Sr anomaly ($Sr/Sr^* = Sr_N / \sqrt{Pr_N \cdot Nd_N}$; N refers to chondrite-normalized values) greater than ~0.7. This observation strongly indicates that the composition of MORB is influenced by the melt-rock reaction taking place in the lower oceanic crust. Furthermore, our findings suggest that evolved melts in equilibrium with clinopyroxene having Sr/Sr* values lower than ~0.7 are less likely to erupt onto the seafloor and are instead trapped within the lower oceanic crust. Oxide gabbro is characterized by coarse-granular, pegmatitic textures and exhibits mineralogically and chemically more evolved characteristics compared to olivine gabbro and gabbro. It is inferred that the oxide gabbro formed through the *in situ* freezing of highly

evolved melts within a melt-rich layer. Finally, we present a comprehensive model for melt evolution in the lower oceanic crust at the 7°50'S–8°30'S CIR by integrating all petrological and geochemical data obtained from gabbroic rocks, MORB, and olivine-hosted melt inclusions. This holistic model contributes to a better understanding of the intricate processes governing MORB composition in the context of the lower oceanic crust dynamics at slow-spreading ridges.

keywords:

melt-rock reaction; lower oceanic crust; gabbro; mid-ocean ridge basalt; Central Indian Ridge

2-30 Geochemistry & Geophysics

Microbially-mediated reductive dissolution of Fe-bearing minerals during freeze-thaw cycles

Kim, Jinwook., Park, Young Kyu., Koo, Tae-hee., Jung, Jaewoo., Kang, Insung., **Kim, Kitae.**, Park, Hanbeom., **Yoo, Kyu-Cheul.**, Rosenheim, Brad E. and Conway, Tim M.

Geochimica Et Cosmochimica Acta. 2024. 376: 134–143.

doi: 10.1016/j.gca.2024.05.015.

Constraining the role of microbes in the structural iron (Fe) reduction of iron-bearing minerals improves our understanding of sediments and ice sheets as a source of dissolved Fe (dFe) to the oceans. However, bio-mediated structural Fe-reduction has yet to be studied in cryospheric environments. Here, we show that the Fe reducing psychrophile bacterium *Shewanella vesiculosa*, isolated from sea ice in Antarctica, reduced structural Fe in nontronite (NAu-2) and maghemite ($\gamma\text{-Fe}_2\text{O}_3$), common mineral phases in glacial ice, and marine sediments in Antarctica, during two freeze–thaw cycles (–10 °C to +15 °C), resulting in the release of dFe. The modification of turbostratically disordered nontronite (ferric iron dominant phase) to discrete ordered illite-like structure (ferrous iron dominant phase), and the aggregation of altered small maghemite particles with neoformation of vivianite ($\text{Fe}_3(\text{PO}_4)_2 \cdot n\text{H}_2\text{O}$) indicated the microbially induced reductive dissolution of nontronite and maghemite, respectively. The biotic Fe-reduction gradually decreased and ceased as the temperature approached freezing (–8 °C), however the reaction reactivated in the thawing cycle (–7 to +15 °C). No discernable biotic Fe-reduction was measured for either mineral under freezing conditions, suggesting that temperature limits the activity of the microbes. Further, and regardless of temperatures during two freeze–thaw

cycles, Fe-reduction was not observed in abiotic control. Overall, these results highlight the importance of microbially induced Fe reduction during seasonal freeze–thaw cycles of ice and sediments in continuously supplying bioavailable dFe to cryospheric environments and the often Fe-limited polar oceans.

keywords:

Freeze–thaw cycle; Nontronite (NAu-2); Microbial iron reduction; Psychrophile; Cryosphere; Dissolved Fe

2-31 *Geosciences, Multidisciplinary*

Monitoring activity in Mount Melbourne, Antarctica, by multi-temporal SAR interferometry based on the ICOPS algorithm

Hakim, Wahyu L., Sakina, Raisa N., Fadhillah, Muhammad F., Lee, Seulki., Park, Sungjae., **Kim, Hyun-Cheol.** and Lee, Chang-Wook.
Geosciences Journal. 2024. 28(4): 527-538.

doi: 10.1007/s12303-024-0021-5.

Monitoring active volcanoes is necessary to analyze their current status to pose a mitigation hazard. Mount Melbourne is an active volcano that has erupted in the past, and future eruptions are possible. This condition could threaten future eruptions, particularly near scientific bases. Jang Bogo, a South Korean research station, is located only 30 km from the summit and could be affected by significant ash fallout in case of an explosive eruption. This condition leads to the necessity of observing Mount Melbourne's activity frequently. This study used Sentinel-1 SAR data acquired from 2017 to 2024 to monitor the volcanic activity of Mount Melbourne by utilizing InSAR multitemporal time-series analysis implementing the improved combined scatterers interferometry with optimized point scatterers (ICOPS) method. The ICOPS method combined persistent scatterer (PS) and distributed scatterer (DS) with measurement point (MP) optimization based on convolutional neural network (CNN) and optimized hot spot analysis (OHSA). The ICOPS measurement results maintain reliable MP along the Mount Melbourne summit and around Jang Bogo station. The absence of GPS stations around these two areas makes it difficult to validate the result with the ground truth measurement, so the comparison with another method, small baseline (SBAS) measurement, is made to evaluate the reliability of the ICOPS measurement points. The comparison between the MP from ICOPS and the SBAS methods shows a good correlation with R^2 of about 0.8134 in the Melbourne

area and 0.8678 in the Jang Bogo area. The selected time-series plot around the summit of Mount Melbourne and the Jang Bogo area shows a stable trend of surface deformation. Thus, a total accumulated deformation of around 0.82 cm and an average deformation of about 0.10 cm/year was found around Mount Melbourne. Meanwhile, the Jang Bogo area exhibits a total deformation of about 0.15 cm with an average deformation of about 0.02. Overall, this research is a preliminary study of the ability of the ICOPS algorithm to monitor volcanic activity in snow-covered areas.

keywords:

Mount Melbourne; Jang Bogo; InSAR; ICOPS; time-series

2-32 *Geochemistry & Geophysics*

Neodymium-142 deficits and samarium neutron stratigraphy of C-type asteroid (162173) Ryugu

Torrano, Zachary A., Jordan, Michelle K., Mock, Timothy D., Carlson, Richard W., Gautam, Ikshu., Haba, Makiko K., Yokoyama, Tetsuya., Abe, Yoshinari., Aleon, Jerome., Alexander, Conel., Amari, Sachiko., Amelin, Yuri., Bajo, Ken-ichi., Bizzarro, Martin., Bouvier, Audrey., Chaussidon, Marc., Choi, Byeon-Gak., Dauphas, Nicolas., Davis, Andrew M., Di Rocco, Tommaso., Fujiya, Wataru., Fukai, Ryota., Hibiya, Yuki., Hidaka, Hiroshi., Homma, Hisashi., Hoppe, Peter., Huss, Gary R., Ichida, Kiyohiro., Iizuka, Tsuyoshi., Ireland, Trevor., Ishikawa, Akira., Itoh, Shoichi., Kawasaki, Noriyuki., Kita, Noriko T., Kitajima, Koki., 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., Nguyen, Ann., Nittler, Larry., Onose, Morihiko., Pack, Andreas., **Park, Changkun,** and 41 others.

Meteoritics & Planetary Science. 2024. 59(8): 1966-1982.

doi: 10.1111/maps.14109.

We report Nd and Sm isotopic compositions of four samples of Ryugu returned by the Hayabusa2 mission, including “A” (first touchdown) and “C” (second touchdown) samples, and several carbonaceous chondrites to evaluate potential genetic relationships between Ryugu and known chondrite groups and track the cosmic ray exposure history of Ryugu. We resolved Nd and Sm isotopic anomalies in small (<20 ng Nd and Sm) sample sizes via thermal ionization mass spectrometer using $10^{13} \Omega$ amplifiers. Ryugu samples exhibit resolvable negative $\mu^{142}\text{Nd}$ values consistent with carbonaceous chondrite values, suggesting that Ryugu is related to the parent bodies of carbonaceous

chondrites. Ryugu's negative $\mu^{149}\text{Sm}$ values are the result of exposure to galactic cosmic rays, as demonstrated by the correlation between $^{150}\text{Sm}/^{152}\text{Sm}$ and $^{149}\text{Sm}/^{152}\text{Sm}$ ratios that fall along the expected neutron capture correlation line. The neutron fluence calculated in the "A" samples ($2.75 \pm 1.94 \times 10^{15} \text{ n cm}^{-2}$) is slightly higher compared to the "C" samples ($0.95 \pm 2.04 \times 10^{15} \text{ n cm}^{-2}$), though overlapping within measurement uncertainty. The Sm results for Ryugu, at this level of precision, thus are consistent with a well-mixed surface layer at least to the depths from which the "A" and "C" samples derive.

2-33 Astronomy & Astrophysics

Pervasive aqueous alteration in the early Solar System revealed by potassium isotopic variations in Ryugu samples and carbonaceous chondrites

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

Icarus. 2024. 409.

doi: 10.1016/j.icarus.2023.115884.

C-type asteroids are the presumed home to carbonaceous chondrites, some of which contain abundant life-forming volatiles and organics. For the first time, samples from a C-type asteroid (162173 Ryugu) were successfully returned to Earth by JAXA's Hayabusa2 mission. These pristine samples, uncontaminated by the terrestrial environment, allow a direct comparison with carbonaceous chondrites. This study reports the stable K isotopic compositions (expressed as $\delta^{41}\text{K}$) of Ryugu samples and seven carbonaceous chondrites to constrain the origin of K isotopic variations in the early Solar System. Three aliquots of Ryugu particles collected at two touchdown sites have identical $\delta^{41}\text{K}$ values, averaged

at $-0.194 \pm 0.038\text{‰}$ (2SD). The K isotopic composition of Ryugu falls within the range of $\delta^{41}\text{K}$ values measured on representative CI chondrites, and together, they define an average $\delta^{41}\text{K}$ value of $-0.185 \pm 0.078\text{‰}$ (2SE), which provides the current best estimate of the K isotopic composition of the bulk Solar System. Samples of CI chondrites with $\delta^{41}\text{K}$ values that deviate from this range likely reflect terrestrial contaminations or compositional heterogeneities at sampled sizes. In addition to CI chondrites, substantial K isotopic variability is observed in other carbonaceous chondrites and within individual chondritic groups, with $\delta^{41}\text{K}$ values inversely correlated with K abundances in many cases. These observations indicate widespread fluid activity occurred in chondrite parent bodies, which significantly altered the original K abundances and isotopic compositions of chondrules and matrices established at their accretion.

keywords:

Asteroid Ryugu; Hayabusa2 mission; Carbonaceous chondrites; Stable potassium isotopes; Aqueous alteration

2-34 Geosciences, Multidisciplinary

Petrography and classification of Elephant Moraine 14017 (EET 14017): a new primitive LL3.05 ordinary chondrite from Antarctica

Park, Changkun., Park, Sun Young., **Kim, Hwayoung.** and **Lee, Jong Ik.**

Episodes. 2024. 47(3): 465-476.

doi: 10.18814/epiugs/2024/02403s11.

The mineralogy and petrography of EET 14017 were studied using optical microscope, scanning electron microscope, electron microprobe, and micro-Raman. The mineral chemistry of olivine, pyroxene, plagioclase, spinel, and Fe-Ni metal in EET 14017 is comparable to that of previously studied L/LL3.0x chondrites. In particular, the Cr_2O_3 content in the ferroan chondrule olivine and the excess silica component, $[\text{Si}_4\text{O}_8]$, in the plagioclase lead us to conclude that EET 14017 belongs to subtype 3.05. Raman spectral data of carbonaceous matter from the matrix of EET 14017 suggest a higher degree of thermal metamorphism, probably due to terrestrial weathering in Antarctica. EET 14017 and some of the other L/LL3.0x chondrites from the EET region are possibly a pair, since they have similar Cr_2O_3 contents of ferroan chondrule olivines and Raman spectral data, and moreover they were also found in a

restricted region of the blue ice field. The plagioclase in some chondrules is a late crystal phase in the chondrule melt, which may constrain the timing of chondrule formation and cooling rate. If more L/LL3.0x chondrites like EET 14017 from Antarctica are identified, they would be excellent source material for studying the early evolution of the Solar System.

2-35 Geochemistry & Geophysics

Pyrrhotites in asteroid 162173 Ryugu: Records of the initial changes on their surfaces with aqueous alteration

Yui, Hiroharu., Urashima, Shu-hei., Onose, Morihiko., Morita, Mayu., Komatani, Shintaro., Nakai, Izumi., Abe, Yoshinari., Terada, Yasuko., Homma, Hisashi., Motomura, Kazuko., Ichida, Kiyohiro., Yokoyama, Tetsuya., Nagashima, Kazuhide., 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., Fujiya, Wataru., Fukai, Ryota., Gautam, Ikshu., Haba, Makiko K., Hibiya, Yuki., Hidaka, Hiroshi., Hoppe, Peter., Huss, Gary R., Iizuka, Tsuyoshi., Ireland, Trevor R., Ishikawa, Akira., Itoh, Shoichi., Kawasaki, Noriyuki., Kita, Noriko T., Kitajima, Kouki., Kleine, Thorsten., Krot, Sasha., Liu, Ming-Chang., Masuda, Yuki., Moynier, Frederic., Nguyen, Ann., Nittler, Larry., Pack, Andreas., **Park, Changkun.** and 40 others.

Geochimica Et Cosmochimica Acta. 2024. 379: 172-183.

doi: 10.1016/j.gca.2024.06.016.

The surface chemistry of pyrrhotites from intact particles directly collected from asteroid (162173) Ryugu was investigated by micro-Raman spectroscopy. The Raman peak characteristic to pyrrhotite was observed at around 115 cm^{-1} in Ryugu pyrrhotites, similar to freshly cleaved surfaces of terrestrial pyrrhotites. Additional Raman bands centered at around 220, 275, and 313 cm^{-1} with broadened features were also detected from the Ryugu pyrrhotites. The set of Raman bands at 220 and 275 cm^{-1} was assigned to typical Fe-S stretching vibrations of ν_2 (225 cm^{-1}) and ν_1 (275 cm^{-1}). These bands are not clearly observed in bulk crystals of pyrrhotite but appear in its nanoparticulate phase. These bands are ordinarily seen in amorphous monosulfides that formed under low oxygen fugacity (fO_2) conditions in nature, indicating that the structural alteration of pyrrhotite surfaces occurred heterogeneously on the nanoscale under low fO_2 conditions. Further, the Raman band at 313 cm^{-1} was attributed to a characteristic tetrahedral bonding of Fe(III) in the lattice of $\text{Fe}_{1-3x}^{\text{II}}\text{Fe}_{1-2x}^{\text{III}}\text{S}$, followed by the local breakdown of the crystal

lattice structures from planar bonding with Fe(II). In addition, some areas of the Ryugu pyrrhotite grains showed corroded structures with iridescence. Furthermore, assemblages of magnetite particles were also preferentially observed on small areas of the likely-dissolved pyrrhotite crystals in phyllosilicate matrices. These characteristic features in the Raman spectra and in corroded structures of Ryugu pyrrhotites record changes in the local environmental conditions via aqueous alteration. The corrosion of pyrrhotite crystals followed by the preferential formation of magnetite particles by asteroidal water is the likely product of dissolution of Fe(II) from the pyrrhotite surface and its oxidative precipitation in microchemical environments on the Ryugu parent body.

keywords:

Ryugu; Pyrrhotite; Aqueous alteration; Magnetite

2-36 Geography, Physical; Geosciences, Multidisciplinary

Seafloor geomorphology of the Wrigley Gulf shelf, Amundsen Sea, West Antarctica, reveals two different phases of glaciation

Lee, Jae Il., Hillenbrand, Claus-Dieter., Wellner, Julia S., **Kim, Hyoung Jun.**, Rhee, Hyun Hee., **Yoo, Kyu-Cheul.**, **Kim, Sunghan.** and **Lee, Min Kyung.**

Earth Surface Processes and Landforms. 2024. 49(10): 2901-2913.

doi: 10.1002/esp.5865.

Knowledge of the behaviour of marine-based ice sheets during times of climatic warming, such as the last deglaciation, provides important information to understand how ice sheets respond to external forcing. We analysed swath bathymetric and acoustic sub-bottom profiler data from Wrigley Gulf on the western Amundsen Sea shelf, West Antarctica, to identify glacial features and reconstruct past changes in the extent of the West Antarctic Ice Sheet (WAIS) and ice flow directions. Glacial bedforms mapped within a bathymetric cross-shelf trough include features showing cross-cutting and overprinting relationship and indicate changes in ice-flow orientation. Here, we distinguish at least two phases of different ice-flow patterns on the Wrigley Gulf shelf. During the earlier phase, seaward ice stream flow on the inner shelf was deflected towards the east due to the existence of an ice dome on the middle-outer continental shelf. Retreat of grounded ice towards the centre of this dome is indicated by the asymmetric cross profile of recessional moraines mapped on the middle shelf.

The later glaciation phase was characterized by fast, NNW-directed ice flow across the shelf along a broad front and subsequent stepwise landward retreat, which is evident from the common occurrence and orientation of mega-scale glaciation lineations and grounding zone wedges on the middle-inner shelf. It is uncertain whether the two phases of glaciation recorded on the seafloor occurred during the last and penultimate glacial periods or at different times of the last glaciation. Reliable chronological constraints from sediment cores and additional geomorphological information are needed to understand the cause of the changes in WAIS dynamics reflected by the two ice-flow phases.

keywords:

bathymetry; Getz ice shelf; glacial geomorphology; ice flow change; West Antarctic ice sheet

2-37 Mineralogy

Sedimentary protolith and high-*P* metamorphism of oxidized manganiferous quartzite from the Lanterman Range, northern Victoria Land, Antarctica

Kim, Taehwan., Kim, Yoonsup., Tumiat, Simone., Kim, Daeyeong., Yi, Keewook. and Lee, Mi Jung.

European Journal of Mineralogy. 2024. 36(2): 323-343.

doi: 10.5194/ejm-36-323-2024.

We investigated the mineral assemblage, mineral and bulk-rock chemistry, and zircon U–Pb age of a manganiferous quartzite layer in the Lanterman Range, northern Victoria Land, Antarctica. The mineral assemblage consists primarily of phengite and quartz, along with spessartine-rich garnet, Mn³⁺ and rare earth element–yttrium (REY)-zoned epidote-group minerals, and titanohematite. Mineral inclusions such as tephroite, rutile and pyrophanite are hosted in porphyroblasts of the latter three minerals and suggest prograde blueschist-facies to low-*T* eclogite-facies metamorphism (*M*₁). Epidote-group minerals commonly exhibit multiple growth zones of piemontite and/or epidote (*M*₁), REY-rich piemontite (*M*₂), REY-rich epidote (*M*₃), and epidote (*M*₄) from core to rim. Pseudobinary *fO*₂–*X* diagrams at constant *P*–*T* support the stability of an epidote-group mineral-bearing assemblage under highly oxidized conditions during prograde *M*₂ to peak *M*₃ metamorphism. In marked contrast, tephroite-bearing assemblages (*M*₁) are limited to relatively reduced environments and Mn-

rich, silica-deficient bulk-rock compositions. Mn nodules have such characteristics, and the contribution of this hydrogenous component is inferred from bulk-rock chemical features such as a strong positive Ce anomaly. The major-element composition of the manganiferous quartzite suggests a protolith primarily consisting of a mixture of chert and pelagic clay. The presence of rare detrital zircons supports terrigenous input from a craton and constrains the maximum time of deposition to be ca. 546 Ma. The lack of arc-derived detrital zircons in the quartzite and the predominance of siliciclastic metasedimentary rocks among the surrounding rocks suggest that the deep-sea protolith was most likely deposited in an arc/back-arc setting at a continental margin. High-*P* metamorphism associated with terrane accretion during the Ross orogeny took place in the middle Cambrian (ca. 506 Ma), broadly coeval with the metamorphic peak recorded in the associated high-*P* rocks such as mafic eclogites. Finally, it is noteworthy that the high-*P* manganiferous quartzite was amenable to exhumation because the paleo-position of the protolith was likely distal from the leading edge of the downgoing slab.

2-38 Environmental Sciences; Geosciences, Multidisciplinary; Remote Sensing; Imaging Science & Photographic Technology

Seismic Imaging of the Arctic Subsea Permafrost Using a Least-Squares Reverse Time Migration Method

Kim, Sumin., Kang, Seung-Goo., Choi, Yeonjin., Hong, Jong-Kuk. and Kwak, Joonyoung.

Remote Sensing. 2024. 16(18).

doi: 10.3390/rs16183425.

High-resolution seismic imaging allows for the better interpretation of subsurface geological structures. In this study, we employ least-squares reverse time migration (LSRTM) as a seismic imaging method to delineate the subsurface geological structures from the field dataset for understanding the status of Arctic subsea permafrost structures, which is pertinent to global warming issues. The subsea permafrost structures in the Arctic continental shelf, located just below the seafloor at a shallow water depth, have an abnormally high P-wave velocity. These structural conditions create internal multiples and noise in seismic data, making it challenging to perform seismic imaging and construct a seismic P-wave velocity model using conventional methods. LSRTM offers a promising approach

by addressing these challenges through linearized inverse problems, aiming to achieve high-resolution, subsurface imaging by optimizing the misfit between the predicted and the observed seismic data. Synthetic experiments, encompassing various subsea permafrost structures and seismic survey configurations, were conducted to investigate the feasibility of LSRTM for imaging the Arctic subsea permafrost from the acquired seismic field dataset, and the possibility of the seismic imaging of the subsea permafrost was confirmed through these synthetic numerical experiments. Furthermore, we applied the LSRTM method to the seismic data acquired in the Canadian Beaufort Sea (CBS) and generated a seismic image depicting the subsea permafrost structures in the Arctic region.

keywords:

seismic imaging; subsea permafrost; least-squares reverse time migration

energy transmission efficiency. These high-quality seismic data enabled precise delineation of the subglacial lake's size, structural features, and underlying sedimentary layers, thereby providing critical information for selecting optimal sites for further hot-water drilling. This dataset establishes foundational resources for Antarctic subglacial lake research and will support future studies on subglacial lake dynamics and structural analyses across Antarctica.

keywords:

Subglacial Lake; Seismic Survey; Crevasse; Signal-to-Noise Ratio; Multi-Fold; Georod; Hot-Water Drilling

2-39 Engineering

Seismic Survey for the Subglacial Lake in Antarctica

Ju, Hyeontae., Choi, Yeonjin. and Kang, Seung Goo.

Geophysics and Geophysical Exploration. 2024. 27(4): 244-257.

doi: 10.7582/GGE.2024.27.4.244.

The Korea Polar Research Institute (KOPRI) conducted Korea's first seismic survey of an Antarctic glacier to investigate the size and subsurface structure of subglacial lake D2 beneath the David Glacier. The initial seismic survey was conducted during the 2019-2020 Antarctic summer season, utilizing infrastructure from the Jang Bogo Station and the Korean inland route (K-Route). This survey confirmed the existence of a subglacial lake and provided comprehensive data for preliminary structural analysis. Based on these findings, a second seismic survey was conducted during the summer of 2021-2022. In this survey, we employed a methodology to address the environmental challenges of the Antarctic inland ice sheet and to enhance detection resolution for subglacial lake sedimentary structures. In the second survey, the explosive charge was increased from 400 g to 1,600 g, the number of rod-type receiver channels was expanded from 48 to 96 channels, and the fold number was increased from 1 to 4 or 8, improving data quality and clarity. In addition, 25-30 m hot-water drilling was used to position explosives within the boreholes, which were then allowed to freeze solidly to maximize

2-40 Resources Engineering

Single-Channel Seismic Data Processing via Singular Spectrum Analysis

Woodon, Jeong., Lee, Chanhee. and Kang, Seung-Goo.

Geophysics and Geophysical Exploration. 2024. 27(2): 91-107.

doi: 10.7582/GGE.2024.27.2.091

Single-channel seismic exploration has proven effective in delineating subsurface geological structures using small-scale survey systems. The seismic data acquired through zero- or near-offset methods directly capture subsurface features along the vertical axis, facilitating the construction of corresponding seismic sections. However, substantial noise in single-channel seismic data hampers precise interpretation because of the low signal-to-noise ratio. This study introduces a novel approach that integrate noise reduction and signal enhancement via matrix rank optimization to address this issue. Unlike conventional rank-reduction methods, which retain selected singular values to mitigate random noise, our method optimizes the entire singular value spectrum, thus effectively tackling both random and erratic noises commonly found in environments with low signal-to-noise ratio. Additionally, to enhance the horizontal continuity of seismic events and mitigate signal loss during noise reduction, we introduced an adaptive weighting factor computed from the eigenimage of the seismic section. To access the robustness of the proposed method, we conducted numerical experiments using single-channel Sparker seismic data from the Chukchi Plateau in the Arctic Ocean. The results demonstrated that the seismic sections had significantly improved signal-to-noise ratios and minimal signal loss. These advancements hold promise for enhancing single-channel and high-resolution seismic surveys and aiding in the identification of marine

development and submarine geological hazards in domestic coastal areas.

keywords:

Single channel seismic survey; Seismic data processing; Denoising; Singular spectrum analysis

2-41 Multidisciplinary Sciences

Swirls and scoops: Ice base melt revealed by multibeam imagery of an Antarctic ice shelf

Wahlin, Anna., Alley, Karen E., Begeman, Carolyn., Hegrenaes, Oyvind., Yuan, Xiaohan., Graham, Alastair G. C., Hogan, Kelly., Davis, Peter E. D., Dotto, Tiago S., **Eayrs, Clare.**, Hall, Robert A., Holland, David M., **Kim, Tae Wan.** and 13 others.

Science Advances. 2024. 10(31).

doi: 10.1126/sciadv.adn9188.

Knowledge gaps about how the ocean melts Antarctica's ice shelves, borne from a lack of observations, lead to large uncertainties in sea level predictions. Using high-resolution maps of the underside of Dotson Ice Shelf, West Antarctica, we reveal the imprint that ice shelf basal melting leaves on the ice. Convection and intermittent warm water intrusions form widespread terraced features through slow melting in quiescent areas, while shear-driven turbulence rapidly melts smooth, eroded topographies in outflow areas, as well as enigmatic teardrop-shaped indentations that result from boundary-layer flow rotation. Full-thickness ice fractures, with bases modified by basal melting and convective processes, are observed throughout the area. This new wealth of processes, all active under a single ice shelf, must be considered to accurately predict future Antarctic ice shelf melt.

2-42 Multidisciplinary Sciences

Tectonic trigger to the first major extinction of the Phanerozoic: The early Cambrian Sinsk event

Myrow, Paul M., Goodge, John W., Brock, Glenn A., Betts, Marissa J., **Park, Tae-Yoon S.**, Hughes, Nigel C. and Gaines, Robert R.

Science Advances. 2024. 10(13).

doi: 10.1126/sciadv.adl3452.

The Cambrian explosion, one of the most consequential biological revolutions in Earth history, occurred in two phases separated by the Sinsk event, the first major extinction of the Phanerozoic. Trilobite fossil data show that Series 2 strata in the Ross Orogen, Antarctica, and Delamerian Orogen, Australia, record nearly identical and synchronous tectono-sedimentary shifts marking the Sinsk event. These resulted from an abrupt pulse of contractional supracrustal deformation on both continents during the *Pararaia janeae* trilobite Zone. The Sinsk event extinction was triggered by initial Ross/Delamerian supracrustal contraction along the edge of Gondwana, which caused a cascading series of geodynamic, paleoenvironmental, and biotic changes, including (i) loss of shallow marine carbonate habitats along the Gondwanan margin; (ii) tectonic transformation to extensional tectonics within the Gondwanan interior; (iii) extrusion of the Kalkarindji large igneous province; (iv) release of large volumes of volcanic gasses; and (v) rapid climatic change, including incursions of marine anoxic waters and collapse of shallow marine ecosystems.

2-43 Geography, Physical; Geosciences, Multidisciplinary

The complex basal morphology and ice dynamics of the Nansen Ice Shelf, East Antarctica

Dow, Christine F., Mueller, Derek., Wray, Peter., Friedrichs, Drew., Forrest, Alexander L., McInerney, Jasmin B., Greenbaum, Jamin., Blankenship, Donald D., **Lee, Choon-Ki.** and **Lee, Won Sang.**

Cryosphere. 2024. 18(3): 1105-1123.

doi: 10.5194/tc-18-1105-2024.

Ice shelf dynamics and morphology play an important role in the stability of floating bodies of ice by driving fracturing that can lead to calving, in turn impacting the ability of the ice shelf to buttress upstream grounded ice. Following a 2016 calving event at the Nansen Ice Shelf (NIS), East Antarctica, we collected airborne and ground-based radar data to map ice thickness across the shelf. We combine these data with published satellite-derived data to examine the spatial variations in ice shelf draft, the cause and effects of ice shelf strain rates, and the possibility that a suture zone may be channelizing ocean water and altering patterns of sub-ice-shelf melt and freeze-on. We also use our datasets to assess limitations that may arise from relying on hydrostatic-balance equations applied to ice surface elevation to determine ice draft morphology. We find that the Nansen Ice Shelf has a highly variable basal morphology driven primarily

by the formation of basal fractures near the onset of the ice shelf suture zone. This morphology is reflected in the ice shelf strain rates but not in the calculated hydrostatic-balance thickness, which underestimates the scale of variability at the ice shelf base. Enhanced melt rates near the ice shelf terminus and in steep regions of the channelized suture zone, along with relatively thin ice in the suture zone, appear to represent vulnerable areas in the NIS. This morphology, combined with ice dynamics, induce strain that has led to the formation of transverse fractures within the suture zone, resulting in large-scale calving events. Similar transverse fractures at other Antarctic ice shelves may also be driven by highly variable morphology, and predicting their formation and evolution could aid projections of ice shelf stability.

2-44 Multidisciplinary Sciences

The Ni isotopic composition of Ryugu reveals a common accretion region for carbonaceous chondrites

Spitzer, Fridolin., Kleine, Thorsten., Burkhardt, Christoph., Hopp, Timo., Yokoyama, Tetsuya., 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., Itoh, Shoichi., Kawasaki, Noriyuki., Kita, Noriko T., Kitajima, Kouki., Komatani, Shintaro., Krot, Alexander N., Liu, Ming-Chang., Masuda, Yuki., Morita, Mayu., Moynier, Frederic., Motomura, Kazuko., Nakai, Izumi., Nagashima, Kazuhide., Nguyen, Ann., Nittler, Larry., Onose, Morihiko., Pack, Andreas., **Park, Changkun.** and 41 others.

Science Advances. 2024. 10(39).

doi: 10.1126/sciadv.adp2426.

The isotopic compositions of samples returned from Cb-type asteroid Ryugu and Ivuna-type (CI) chondrites are distinct from other carbonaceous chondrites, which has led to the suggestion that Ryugu/CI chondrites formed in a different region of the accretion disk, possibly around the orbits of Uranus and Neptune. We show that, like for Fe, Ryugu and CI chondrites also have indistinguishable Ni isotope anomalies, which differ from those of other carbonaceous chondrites. We propose that this unique Fe and Ni isotopic composition reflects different accretion efficiencies of small FeNi metal grains among the carbonaceous chondrite

parent bodies. The CI chondrites incorporated these grains more efficiently, possibly because they formed at the end of the disk's lifetime, when planetesimal formation was also triggered by photoevaporation of the disk. Isotopic variations among carbonaceous chondrites may thus reflect fractionation of distinct dust components from a common reservoir, implying CI chondrites/Ryugu may have formed in the same region of the accretion disk as other carbonaceous chondrites.

2-45 Chemistry, Multidisciplinary; Geochemistry & Geophysics

Theoretical Insights into Gas Migration Within Ice on Earth and Icy Celestial Bodies

Yi, Yoo Soo. and **Han, Yeongcheol.**

Acc Earth and Space Chemistry. 2024. 8(12): 2611-2620.

doi: 10.1021/acsearthspacechem.4c00266.

Atmospheric gases trapped in icy environments, such as Earth's polar regions and Jupiter's moon Europa, offer a unique opportunity to explore paleoclimate and astrogeological history. While previous studies have addressed the diffusive behaviors of these gases and their implications for paleoclimatological and geochronological reconstructions, the underlying mechanisms of gas migration in ice remain largely unexplored. Achieving an atomistic-level understanding of gas migration is therefore essential for improving our knowledge of the long-term behavior of gases in icy environments. In this study, we investigated the migration of noble gases encapsulated in isolated air bubbles within bulk ice using density functional theory calculations. We focused on both the dissolution at the gas-ice interface and the subsequent molecular diffusion through the ice lattice. Our results show that energy barriers for dissolution and molecular diffusion increase almost linearly with atomic size, leading to nonlinear, exponential-like decreases in solubility and diffusivity, due to their Arrhenius behavior in relation to the corresponding energy barriers. These energy barriers primarily arise from the structural distortions in the ice lattice, as it accommodates noble gas atoms. Additionally, our findings indicate that dissolution is energetically both more demanding and slower than molecular diffusion, making it the rate-limiting step in gas migration through ice. These findings provide valuable insights into gas migration and fractionation mechanisms in Earth's polar ice, highlighting the importance of incorporating atomic-level interactions into geochronological models. By deepening

our fundamental understanding of gas mobility, this work not only advances methodologies for analyzing Earth's ice but also broadens our perspective on extraterrestrial icy environments, with potential implications for the search for life-supporting conditions beyond Earth.

keywords:

gas migration in ice; paleoclimatology; geochronology; noble gas; age dating; density functional theory

2-46 Multidisciplinary Sciences

Time-series InSAR measurement using ICOPS and estimation of along-track surface deformation using MAI during the 2021 eruption of Fagradalsfjall Volcano, Iceland

Hakim, Wahyu Luqmanul., Fadhillah, Muhammad Fulki., Lee, Seulki., Park, Sungjae., Baek, Won-Kyung., Hong, Chang-Ki., **Kim, Hyun-Cheol.** and Lee, Chang-Wook.

Scientific Reports. 2024. 14(1).

doi: 10.1038/s41598-024-79128-1.

The eruption in Fagradalsfjall Volcano, located in Reykjanes Peninsula, Iceland, from several centuries' dormant states, occurred for the first time on March 19, 2021. Observations of Fagradalsfjall Volcano were conducted in 2021, and the eruption period lasted for six months until 18 September 2021. Six days pair of interferograms were generated from ninety synthetic aperture radar (SAR) data. Thus, the SAR data will be acquired from the Sentinel-1 satellite from January until December 2021. Time-series measurements were conducted using a combination of persistent scatterer (PS) and distributed scatterer (DS) points to produce denser measurement points (MPs) in the study area. The improved combined scatterers interferometry with optimized point scatterers (ICOPS) algorithm is the time-series method that utilizes both PS and DS MPs and optimizes those combined MPs using a deep learning algorithm over different temporal intervals and using a statistical clustering approach to optimize the MPs spatially. Validation was conducted by comparing the ICOPS result with GPS measurement in Reykjavik. The comparison with the GPS measurement was performed to validate the line-of-sight (LOS) deformation from the ICOPS measurement, which resulted in an RMSE value of about 0.58 cm, which is considered a good correlation. Besides the time-series Interferometry SAR (InSAR) measurement, we used the integrated InSAR and multiple aperture interferometry (MAI)

methods to estimate both LOS and along-track surface deformation, respectively, during the Fagradalsfjall, Iceland volcanic eruption. A pair of ALOS-2 data was used between 28 February 2021 and 23 May 2021. The result from the MAI method shows a deformation of approximately ± 2 mm in the azimuth direction around Fagradalsfjall Volcano. The deformation around Fagradalsfjall Volcano was suggested to be due to the activity of the magma reservoir beneath the Earth's surface, which was formed by dike intrusion. The analysis of the seismicity in Fagradalsfjall was discussed by visualization of the distribution of earthquakes during the deformation occurrence. Further analysis can be conducted by applying multitrack analysis to find the 3D deformation pattern due to the eruption.

2-47 Environmental Sciences; Geosciences, Multidisciplinary; Meteorology & Atmospheric Sciences

Unraveling Environmental Forces Shaping Surface Sediment Geochemical "Isodrapes" in the East Asian Marginal Seas

Paradis, Sarah., Diesing, Markus., Gies, Hannah., Haghipour, Negar., Narman, Lena., Magill, Clayton., Wagner, Thomas., Galy, Valier V., Hou, Pengfei., Zhao, Meixun., **Kim, Jung-Hyun.** and 8 others.

Global Biogeochemical Cycles. 2024. 38(4).

doi: 10.1029/2023gb007839.

As major sites of carbon burial and remineralization, continental margins are key components of the global carbon cycle. However, heterogeneous sources of organic matter (OM) and depositional environments lead to complex spatial patterns in sedimentary organic carbon (OC) content and composition. To better constrain the processes that control OM cycling, we focus on the East Asian marginal seas as a model system, where we compiled extensive data on the OC content, bulk isotopic composition ($\delta^{13}\text{C}$ and $\Delta^{14}\text{C}$), total nitrogen, and mineral surface area of surficial sediments from previous studies and new measurements. We developed a spatial machine learning modeling framework to predict the spatial distribution of these parameters and identify regions where sediments with similar geochemical signatures drape the seafloor (i.e., "isodrapes"). We demonstrate that both provenance (44%–77%) and hydrodynamic processes (22%–53%) govern the fate of OM in this margin. Hydrodynamic processes can either promote the degradation of OM in mobile mud-belts or preserve it in stable mud-deposits. The distinct isotopic composition of OC sources from marine productivity and individual rivers regulates the age and

reactivity of OM deposited on the sea-floor. The East Asian marginal seas can be separated into three main *isodrapes*: hydrodynamically energetic shelves with coarser-grained sediment depleted in OC, OM-enriched mud deposits, and a deep basin with fine-grained sediments and aged OC affected by long oxygen exposure times and petrogenic input from rivers. This study confirms that both hydrodynamic processes and provenance should be accounted for to understand the fate of OC in continental margins.

keywords:

organic matter; radiocarbon; stable isotopes; organo-mineral interactions; surface sediment; machine learning

2-48 *Paleontology*

**Virtual taphonomy of trilobite heads:
understanding compressive deformation using
3D modeling and rigid body simulation**

Jung, Jikhan., Park, Tae-Yoon S. and Hughes, Nigel C.

Journal of Paleontology. 2024. 98(4): 720-731.

doi: 10.1017/jpa.2024.18.

Shape deformation during fossilization can prevent accurate reconstruction of an organism's form during life, hampering areas of paleontology ranging from functional morphology to systematics. Retrodeformation attempts to restore the original shape of deformed fossil specimens and requires an adequate knowledge of the deformation process. Although tectonic processes and retrodeformation are relatively well understood, research on quantifying the effect of compressive deformation on fossil morphology is scant. Here we investigate the factors that can cause changes in the shape of fossil specimens during compressive deformation. Three-dimensional (3D) models of trilobite cranidia/cephala are subjected to simulated deposition and compaction using rigid body simulation and scaling features of the open-source 3D software Blender. The variation in pitch and roll angle is lowest on flat surfaces, intermediate on tilted surfaces, and highest on irregular surfaces. These trends are reflected in the morphological differences captured by principal component scores in geometric morphometric analyses using landmarks. In addition, the different shapes of trilobite cranidia/cephala according to their systematic affinity influence the degree of angular variation, which in turn affects their posture—normal or inverted. Inverted cranidia/cephala show greater morphological variability than those with normal postures.

Part 3.

Marine Sciences

3-1 Multidisciplinary Sciences

A position and wave spectra dataset of Marginal Ice Zone dynamics collected around Svalbard in 2022 and 2023

Rabault, Jean., Taelman, Catherine., Idzanovic, Martina., Hope, Gaute., Nose, Takehiko., Kristoffersen, Yngve., Jensen, Atle., Breivik, Oyvind., Bryhni, Helge Thomas., Hoppmann, Mario., Demchev, Denis., Korosov, Anton., Johansson, Malin., Eltoft, Torborn., Dagestad, Knut-Frode., Rohrs, Johannes., Eriksson, Leif., Moro, Marina Duran., Rikardsen, Edel S. U., Waseda, Takuji., Kodaira, Tsubasa., Lohse, Johannes., Desjonqueres, Thibault., Olsen, Sveinung., Gundersen, Olav., de Aguiar, Victor Cesar Martins., Karlsen, Truls., Babanin, Alexander., Voermans, Joey., **Park, Jeong-Won.** and Muller, Malte.
Scientific Data. 2024. 11(1).
 doi: 10.1038/s41597-024-04281-1.

Sea ice is a key element of the global Earth system, with a major impact on global climate and regional weather. Unfortunately, accurate sea ice modeling is challenging due to the diversity and complexity of underlying physics happening there, and a relative lack of ground truth observations. This is especially true for the Marginal Ice Zone (MIZ), which is the area where sea ice is affected by incoming ocean waves. Waves contribute to making the area dynamic, and due to the low survival time of the buoys deployed there, the MIZ is challenging to monitor. In 2022-2023, we released 79 OpenMetBuoys (OMBs) around Svalbard, both in the MIZ and the ocean immediately outside of it. OMBs are affordable enough to be deployed in large number, and gather information about drift (GNSS position) and waves (1-dimensional elevation spectrum). This provides data focusing on the area around Svalbard with unprecedented spatial and temporal resolution. We expect that this will allow to perform validation and calibration of ice models and remote sensing algorithms.

3-2 Fishery Science

A study on the multi-frequency acoustic target strength of krill using a stochastic distorted-wave born approximation (SDWBA) model

Son, Wuju., Oh, Wooseok., **La, Hyoung Sul.** and Lee, Kyounghoon.
Fisheries and Aquatic Sciences. 2024. 27(4): 225-230.
 doi: 10.47853/FAS.2024.e22

We examined the dB difference in target strength at multiple frequencies (ΔTS) for the identification of Antarctic krill (*Euphausia superba*) and ice krill (*Euphausia crystallorophias*) using a stochastic distorted-wave Born approximation model. Our investigation focused on ΔTS patterns at multiple frequencies in relation to size, along with key acoustic properties influencing TS, including density and sound speed contrast, fatness, and orientation. The findings revealed that the orientation and fatness significantly affect the ΔTS patterns. The results provide insight into the importance of the multi-frequency technique for estimating krill biomass and their ecological interactions with environmental features in the Southern Ocean.

keywords:

Antarctic krill; Ice krill; Multi-frequency acoustics; Target strength; Stochastic distorted-wave Born approximation (SDWBA) model

3-3 Multidisciplinary Sciences

Amundsen Sea circulation controls bottom upwelling and Antarctic Pine Island and Thwaites ice shelf melting

Park, Taewook., Nakayama, Yoshihiro. and Nam, Sunghyun.
Nature Communications. 2024. 15(1).
 doi: 10.1038/s41467-024-47084-z.

The Pine Island and Thwaites Ice Shelves (PIIS/TIS) in the Amundsen Sea are melting rapidly and impacting global sea levels. The thermocline depth (TD) variability, the interface between cold Winter Water and warm modified Circumpolar Deep Water (mCDW), at the PIIS/TIS front strongly correlates with basal melt rates, but the drivers of its interannual variability remain uncertain. Here, using an ocean model, we propose that the strength of the eastern Amundsen Sea on-shelf circulation primarily controls

TD variability and consequent PIIS/TIS melt rates. The TD variability occurs because the on-shelf circulation meanders following the submarine glacial trough, creating vertical velocity through bottom Ekman dynamics. We suggest that a strong or weak ocean circulation, possibly linked to remote winds in the Bellingshausen Sea, generates corresponding changes in bottom Ekman convergence, which modulates mCDW upwelling and TD variability. We show that interannual variability of off-shelf zonal winds has a minor effect on ocean heat intrusion into PIIS/TIS cavities, contrary to the widely accepted concept.

3-4 Oceanography

Benthic Foraminiferal Assemblages as Indicators of Recent Environmental Conditions in the Northeastern East Siberian Sea

Ovsepyan, E. A., Ovsepyan, Ya S., Mitrofanova, N. O., Korsun, S. A., Rhee, Tae Siek. and Jin, Young Keun.

Oceanology. 2024. 64(5): 695-707.

doi: 10.1134/s0001437024700371.

Quantitative analyses of the species composition and abundance of benthic foraminifers in surface sediments along a submeridional profile in the northeastern East Siberian Sea have revealed three assemblages associated with the middle-outer shelf and upper and middle continental slope. The maximum abundance of “living” benthic foraminifers is found near the shelf break, which is possibly related to enhanced sea surface bioproductivity. Active dissolution of calcareous microfossils has been detected in the shelf area whereas preservation of calcareous tests becomes better with depth. Some micropaleontological and grain-size data indirectly point to the development of compensatory currents on the middle-outer shelf in the East Siberian Sea.

keywords:

Rose Bengal; preservation; living and dead foraminifera; dissolution; shelf; continental slope; upwelling; compensatory currents; Arctic

Biological and paleoceanographic controls on the postglacial sulfur isotope records in Arctic shelf sediments

Moon, Jonghan., Oh, Eunje., Kim, Ji-Hoon., Nam, Seung-Il., Joo, Joung Ji. and Sim, Min Sub.

Palaeogeography Palaeoclimatology Palaeoecology. 2024. 646.

doi: 10.1016/j.palaeo.2024.112240.

The Arctic Ocean has experienced environmental fluctuations during the Pleistocene glacial-interglacial cycles. Since the last deglaciation, the reinundation of the Bering Strait and regional transgression have led to dramatic changes in the western Arctic Ocean, affecting coastal landscapes, depositional processes, marine ecosystem, and, inherently, biogeochemical element cycles. Here, we investigate the records of sulfur, carbon, and iron cycles in the Chukchi Sea of the western Arctic, with a primary focus on microbial sulfate reduction and subsequent pyrite formation. Variations in the pyrite abundance and sulfur isotopic composition, derived from a 10-m sediment core, demonstrate that dynamic changes in the factors governing pyrite formation – organic electron donor, reactive iron, and sulfate – are closely linked to the regional environmental conditions. In the early Holocene sediment, pyrite precipitation was impeded by the lack of organic matter, even in the presence of abundant sulfate and reactive iron. In the overlying sediment, pyrite contents increased due to vigorous microbial sulfate reduction fueled by enhanced availability of organic substrate and additional methane from the sulfate-methane transition zone. In general, the increased supply of organic matter to the Chukchi Shelf sediments can be attributed to the resumed inflow of nutrient-rich Pacific Water through the flooded Bering Strait. The increase in pyrite content, however, does not correlate exactly with either the increase in TOC or the opening of the Bering Strait, both of which precede the increased pyrite formation. These lags reflect the balance between marine primary production and terrestrial carbon sources, as well as the balance between the Pacific Inflow and the Beaufort Gyre. While a comparable increase in pyrite and TOC contents during the Holocene deglaciation has also been reported in the Black and Baltic Sea sediments, their distinct sulfur isotope records, contingent upon the availability of sulfate and reactive iron, highlight that pyrite can serve as a valuable proxy for tracking past climate and environmental change, especially in barren sedimentary records such as those found in the Arctic Ocean.

keywords:

Sulfur isotopes; Pyrite; Microbial sulfate reduction; Chukchi Shelf; Sea -level rise; Deglacial warming

3-5 Geography, Physical; Geosciences, Multidisciplinary; Paleontology

3-6 Geosciences, Multidisciplinary; Marine & Freshwater Biology; Oceanography

Characterization of pelagic communities in the Pacific sector of the Arctic Ocean using a broadband acoustic system, net samplers, and optical instruments

Kang, Myounghee., Adrianus, Aldwin., Cho, Kyoung-Ho., Kim, Jee-Hoon., Son, Wuju., Yoo, Jaeill., Yang, Eun Jin. and La, Hyoung Sul. *Journal of Marine Systems*. 2024. 244.
doi: 10.1016/j.jmarsys.2024.103976.

Rising Arctic temperatures are causing substantial declines in sea ice, altering ice retreat and formation in the Pacific Arctic and impacting marine communities. Despite the significant challenges facing the Pacific Arctic, there are still gaps in our understanding of the environmental impacts on pelagic communities, particularly sound scattering layers (SSLs), and their distributions in the southern Chukchi Sea (SCS), northern Chukchi Sea (NCS), and East Siberian Sea (ESS). This study utilized a wideband autonomous transceiver, net samplers, and optical instruments to explore SSLs in the Pacific Arctic, detailing their relationships with hydrographic properties. The findings indicated a greater vertical distribution of pelagic communities in the SCS than in the NCS and ESS. Significant differences in frequency spectra patterns were observed between the SCS and both the NCS and the ESS, though not between the NCS and the ESS. The correlations between the broadband acoustic and hydrographic values were generally weak to moderate. Elevated acoustic values in the SCS were linked to higher water temperature, dissolved oxygen, and chlorophyll and lower salinity. This study also revealed the behavioral properties of individual pelagic animals and identified Ctenophores and Copepods as the most abundant classes based on camera images and net samples. This research offers crucial insights into the distribution and interactions of pelagic communities with environmental factors, laying the groundwork for understanding climate change impacts. Additionally, this paper presents the first findings of frequency spectra from a broadband system in the Arctic Ocean.

keywords:

Broadband echosounder; Frequency spectra; Arctic Ocean; Camera; Bongo net

3-7 Chemistry, Medicinal; Pharmacology & Pharmacy

Characterization of Phytoplankton-Derived Amino Acids and Tracing the Source of Organic Carbon Using Stable Isotopes in the Amundsen Sea

Min, Jun-Oh., Kim, Min-Seob., Lee, Boyeon., Gal, Jong-Ku., Jung, Jinyoung., Kim, Tae-Wan., Park, Jisoo. and Ha, Sun-Yong. *Marine Drugs*. 2024. 22(10).
doi: 10.3390/md22100476.

We utilized amino acid (AA) and carbon stable isotope analyses to characterize phytoplankton-derived organic matter (OM) and trace the sources of organic carbon in the Amundsen Sea. Carbon isotope ratios of particulate organic carbon ($\delta^{13}\text{C}$ -POC) range from -28.7‰ to -23.1‰ , indicating that particulate organic matter originated primarily from phytoplankton. The dissolved organic carbon isotope ($\delta^{13}\text{C}$ -DOC) signature (-27.1 to -21.0‰) observed in the sea-ice melting system suggests that meltwater contributes to the DOC supply of the Amundsen Sea together with OM produced by phytoplankton. A negative correlation between the degradation index and $\delta^{13}\text{C}$ -POC indicates that the quality of OM significantly influences isotopic fractionation ($r^2 = 0.59$, $p < 0.001$). The AA distribution in the Amundsen Sea ($5.43 \pm 3.19 \mu\text{M}$) was significantly larger than previously reported in the Southern Ocean and was associated with phytoplankton biomass ($r^2 = 0.49$, $p < 0.01$). Under conditions dominated by *P. antarctica* ($\text{DI} = 2.29 \pm 2.30$), OM exhibited greater lability compared to conditions co-dominated by diatoms and *D. speculum* ($\text{DI} = 0.04 \pm 3.64$). These results highlight the important role of *P. antarctica* in influencing the properties of OM, suggesting potential impacts on carbon cycling and microbial metabolic activity in the Amundsen Sea.

keywords:

Amundsen Sea; antarctica; amino acid; *P. antarctica*; stable isotope

3-8 Chemistry, Multidisciplinary; Oceanography

Contrasting optical properties of dissolved organic matter between oceanic regions near the Getz and Dotson ice shelves in the Amundsen Sea, West Antarctica

Son, Juyoung., Jung, Jinyoung., Lee, Youngju., Kim, Tae-Wan., Park,

Jisoo, Jeon, Mi Hae. and Park, Mi Ok.

Marine Chemistry. 2024. 258.

doi: 10.1016/j.marchem.2023.104335.

The Amundsen Sea, located in West Antarctica, is experiencing rapid melting due to the intrusion of Circumpolar Deep Water, which is causing ice sheet thinning and basal melting. The resulting changes can affect the biogeochemical cycle of dissolved organic matter (DOM) by supplying iron from sea ice and/or glacier, thereby influencing primary production and ocean circulation. Therefore, it is crucial to understand the dynamics of the DOM in this region. In this study, our primary focus was to examine the optical properties of DOM in the oceanic regions adjacent to the West Getz Ice Shelf (WGIS) and the Dotson Ice Shelf (DIS). Significant differences in DOM optical properties, including the chromophoric DOM (CDOM) absorption coefficient at 350 nm (a_{350}), spectral slope coefficient ($S_{275-295}$), and specific UV absorbance at 254 nm ($SUVA_{254}$), were observed between the WGIS and DIS regions (t -test, $p < 0.05$). Notably, the WGIS regions exhibited high a_{350} values. Additionally, the $S_{275-295}$ and $SUVA_{254}$ values, which serve as indices of molecular weight, indicated that the DOM pool in the WGIS regions was dominated by high molecular weight compounds with a substantial proportion of aromatic compounds. In contrast, the low values of a_{350} and $SUVA_{254}$ along with the high $S_{275-295}$ values in the DIS region suggested the dominance of low molecular weight CDOM associated with compounds of lower aromaticity. Furthermore, significant negative correlations were found between biomass of *Phaeocystis antarctica* (*P. antarctica*) and phosphate (PO_4) in the WGIS regions ($r^2 = 0.82$, $p < 0.01$ for WGIS 1 and $r^2 = 0.73$, $p < 0.01$ for WGIS 2). However, no significant relationship was observed in the DIS region. These findings suggest that the high value and molecular weight of a_{350} , extending from the surface layer to the deep layer, in the WGIS regions were associated with autochthonous sources, primarily driven by the colony-forming bloom of *P. antarctica*. These findings demonstrate that the quantity and quality of DOM in the Amundsen Sea are strongly affected by bloom conditions. The results emphasize that a combination of physical and biological processes interacts in complex ways to determine the characteristics of DOM in the Amundsen Sea.

keywords:

Amundsen Sea; Getz ice shelf; Dotson ice shelf; Chromophoric dissolved organic matter; Fluorescent dissolved organic matter; Circumpolar deep water

Cross-shelf processes of terrigenous organic matter drive mercury speciation on the east siberian shelf in the Arctic Ocean

Kim, Jihee., Soerensen, Anne L., Jeong, Hakwon., Jeong, Seorin., Kim, Eunsuk., Lee, Yung Mi., Jin, Young Keun., Rhee, Tae Siek., Hong, Jong Kuk. and Han, Seunghee.

Environmental Pollution. 2024. 343.

doi: 10.1016/j.envpol.2023.123270.

The cross-shelf distributions of total mercury (THg), methylmercury (MeHg) and organic and inorganic matter, as well as the presence of the *hgcA* gene were investigated on the East Siberian Shelf (ESS) to understand the processes underlying the speciation of sedimentary Hg. Samples were collected from 12 stations grouped into four zones based on water depth: inner shelf (5 stations), mid-shelf (3 stations), outer shelf (2 stations), and slope (2 stations). The THg concentration in the surface sediment increased from the inner shelf ($0.25 \pm 0.023 \text{ nmol g}^{-1}$) toward the slope (0.52 nmol g^{-1}), and, when normalized to total organic carbon content, the THg showed a positive correlation with the clay-to-sand ratio ($r^2 = 0.48$, $p = 0.012$) and degree of chemical weathering ($r^2 = 0.79$, $p = 0.0001$). The highest MeHg concentrations ($3.0 \pm 1.8 \text{ pmol g}^{-1}$), as well as peaks in the S/C ratio (0.012 ± 0.002) of sediment-leached organic matter, were found on the mid-shelf, suggesting that the activities of sulfate reducers control the net Hg(II) methylation rates in the sediment. This was supported by results from a principal component analysis (PCA) performed with Hg species concentrations and sediment-leached organic matter compositions. The site-specific variation in MeHg showed the highest similarity with that of CHONS compounds in the PCA, where *Deltaproteobacteria* were projected to be putative Hg(II) methylators in the gene analysis. In summary, the hydrodynamic sorting of lithogenic particles appears to govern the cross-shelf distribution of THg, and in situ methylation is considered a major source of MeHg in the ESS sediment.

keywords:

Arctic shelf; East Siberian shelf; Mercury methylation; *hgcA* gene; Deltaproteobacteria

3-10 Oceanography

Development and Assessment of LSTM Model for Correcting Underestimation of Water Temperature in Korean Marine Heatwave Prediction System

Im, Na Kyoung., Jin, Hyunkun., Pak, Gyundo., Park, Young Gyu., Kim, Kyeong Ok., **Choi, Yonghan.** and Kim, Young ho.

The Sea Journal of the Korean Society of Oceanography. 29(2): 101-115.

doi: 10.7850/jkso.2024.29.2.101.

The ocean heatwave is emerging as a major issue due to global warming, posing a direct threat to marine ecosystems and humanity through decreased food resources and reduced carbon absorption capacity of the oceans. Consequently, the prediction of ocean heatwaves in the vicinity of the Korean Peninsula is becoming increasingly important for marine environmental monitoring and management. In this study, an LSTM model was developed to improve the underestimated prediction of ocean heatwaves caused by the coarse vertical grid system of the Korean Peninsula Ocean Prediction System. Based on the results of ocean heatwave predictions for the Korean Peninsula conducted in 2023, as well as those generated by the LSTM model, the performance of heatwave predictions in the East Sea, Yellow Sea, and South Sea areas surrounding the Korean Peninsula was evaluated. The LSTM model developed in this study significantly improved the prediction performance of sea surface temperatures during periods of temperature increase in all three regions. However, its effectiveness in improving prediction performance during periods of temperature decrease or before temperature rise initiation was limited. This demonstrates the potential of the LSTM model to address the underestimated prediction of ocean heatwaves caused by the coarse vertical grid system during periods of enhanced stratification. It is anticipated that the utility of data-driven artificial intelligence models will expand in the future to improve the prediction performance of dynamical models or even replace them.

keywords:

Marine heatwave; Machine learning; Artificial intelligence; LSTM

3-11 Marine & Freshwater Biology; Oceanography

Different amino acid compositions and food quality of particulate organic matter driven by

two major phytoplankton groups in the Ross Sea

Kim, Jaesoon., Jo, Naeun., **Park, Jisoo.** Kim, Kwanwoo., Park, Sanghoon., Kim, Yejin., Kim, Jaehong., Kim, Bo Kyung., **Lee, Boyeon.** and Lee, Sang Heon.

Journal of Sea Research. 2024. 201.

doi: 10.1016/j.seares.2024.102524.

Understanding the amino acid (AA) composition of phytoplankton-derived particulate organic matter (POM) is crucial for unraveling phytoplankton physiology and assessing food quality. This study investigated AA compositions and food quality of POM associated with two phytoplankton groups in the Ross Sea polynya. The *Phaeocystis antarctica* (*P. antarctica*)-predominant group, with *P. antarctica* overwhelmingly contributing to its composition, demonstrated a fresh state and heightened physiological activity. In contrast, the *P. antarctica* and diatoms-mixed group exhibited superior essential amino acids (EAAs) contributions and a higher EAA index (EAAI), indicating enhanced food quality. Dissimilarity Index values provided nuanced insights into degradation stages not captured by other indices. Despite lower physiological activity, diatoms in the mixed group stood out as crucial sources of high-quality nutrition for higher trophic levels in the Ross Sea polynya. The observed variations in AA compositions not only reflected the phytoplankton community structure but also provided insights into their physiological conditions. Given the ongoing climate-induced environmental changes potentially influencing phytoplankton communities, this study underscores the potential impacts on the intricate food web dynamics in the Ross Sea polynya. The assessment of AA composition emerged as a valuable tool for understanding the ecological implications for higher trophic levels in this polar region.

keywords:

Particulate organic matter; Phytoplankton; Amino acid composition; Food quality; Ross Sea polynya; Antarctica

3-12 Marine & Freshwater Biology; Oceanography

Dynamics of Carbon Export and Lower Trophic Ecosystems: A Comparative Model Study in the Yellow Sea and Dokdo Waters

Kwon, Young Shin. and 3 others.

Ocean Science Journal. 2024. 59(4).

doi: 10.1007/s12601-024-00180-z.

This study employs a sophisticated ecosystem modeling approach, specifically the European Regional Seas Ecosystem Model (ERSEM) coupled with the General Ocean Turbulence Model (GOTM), to conduct a comparative analysis of the pelagic ecosystem dynamics in the Yellow Sea and the waters surrounding Dokdo in the East Sea. Our research focuses on the complexities of carbon flux mechanisms within these ecosystems, emphasizing lower trophic levels and their roles in carbon export dynamics. Key findings reveal substantial differences in primary productivity, particulate organic carbon (POC) fluxes, and the timing of biological events between these two distinct marine environments. The Yellow Sea is characterized by significant stratification and lower light penetration, resulting in a condensed period of primary productivity, while the Dokdo waters benefit from clearer conditions that facilitate earlier and more sustained phytoplankton blooms. These disparities are critical for understanding the foundation of higher trophic levels and the efficiency of carbon export mechanisms. Our study underscores the profound impact of benthic-pelagic coupling, particularly in the Yellow Sea, highlighting the need for an integrated approach in marine ecosystem research. Through this comparative analysis, we advocate for enhanced monitoring and predictive modeling of shelf sea ecosystems to better understand their responses to environmental changes and to accurately forecast future dynamics.

keywords:

Marine ecosystem modeling; Primary productivity; Benthic-pelagic interactions; Carbon cycling; Phytoplankton phenology

extracted from airgun sounds received in the East Siberian Sea. The seismic survey was conducted in September 2019 by the icebreaking research vessel R/V Araon, operated by the Korea Polar Research Institute. A single hydrophone was moored at the East Siberian Shelf, characterized by nearly range-independent shallow water (<70 m) with a hard bottom. In the spectrogram of the received sounds, the dispersion curves of the first two modes were clearly observed. Utilizing a combination of warping transform and wavelet synchrosqueezing transform these two modes were separated. Then, the geoacoustic parameters, such as sound speed and density in the sediment layer, were estimated by comparing the two modal curves extracted at a source-receiver distance of approximately 18.6 km with the predictions obtained by the KRAKEN normal-mode propagation model. Subsequently, the distances between the airgun and the receiver system in the 18.6 to 121.5 km range were estimated through the comparison between the measured modal curves and the model replicas predicted using the estimated geoacoustic parameters.

keywords:

seismic airgun sounds; dispersion curves; warping; geoacoustic inversion; East Siberian Sea; Arctic Ocean

3-14 Geosciences, Multidisciplinary

Fast and Slow Responses of Atlantic Meridional Overturning Circulation to Antarctic Meltwater Forcing

Shin, Yechul., Geng, Xin., Oh, Ji-Hoon., Noh, Kyung-Min., **Jin, Emilia Kyung.** and Kug, Jong-Seong.

Geophysical Research Letters. 2024. 51(9).

doi: 10.1029/2024gl108272.

Antarctic meltwater discharge has been largely emphasized for its potential role in climate change mitigation, not only by reducing global warming, but also by stabilizing the Atlantic Meridional Overturning Circulation (AMOC). Despite the tremendous impact of the AMOC on the climate system, its temporal evolution in response to the meltwater remains poorly understood. Here, we investigate the meltwater impacts on the AMOC based on the GFDL CM2.1 experiments and discover its fast weakening and slow strengthening to the Antarctic meltwater discharge. Cold ocean surface caused by meltwater spread throughout the globe and eventually strengthened the AMOC. However, in the early stages, the tropical temperature response could

3-13 Environmental Sciences; Marine & Freshwater Biology

Estimation of geoacoustic parameters and source range using airgun sounds in the East Siberian Sea, Arctic Ocean

Lee, Dae Hyeok., Han, Dong-Gyun., Choi, Jee Woong., **Son, Wuju., Yang, Eun Jin., La, Hyoung Sul.** and Tang, Dajun.

Frontiers in Marine Science. 2024. 11.

doi: 10.3389/fmars.2024.1370294.

Dispersion is a representative property of low-frequency sound propagation over long distances in shallow-water waveguides, making dispersion curves valuable for geoacoustic inversion. This study focuses on estimating the geoacoustic parameters using the dispersion curves

stimulate the Rossby wave teleconnection, modulating atmospheric circulation in the North Atlantic, and weakening convection and even the AMOC. This counterintuitive evolution implies a potential destabilizing effect of Antarctic meltwater, underscoring the importance of the atmospheric dynamics in the interaction between the two poles.

keywords:

Antarctic meltwater; AMOC; climate change; Climate Change

3-15 Environmental Sciences; Marine & Freshwater Biology

Geographical distribution of the mesozooplankton community in highly productive coastal polynyas of the Ross Sea region marine protected area (RSR MPA) during early summer

Kim, Sung Hoon., Son, Wuju., Yoo, Jaeill., Lee, Boyeon., Kim, Jeong-Hoon. and La, Hyoung Sul.

Marine Pollution Bulletin. 2024. 204.

doi: 10.1016/j.marpolbul.2024.116524.

We investigated the recent spatial variation in the mesozooplankton community on the broad shelf of the RSR MPA during the bloom season. The mesozooplankton community was geographically divided into three regions: the Terra Nova Bay polynya, the Ross Sea polynya, and the marginal polynya. Larval euphausiids were dominant in the two polynya regions, whereas copepods were predominant in the marginal polynya region. Salinity, sea ice, and dissolved oxygen related to the different water mass compositions were the most significant factors distinguishing the mesozooplankton community. The key environmental variable separating the three groups was salinity. In accordance with the relatively high mesozooplankton abundance in the polynya regions, the occurrence and size of the polynyas in the December Ross Sea are thought to affect the spatial distribution of mesozooplankton. Consequently, this study indicates that two polynyas in the Ross Sea are vital habitats for krill during summer. Our observation results provide fundamental information for evaluating marine ecosystems and establishing a management plan for the RSR MPA.

keywords:

Ross Sea region marine protected area; Terra Nova Bay polynya; Ross Sea polynya; Pelagic zooplankton; Community composition; Larval krill; Ice krill; Early summer

3-16 Multidisciplinary Sciences

High Salinity Shelf Water production rates in Terra Nova Bay, Ross Sea from high-resolution salinity observations

Miller, Una Kim., Zappa, Christopher J., Gordon, Arnold L., Yoon, Seung-Tae., Stevens, Craig. and Lee, Won Sang.

Nature Communications. 2024. 15(1).

doi: 10.1038/s41467-023-43880-1.

High Salinity Shelf Water (HSSW) formed in the Ross Sea of Antarctica is a precursor to Antarctic Bottom Water (AABW), a water mass that constitutes the bottom limb of the global overturning circulation. HSSW production rates are poorly constrained, as in-situ observations are scarce. Here, we present high-vertical-and-temporal-resolution salinity time series collected in austral winter 2017 from a mooring in Terra Nova Bay (TNB), one of two major sites of HSSW production in the Ross Sea. We calculate an annual-average HSSW production rate of $\sim 0.4 \text{ Sv}$ ($10^6 \text{ m}^3 \text{ s}^{-1}$), which we use to ground truth additional estimates across 2012–2021 made from parametrized net surface heat fluxes. We find sub-seasonal and interannual variability on the order of 0.1 Sv , with a strong dependence on variability in open-water area that suggests a sensitivity of TNB HSSW production rates to changes in the local wind regime and offshore sea ice pack.

3-17 Marine & Freshwater Biology; Oceanography

High Spatial Variability in Under-Ice Export Fluxes over the Chukchi Plateau in the Pacific Arctic Region

Lalande, Catherine., Moon, Jong-Kuk., Jung, Jinyoung. and Yang, Eun Jin.

Ocean Science Journal. 2024. 59(2).

doi: 10.1007/s12601-024-00148-z.

A large proportion of algal production and carbon export occurs after snowmelt and before ice melt in the Arctic Ocean. To determine the magnitude of under-ice export fluxes over the Chukchi Plateau (CP), a total of 25 sediment trap deployments were completed at two ice camps during the annual field survey of the Korean IBRV *Araon* in 2018: a first ice camp (CP1) conducted from August 17 to 19 and a second ice camp (CP2) conducted from August 20 to 22. Chlorophyll *a* (chl *a*) and particulate organic carbon (POC) fluxes were measured at 2, 5, 10 and

30 m under ice, and zooplankton collected in the sediment traps were enumerated and identified. Both chl *a* and POC fluxes were the highest at 5 m under ice at CP2, likely due to enhanced fluxes of the sea ice algae *Melosira arctica* and to a potential higher release of particulate matter from a thinner sea ice cover. Whereas *Calanus glacialis/marshallae* were dominant at all depths and both sites, the large numbers of individuals observed at 10 m at CP1 likely enhanced zooplankton grazing pressure at that site, further contributing to the high spatial variability in under-ice export fluxes. Overall, under-ice fluxes obtained in August 2018 highlighted the importance of *M. arctica* aggregates as a source of carbon for pelagic consumers and for carbon export during summer over the Chukchi Plateau.

keywords:

Arctic Ocean; Carbon export; Chukchi Plateau; Sea ice algae; Sediment trap

3-18 *Environmental Sciences; Marine & Freshwater Biology*

Insight into the latitudinal gradient of biodiversity based on spatial variations in pelagic ciliate communities along the western Arctic Ocean

Xu, Guangjian., Wang, Fayuan., Yang, Eun Jin., Lee, Youngju., Jung, Jinyoung. and Kang, Sung Ho.

Marine Pollution Bulletin. 2024. 200.

doi: 10.1016/j.marpolbul.2024.116118.

The latitudinal dynamics of biodiversity has been the focus of global attention. This study is based on the latitude gradient of biodiversity in the spatial changes of pelagic ciliate communities in the western Arctic Ocean. The gradient pattern of pelagic ciliate communities across four latitudes were investigated from the water surface at 22 sampling station in the northern Bering Sea of the western Arctic Ocean and Chukchi Sea from August 5 to August 24, 2016. Based on multivariate analyses, the results showed that (1) the spatial patterns of pelagic ciliates represented a significant latitudinal gradient along the western Arctic Ocean; (2) the species number and abundance of pelagic ciliate communities declined from 64°N to 80°N; (3) variations in the horizontal distribution of ciliates were significantly correlated with changes in physicochemical variables, especially water temperature and Chl *a*; Thus it is suggested that the expected latitudinal decline of biodiversity was evident along the western Arctic Ocean.

keywords:

Latitudinal gradient; Biodiversity; Horizontal variation; Pelagic ciliate; Arctic Ocean

3-19 *Environmental Sciences; Meteorology & Atmospheric Sciences*

Lagged effect of Southern Annular Mode on chlorophyll-*a* in the mid-latitude South Pacific and Indian Oceans

Yoon, Jae-Seung., Park, Keyhong., Park, Jisoo., Park, Taewook. and Kim, Tae-Wook.

Environmental Research Letters. 2024. 19(4).

doi: 10.1088/1748-9326/ad2eed.

This study investigates the influence of the Southern Annular Mode (SAM) on chlorophyll-*a* (Chl-*a*) concentrations and the underlying mechanisms governing their associated environmental variations in the mid-latitude (35–50° S) ocean from 1998 to 2021. The intensification of westerly winds during positive SAM phases influences meridional water transport and mixed layer depth (MLD), which are both critical factors that affect surface nutrient availability. A marked contrast in the relationship between the meridional current anomaly and the SAM was observed, with reduced northward transport of nutrient-rich water in regions north of 50° S during positive SAM phases. This reduction could be attributed to the poleward migration of the westerly winds, which impeded the meridional current from reaching the mid-latitudes. The relationship between SAM and MLD south of 50° S was positive whereas that in the mid-latitude eastern (60–110° E) South Indian Ocean and eastern (90–140° W) South Pacific Ocean was negative or weak. The immediate effect of a more positive SAM on Chl-*a* in the mid-latitude ocean was reduced productivity caused by enhanced nutrient depletion. However, in the mid-latitude eastern South Pacific Ocean, the northward migration of the zonal mean meridional current anomaly closely aligned with the lagged correlation pattern between SAM variability and Chl-*a* over time, suggesting that the delayed northward transport of nutrient-rich waters may partially counterbalance the immediate effects of the SAM on ocean productivity. This mechanism was not present in the mid-latitude eastern South Indian Ocean, implying that future climate change may variably affect these regions. Our findings emphasize the importance of considering regional differences and temporal lags when evaluating the influence of SAM variability on ocean productivity and nutrient

dynamics in the context of climate change.

keywords:

Southern Annular Mode; chlorophyll-*a*; South Pacific Ocean; South Indian Ocean; atmospheric circulation

3-20 Multidisciplinary Sciences

Near surface oxidation of elemental mercury leads to mercury exposure in the Arctic Ocean biota

Lim, Seung Hyeon., Kim, Younggwang., Motta, Laura C., **Yang, Eun Jin., Rhee, Tae Siek., Hong, Jong Kuk.**, Han, Seunghee. and Kwon, Sae Yun.

Nature Communications. 2024. 15(1).

doi: 10.1038/s41467-024-51852-2.

Atmospheric mercury (Hg(0), Hg(II)) and riverine exported Hg (Hg(II)) are proposed as important Hg sources to the Arctic Ocean. As plankton cannot passively uptake Hg(0), gaseous Hg(0) has to be oxidized to be bioavailable. Here, we measured Hg isotope ratios in zooplankton, Arctic cod, total gaseous Hg, sediment, seawater, and snowpack from the Bering Strait, the Chukchi Sea, and the Beaufort Sea. The $\Delta^{200}\text{Hg}$, used to differentiate between Hg(0) and Hg(II), shows, on average, 70% of Hg(0) in all biota and differs with seawater $\Delta^{200}\text{Hg}$ (Hg(II)). Since $\Delta^{200}\text{Hg}$ anomalies occur via tropospheric Hg(0) oxidation, we propose that near-surface Hg(0) oxidation via terrestrial vegetation, coastally evaded halogens, and sea salt aerosols, which preserve $\Delta^{200}\text{Hg}$ of Hg(0) upon oxidation, supply bioavailable Hg(II) pools in seawater. Our study highlights sources and pathways in which Hg(0) poses potential ecological risks to the Arctic Ocean biota.

3-21 Microbiology

New observations of Papulifères, putative ciliate cysts, from the plankton of the Chukchi Sea (Western Arctic Ocean) in August of 2023

Dolan, John R., **Yang, Eun Jin.** and Moon, Jong-Kuk.

Acta Protozoologica. 2024. 63.

doi: 10.4467/16890027ap.24.001.19426.

We recently documented the existence of 26 different forms of Papulifères, presumptive ciliate cysts, from plankton net tow material of the Chukchi Sea gathered in 2015, 2021, and 2022. The forms appeared to be rare, found in only 7 of the 308 samples taken in annual August surveys from 2010 to 2022. Thus, we were surprised to find them relatively common and widespread in samples gathered in August of 2023. We found 18 different Papulifère forms, 8 of which appear to be new forms, in samples from 19 of the 36 stations sampled. They were found in localities ranging from 70.5°N to 80°N. Here we report on these Papulifère forms found in 2023, providing information on morphologies and geographical distributions. With this report we have expanded the catalogue of observed Papulifère, and photographed, forms of the Chukchi Sea to a grand total of 34 of morphologically distinct forms. However, we continue to urge caution in assigning a ciliate identity to any given Papulifère form in the absence of corroborating data.

keywords:

Fusopsis; Piropsis; Sphaeropsis; microzooplankton; tintinnids; oligotrichs

3-22

Next steps for assessing ocean iron fertilization for marine carbon dioxide removal

Buesseler, Ken O., Bianchi, Daniele., Chai, Fei., Cullen, Jay T., Estapa, Margaret., Hawco, Nicholas., John, Seth., McGillicuddy, Dennis J., Morris, Paul J., Nawaz, Sara., Nishioka, Jun., Pham, Anh., Ramakrishna, Kilaparti., Siegel, David A., Smith, Sarah R., Steinberg, Deborah., Turk-Kubo, Kendra A., Twining, Benjamin S., Webb, Romany M., Wells, Mark., White, Angelique., Xiu, Peng. and **Yoon, Joo-Eun.**

Frontiers in Climate. 2024. Volume 6 - 2024.

doi: 10.3389/fclim.2024.1430957.

There are many potential approaches to marine carbon dioxide removal (mCDR), of which ocean iron fertilization (OIF) has the longest history of study. However, OIF studies to date were not primarily designed to quantify the durability of carbon (C) storage, nor how wise OIF might be as an mCDR approach. To quantify C sequestration, we introduce a metric called the “centennial tonne,” defined as 1,000 kg of C isolated from atmospheric contact for on average at least 100 years. We present the activities needed to assess OIF from a scientific and technological perspective, and additionally, how it might be responsibly studied and potentially deployed. The five activities include: field studies in the

Northeast Pacific; improved modeling for field studies, data assimilation and predictions at larger scales; improvements in monitoring, reporting and verification (MRV) for C, and also MRV for tracking ecological and environmental impacts; and developing new iron sources and their delivery, to increase efficiencies and reduce costs. The fifth activity is to understand whether public and community support exists for OIF, and what governance structures might support further research and possible deployment of OIF. This article is written by a multidisciplinary experts group called Exploring Ocean Iron Solutions (ExOIS) that is organized around a responsible code of conduct. Of the mCDR approaches, OIF has the potential to be low cost, scalable, and rapidly deployable. Reducing CO₂ emissions must lead the way, but there is also an urgency to decide under what conditions and whether OIF might be deployed or not.

keywords:

marine carbon dioxide removal; ocean iron fertilization; carbon sequestration; climate ethics; exploring ocean iron solutions; centennial tonne; monitoring reporting and verification; ecological environmental monitoring reporting and verification

change might go undetected in the time needed to build up large-scale, long time series. These global-scale issues are epitomised by Antarctic krill (*Euphausia superba*), which is concentrated in rapidly warming areas, exports substantial quantities of carbon and supports an expanding fishery, but opinion is divided on how resilient their stocks are to climatic change. Based on a workshop of 137 krill experts we identify the challenges of observing climate change impacts with shifting sampling methods and suggest three tractable solutions. These are to: improve overlap and calibration of new with traditional methods; improve communication to harmonise, link and scale up the capacity of new but localised sampling programs; and expand opportunities from other research platforms and data sources, including the fishing industry. Contrasting evidence for both change and stability in krill stocks illustrates how the risks of false negative and false positive diagnoses of change are related to the temporal and spatial scale of sampling. Given the uncertainty about how krill are responding to rapid warming we recommend a shift towards a fishery management approach that prioritises monitoring of stock status and can adapt to variability and change.

keywords:

ecosystem monitoring; population change; Antarctic krill; fishery management; new technologies

3-23 *Environmental Sciences; Marine & Freshwater Biology*

Observing change in pelagic animals as sampling methods shift: the case of Antarctic krill

Hill, Simeon L., Atkinson, Angus., Arata, Javier A., Belcher, Anna., Nash, Susan Bengtson., Bernard, Kim S., Cleary, Alison., Conroy, John A., Driscoll, Ryan., Fielding, Sophie., Flores, Hauke., Forcada, Jaume., Halfter, Svenja., Hinke, Jefferson T., Huckstadt, Luis., Johnston, Nadine M., Kane, Mary., Kawaguchi, So., Krafft, Bjorn A., Kruger, Lucas., **La, Hyoung Sul.** and 20 others.

Frontiers in Marine Science. 2024. 11.

doi: 10.3389/fmars.2024.1307402.

Understanding and managing the response of marine ecosystems to human pressures including climate change requires reliable large-scale and multi-decadal information on the state of key populations. These populations include the pelagic animals that support ecosystem services including carbon export and fisheries. The use of research vessels to collect information using scientific nets and acoustics is being replaced with technologies such as autonomous moorings, gliders, and meta-genetics. Paradoxically, these newer methods sample pelagic populations at ever-smaller spatial scales, and ecological

3-24 *Oceanography*

Ocean processes south of the Drygalski Ice Tongue, western Ross Sea

Stevens, Craig., Yoon, Seung-Tae., Zappa, Christopher J., Miller, Una Kim., Wang, Xianwei., Elliott, Fiona., Cornelissen, Liv., **Lee, Choon-Ki., Yun, Sukyoung.** and **Lee, Won Sang.**

Deep-Sea Research Part II-Topical Studies in Oceanography. 2024. 217.

doi: 10.1016/j.dsr2.2024.105411.

We describe the first year-long hydrographic mooring timeseries from a location just to the south of the Drygalski Ice Tongue - the ice margin that forms the southern boundary of the Terra Nova Bay Polynya in the western Ross Sea. The region is where any northward flowing component of the Victoria Land Coastal Current encounters the ice tongue and supports an occasional polynya. The hydrographic mooring was deployed nearby Geikie Inlet from February 2017 through to March 2018, and was coupled with several contemporaneous oceanographic moorings to the north of the Drygalski Ice Tongue. This provides data with

which to examine the water column dynamics in the context of local circulation and interaction with the ice tongue. The Terra Nova Bay region is subject to strong katabatic winds, however the polynya to the south of the Drygalski Ice Tongue operates at different times through the annual cycle when compared to the Terra Nova Bay Polynya to the north, as the sea ice in the south-side region is far more constrained in its motion yet, temperature and salinity are broadly consistent north and south of the ice tongue. Sub-surface Ice Shelf Water is observed south of the ice tongue. Transients in near-bed temperature and salinity are observed on both sides of the ice tongue, albeit with the northside leading by ~8–9 days. Notably, the temperature transient precedes that of salinity by around 40 days. This suggests that, at this near-coastal position, the circulation beneath the ice tongue is primarily southward.

keywords:

Convection; Sea ice; Katabatic wind; Oceanography; Antarctica; High salinity shelf water; Polynya

glaciale, which is usually found in the Atlantic sector of Arctic Ocean, was observed in the northern Chukchi Sea. In addition to these unusual species distributions, several species that are mainly observed in coastal areas are observed in the Chukchi Sea region. The observed influx of various uncommon fish species into the Chukchi Sea can be attributed to multiple factors, including freshwater inflow from the East Siberian Sea and the intrusion of warm Atlantic and Pacific waters, which are strongly affected by global warming. Consequently, it is imperative to conduct rigorous monitoring of the Pacific Arctic region, with a particular focus on the Chukchi Sea, to better understand the implications of global warming.

keywords:

ichthyoplankton; community structure; Pacific Arctic Ocean; East Siberian Sea; Chukchi Sea; Bering Sea; Bering Strait

3-25 Environmental Sciences; Marine & Freshwater Biology

Patterns of summer ichthyoplankton distribution, including invasive species, in the Bering and Chukchi Seas

Kim, Sung Hoon., Son, Wuju., Yoo, Jaeill., Cho, Kyoung-Ho., Park, Taewook., Yang, Eun Jin., Kang, Sung-Ho. and La, Hyoung Sul.

Frontiers in Marine Science. 2024. 11.

doi: 10.3389/fmars.2024.1351844.

A multidisciplinary survey was carried out in the Pacific Arctic and sub-Arctic regions of the North Pacific Ocean on the Korean icebreaking research vessel *Araon*. During this survey, ichthyoplankton fishes in the Pacific Arctic and sub-Arctic region ranged from the Bering Sea to the northern Chukchi Shelf in summer. The most dominant species was *Gadus chalcogrammus*, followed by *Pleuronectes quadrituberculatus* and *Boreogadus saida*. *Gadus chalcogrammus* and *P. quadrituberculatus* were particularly abundant near the Bering Sea and Bering Strait, whereas *B. saida* was dominant in the Chukchi Sea. Hierarchical cluster analysis revealed four distinct ichthyoplankton communities in Pacific Arctic and sub-Arctic regions based on geographical regions. However, *Eleginus gracilis*, which was previously known to be seen between latitudes 66.5°N and 69.5°N, was found above 70°N, suggesting that its distribution extends further north. Furthermore, we noticed that *Benthosema*

3-26 Limnology; Marine & Freshwater Biology; Oceanography

pCO₂ variation in ice-covered regions of the Arctic Ocean from the summer 2022 observation

Mo, Ahra., Park, Keyhong., Kim, Tae-Wook., Hahm, Doshik., Choi, Jung-Ok., Geum, Sohyeon., Jung, Jinyoung. and Yang, Eun Jin.

Limnology and Oceanography Letters. 2024. 9(5): 573-582.

doi: 10.1002/lol2.10415.

To enhance our understanding of the carbon cycle in the Arctic Ocean, comprehensive observational data are crucial, including measurements from the underlying ice water. This study proposed a practical method for calibrating *p*CO₂ sensor using measured dissolved inorganic carbon and total alkalinity. Our findings suggested the minimum number of bottle samples needed for calibration to ensure 1% accuracy. Additionally, we identified the significant role of a decrease in dissolved inorganic carbon due to photosynthesis and the increase in buffer capacity of the seawater from the release of excess alkalinity by sea ice in regulating *p*CO₂. The mean air–sea CO₂ fluxes were -48.9 ± 44.6 , -7.3 ± 14.6 , and -1.4 ± 2.8 mmol m⁻² d⁻¹ in the southern Chukchi Sea, northern Chukchi Sea, and northern East Siberian Sea, respectively. We found a robust negative correlation between the flux and sea ice concentration in the Arctic Sea ice regions.

3-27 Environmental Sciences; Meteorology & Atmospheric Sciences

Revealing the seasonal cycles of Arctic phytoplankton: insights from year-round chlorophyll monitoring

Ko, Eunho., Park, Jisoo., Cho, Kyoung-Ho., Yoo, Jaeill., Moon, Jong Kuk., Shim, Chorom. and Yang, Eun Jin.

Environmental Research Letters. 2024. 19(2).

doi: 10.1088/1748-9326/ad1e7e.

Rapid Arctic Ocean warming has caused severe sea ice decline, impacting light distribution, phytoplankton blooms, and primary production. We investigated Arctic phytoplankton bloom timing using continuous chlorophyll-a fluorescence data obtained from three Korea Arctic Mooring Systems (KAMSs) deployed north of the East Siberian Sea (KAMS1), north of the Chukchi Sea (KAMS2), and the middle of the Northwind Ridge (KAMS4). Our findings revealed that the bloom initiation times were June 4 (± 28 d) in KAMS1, June 24 in KAMS2, and May 21 (± 6 d) in KAMS4, when the sea ice concentration (SIC) was $>90\%$ and the ice thickness was 1–2 m, indicating that the under-ice phytoplankton blooms (UIBs) developed 1–2 months before the sea ice retreated (mid-July, when SIC was $<80\%$). Peak bloom and termination times were consistently observed in early August and mid-October, respectively. The average phytoplankton bloom lasted for approximately four months, longer than the open water periods at the mooring sites. However, the timing of the phytoplankton blooms from the biogeochemical model-based reconstructions was, on average, 6–10 weeks later than that deduced from the observed data. Furthermore, the maximum chlorophyll-a concentration observed during the bloom peak was approximately ten-times higher than that indicated by the biogeochemical model-based reconstructions (1.81 vs. 0.17 mg $^{-3}$). The differences in chlorophyll-a concentrations and bloom timings indicate that biogeochemical models remain insufficient for simulating the phytoplankton dynamics of the Arctic Ocean, such as UIBs and the subsurface chlorophyll maximum layer. Based on the continuously observed chlorophyll-a concentrations, we gained a precise understanding of the seasonal cycles of Arctic phytoplankton, including UIBs. These valuable data will contribute to improving the accuracy of biogeochemical models of the Arctic Ocean.

keywords:

phytoplankton seasonality; chlorophyll; Arctic Ocean; under-ice blooms; Korean Arctic Mooring System

3-28 Biotechnology & Applied Microbiology

Salinity-controlled distribution of prokaryotic communities in the Arctic sea-ice melt ponds

Vipindas, Puthiya Veettil., Venkatachalam, Siddarthan., Jabir, Thajudeen., Yang, Eun Jin., Jung, Jinyoung., Jain, Anand. and Krishnan, Kottekkatu Padinchati.

World Journal of Microbiology & Biotechnology. 2024. 40(1).

doi: 10.1007/s11274-023-03850-7.

The thawing of snow and sea ice produces distinctive melt ponds on the surface of the Arctic sea ice, which covers a significant portion of the surface sea ice during summer. Melt-pond salinity impacts heat transfer to the ice below and the melting rate. It is widely known that melt ponds play a significant role in heat fluxes, ice-albedo feedback, and sea-ice energy balance. However, not much attention has been given to the fact that melt ponds also serve as a unique microbial ecosystem where microbial production begins as soon as they are formed. Here, we investigated the role of melt pond salinity in controlling the diversity and distribution of prokaryotic communities using culture-dependent and -independent approaches. The 16 S rRNA gene amplicon based next generation sequencing analysis retrieved a total of 14 bacterial phyla, consisting of 146 genera, in addition to two archaeal phyla. Further, the culture-dependent approaches of the study allowed for the isolation and identification of twenty-four bacterial genera in pure culture. *Flavobacterium*, *Candidatus_Aquiluna*, *SAR11 clade*, *Polaribacter*, *Glaciecola*, and *Nonlabens* were the dominant genera observed in the amplicon analysis. Whereas *Actinimicrobium*, *Rhodoglobus*, *Flavobacterium*, and *Pseudomonas* were dominated in the culturable fraction. Our results also demonstrated that salinity, chlorophyll a, and dissolved organic carbon were the significant environmental variables controlling the prokaryotic community distribution in melt ponds. A significant community shift was observed in melt ponds when the salinity changed with the progression of melting and deepening of ponds. Different communities were found to be dominant in melt ponds with different salinity ranges. It was also observed that melt pond prokaryotic communities significantly differed from the surface ocean microbial community. Our observations suggest that complex prokaryotic communities develop in melt ponds immediately after its formation using dissolved organic carbon generated through primary production in the oligotrophic water.

keywords:

Archaea; Bacteria; Diversity; Ecology; Phylogenetic analysis; Polyphasic taxonomy

3-29 Oceanography

Seasonal variations in the contribution of zooplankton fecal pellets to the particulate organic carbon fluxes over the slopes of the Pacific Arctic region

Kim, Jeong-Hyun., Lalande, Catherine., Yang, Eun Jin., Cho, Kyoung-Ho., Kim, Dongseon., Moon, Jong-Kuk. and Yoo, Hyeju. *Progress in Oceanography*. 2024. 228.
doi: 10.1016/j.pocean.2024.103335.

As part of the Korea Arctic Mooring System (KAMS), sequential sediment traps were deployed at KAMS1 over the East Siberian Sea slope (~115 and ~335 m) and at KAMS2 over the Chukchi Sea slope (325 m) to collect sinking particles from August 2017 to August 2019. Fecal pellet carbon (FPC) fluxes and their contribution to the particulate organic carbon (POC) fluxes were measured to assess the role of zooplankton fecal pellets in the biological carbon pump at both sites. FPC fluxes increased at the onset of an under-ice bloom and peaked during the melt period at both sites in 2018. At KAMS1, a remarkable increase in FPC fluxes reflected the enhanced grazing of large copepods during the anomalously productive spring and summer of 2018, however their contributions to the POC fluxes mostly remained <10%. At KAMS2, relatively low FPC fluxes during the under-ice bloom suggested the export of a larger proportion of pellets produced by small copepods. Sustained FPC fluxes from January to May 2018 at KAMS2 contributed up to 24% of the POC fluxes, possibly resulting from pellet production by overwintering copepods grazing on particles laterally transported into the region in the presence of ice. These results indicate that despite their limited contribution to the POC fluxes, FPC fluxes varied with food availability, zooplankton community structure, and hydrographic conditions over the East Siberian and Chukchi Sea slopes.

keywords:

Fecal pellet; Zooplankton; Sediment trap; Arctic Ocean; Carbon flux

3-30 Ecology; Geosciences, Multidisciplinary

Significant role of physical transport in the marine carbon monoxide (CO) cycle: observations in the East Sea (Sea of Japan), the western North Pacific, and the Bering Sea in summer

Kwon, Young Shin., Rhee, Tae Siek., Kim, Hyun-Cheol. and Kang, Hyoun-Woo. *Biogeosciences*. 2024. 21(7): 1847-1865.
doi: 10.5194/bg-21-1847-2024.

The carbon monoxide (CO) in the marine boundary layer and in the surface waters and water column were measured along the western limb of the North Pacific from the Korean Peninsula to Alaska, USA, in summer 2012. The observation allows us to estimate the CO budgets in the surface mixed layer of the three distinct regimes: the East Sea (Sea of Japan) (ES), the Northwest Pacific (NP), and the Bering Sea (BS). CO photochemical production rates were $56(\pm 15) \mu\text{mol m}^{-2} \text{d}^{-1}$, $27(\pm 3) \mu\text{mol m}^{-2} \text{d}^{-1}$, and $26(\pm 2) \mu\text{mol m}^{-2} \text{d}^{-1}$, while microbial consumption rates were $30(\pm 8) \mu\text{mol m}^{-2} \text{d}^{-1}$, $24(\pm 5) \mu\text{mol m}^{-2} \text{d}^{-1}$, and $63(\pm 19) \mu\text{mol m}^{-2} \text{d}^{-1}$ in the ES, NP, and BS, respectively, both of which are the dominant components of the CO budget in the ocean. The other two known components, air-sea gas exchange and downward mixing, remained negligible (less than $3 \mu\text{mol m}^{-2} \text{d}^{-1}$) in all regimes. While the CO budget in the surface mixed layer of the NP was in balance, the CO production surpassed the consumption in the ES, and vice versa in the BS. The significant imbalances in the CO budget in the ES ($25 \pm 17 \mu\text{mol m}^{-2} \text{d}^{-1}$) and the BS ($40 \pm 19 \mu\text{mol m}^{-2} \text{d}^{-1}$) are suggested to be compensated by external physical transport such as lateral advection, subduction, or ventilation. Notably, the increase in the CO column burden correlated with the imbalance in the CO budget, highlighting the significant role of the physical transport in the marine CO cycles. Our observation, for the first time, underscores the potential importance of physical transport in driving CO dynamics in the marine environment.

3-31 Biodiversity Conservation; Ecology

Spatial Distribution Pattern of the Meso zooplankton Community in Ross Sea Region Marine Protected Area (RSR MPA) during Summer

Kim, Sung Hoon., Son, Wuju., Kim, Jeong-Hoon. and La, Hyoung Sul. *Diversity-Basel*. 2024. 16(3).
doi: 10.3390/d16030174.

The Ross Sea region Marine Protected Area (RSR MPA) is one of the most productive regions in the Southern Ocean. Meso zooplankton intermediates the primary product to the higher predators, such as penguins and seals, in this

ecosystem. In this study, the mesozooplankton community structure and spatial pattern in the RSR MPA in January were investigated by using 505 μm -mesh-size bongo net samples. As a result, 37 mesozooplankton taxa with a total mean abundance of 35.26 ind./ m^3 , ranging from 2.94 to 139.17 ind./ m^3 , were confirmed. Of the 37 taxa, 7 occupied almost 84% of the total abundance, with copepods being the main dominant taxa. As shown by our hierarchical analysis, the mesozooplankton community was divided into four groups, each associated with a specific geographical distribution. Group A was composed of stations around Terra Nova Bay and showed relatively low abundance. Group B included stations around the continental slope region. Group D was composed of the Ross Sea continental shelf stations, while group C consisted of stations geographically located between those of groups B and D. These four groups were influenced by various environmental factors, such as water temperature and salinity. In summary, the mesozooplankton community can be separated according to geographical pattern. This pattern is related to several environmental factors.

keywords:

Ross Sea region Marine Protected Area (RSR MPA); zooplankton; January; Southern Ocean; community structure

3-32 Ecology; Geosciences, Multidisciplinary

Temperature-enhanced effects of iron on Southern Ocean phytoplankton

Eich, Charlotte., van Manen, Mathijs., McCain, J. Scott P., Jabre, Loay J., van de Poll, Willem H., Jung, Jinyoung. and 7 others. *Biogeosciences*. 2024. 21(20): 4637-4663. doi: 10.5194/bg-21-4637-2024.

Iron (Fe) is a key limiting nutrient for Southern Ocean phytoplankton. Input of Fe into the Southern Ocean is projected to change due to global warming, yet the combined effects of a concurrent increase in temperature with dissolved Fe (dFe) addition on phytoplankton growth and community composition have not been extensively studied. To improve our understanding of how Antarctic phytoplankton communities respond to Fe and enhanced temperature, we performed four full factorial onboard bioassays under trace-metal-clean conditions with phytoplankton communities from different regions of the Weddell Sea and the Amundsen Sea in the Southern Ocean. Treatments consisted of 2 nM Fe addition with 2 °C warming

(TF), Fe addition at in situ temperature (F) +2 °C warming with no Fe addition (T) and a control at in situ temperature with no Fe addition (control, C). Temperature had a limited effect by itself but boosted the positive response of the phytoplankton to Fe addition. Photosynthetic efficiency, phytoplankton abundances and chlorophyll a concentrations typically increased (significantly) with Fe addition (F and/or TF treatment), and the phytoplankton community generally shifted from haptophytes to diatoms upon Fe addition. The < 20 μm phytoplankton fraction displayed population-specific growth responses, resulting in a pronounced shift in community composition and size distribution (mainly towards larger-sized phytoplankton) for the F and TF treatments. Such a distinct enhanced impact of dFe supply with warming on Antarctic phytoplankton size, growth and composition will likely affect trophic transfer efficiency and ecosystem structure, with potential significance for the biological carbon pump.

3-33 Oceanography

The coupling of winds, ocean turbulence, and High Salinity Shelf Water in the Terra Nova Bay Polynya

Miller, Una Kim., Zappa, Christopher J., Gordon, Arnold L., Yoon, Seung-Tae., Stevens, Craig., Cornelissen, Liv., Yun, Sukyoung. and Lee, Won Sang.

Deep-Sea Research Part II-Topical Studies in Oceanography. 2024. 218. doi: 10.1016/j.dsr2.2024.105412.

The Terra Nova Bay (TNB) Polynya in the Western Ross Sea of Antarctica is a major producer of High Salinity Shelf Water (HSSW), a precursor to Antarctica Bottom Water (AABW). Processes occurring in and around the polynya can therefore effect change in the lower limb of overturning circulation in this region. Here, we use data from a densely-instrumented upper-ocean mooring, deployed for 1 year in a region of active HSSW formation within TNB, to examine the coupling of surface brine rejection and vertical mixing to katabatic wind forcing. We find a high correlation between salinity and winds during the wintertime HSSW production season at the mooring site, with a lag-response of 20 h in near-surface (~47 m) salinity to winds measured at the nearby Automatic Weather Station (AWS) Manuela. Salinity and temperature measurements show a fully destratified water column by June, with a lag-response of near-seabed (~360 m) salinity to near-surface salinity of just 5 h. Measurements of turbulent kinetic energy (TKE)

dissipation rate (ϵ) from moored pulse-coherent acoustic Doppler current profilers (ADCPs) show general agreement with classic boundary layer scaling (BLS), and calculations of a vertical mixing timescale using the Obukhov length scale average to ~ 2.5 h during austral winter, consistent with the 5-h lag time observed in the salinity data. Comparisons to data from concurrent mooring deployments along the southern boundary of TNB, as well as to previously published assessments of model simulations and data from Climatic Long-term Interaction for the Mass-balance in Antarctica (CLIMA) moorings, allow us to explore spatial variability in the coupling of winds and salinity across TNB and to speculate on possible HSSW circulation pathways.

3-34 Environmental Sciences; Marine & Freshwater Biology

Tracing freshwater sources and particle discharge in Kongsfjorden: insights from a water isotope approach

Fang, Ling., **Yang, Eun Jin.**, Yoo, Junho. and Kim, Minkyung.
Frontiers in Marine Science. 2024. 11.
doi: 10.3389/fmars.2024.1426793.

Arctic fjords are inherently vulnerable to global warming, particularly because of the substantial freshwater influx resulting from the melting of glaciers. In this study, precipitation, river water, surface ice, and seawater samples from Kongsfjorden were collected to identify the main sources of freshwater. The dual water isotope ($\delta^{18}\text{O}$ and δD) results and temperature–salinity profiles revealed that between 0% and 7% freshwater contributed to the fjord's water. Furthermore, different freshwater sources for surface and deep water were identified by the dual water isotope analysis. Turbidity profiles confirmed the alter in particle discharge associated with surface runoff and subglacial discharge. Our study highlighted the sensitivity of water isotope analysis in elucidating the hydrological processes within the fjord system and demonstrated its potential for investigating the impact of meltwater on biological processes in the Arctic.

keywords:

stable water isotopes; meltwater; turbidity; terrestrial particle discharge; Arctic fjord; Kongsfjorden

3-35 Ecology; Evolutionary Biology

Underwater soundscape in Seaview Bay, Antarctica, and triple ascending trill of the leopard seal (*Hydrurga leptonyx*) underwater vocalizations

Han, Dong-Gyun., Choi, Jee Woong., **Kim, Jong-U.**, Kim, Jeong-Hoon. and **La, Hyoung Sul.**
Ecology and Evolution. 2024. 14(7).
doi: 10.1002/ece3.70038.

The underwater soundscape was recorded in Seaview Bay off Inexpressible Island, Ross Sea region Marine protected area, for 3 days in December 2021. Leopard seal *Hydrurga leptonyx* vocalizations were a prominent sound source that led to variations in ambient sound pressure levels in a frequency range of approximately 150–4500 Hz. Among the 14 call types previously identified, except ultrasound vocalizations, six types of broadcast calls were classified, and their acoustic characteristics were analyzed. We focused on the acoustic characteristics of four low-frequency calls, clustered in a relatively narrow bandwidth, which have been relatively less studied. We identified a new call type of a triple ascending trill consisting of three trill parts, expanding upon the findings of previous studies. The audio data extracted from leopard seal vocalization videos, recorded by a monitoring camera on sea ice, enhanced the reliability of identifications of the underwater triple ascending trill. We present the unique results of underwater passive acoustic monitoring conducted at Seaview Bay, designated as Antarctic Specially Protected Area No 178. Our results could contribute to the development of detection and localization algorithms for leopard seal vocalizations and can be used as fundamental data for studies related to the vocalization and behavior of this species.

keywords:

acoustic characteristics; leopard seal vocalization; passive acoustic monitoring; Seaview Bay; triple ascending trill; underwater soundscape

3-36 Geosciences, Multidisciplinary

Variability of Inflowing Current Into the Dotson Ice Shelf and Its Cause in the Amundsen Sea

Yang, Heewon., Kim, Tae-Wan., Kim, Yeonggi., Yoo, Jaeill., Park,

Jisoo. and Cho, Yang-Ki.

Geophysical Research Letters. 2024. 51(3).

doi: 10.1029/2023gl105404.

The inflow of warm and salty Circumpolar Deep Water affects the melting of the ice shelf on the Amundsen Sea, a significant contributor to global sea level rise. Multi-year mooring data (2014–2016 and 2018–2020) from the front of the Dotson Ice Shelf show the modified Circumpolar Deep Water layer was thicker during 2018–2020 than during 2014–2016. During 2014–2016, Ocean surface stress curl influenced the barotropic process and strengthened southward velocity, while during 2018–2020, it caused lift and downwelling of thermocline depth, increasing the impact of the baroclinic process in ocean circulation. The heat transport to the ice shelf during 2018–2020 (57.42 MW m^{-1}) was half as much as it was during 2014–2016 (111.06 MW m^{-1}) due to a weaker lower layer current. The difference in ocean circulation between two periods, caused by a difference in warm layer thickness, ultimately impacts the heat transport entering the ice shelf cavity.

keywords:

Amundsen Sea; Dotson Ice Shelf; Circumpolar Deep Water; ocean surface stress curl

bottom temperature are related to changes in the intensity of the Atlantic Water (AW) boundary current, concurrent with the deepening of the lower AW layer by approximately 50 m. The difference in sea surface height (SSH) between the Canada Basin and the Chukchi Shelf increased because of the negative wind stress curl (WSC) and retarded the AW boundary current according to the geostrophic effect. When the near-bottom temperature increased during the winter-spring period, the SSH in the Chukchi Shelf was lower than that in the summer-fall period because of the less negative WSC. Quasi-monthly variations were related to SSH on the Chukchi Shelf owing to the negative WSC. HYCOM outputs from 1994 to 2015 showed that the AW boundary current weakened more recently than in the past due to the increased melting of sea ice. The results imply that a longer sea-ice-free season in the Arctic amplifies changes in the AW boundary current and deep ocean temperature owing to increased atmospheric forcing.

3-37 Oceanography

Wind-Induced Quasi-Seasonal and Quasi-Monthly Variations of Near-Bottom Temperature on the Chukchi Slope of the Southwestern Canada Basin

Ku, Ahyoung., Jeon, Chanhung., Peacock, Thomas., Chae, Jeong-Yeob., Park, Taewook., Cho, Kyoung-Ho. and Park, Jae-Hun.

Journal of Geophysical Research-Oceans. 2024. 129(7).

doi: 10.1029/2023jc020490.

The time series of near-bottom temperatures collected from September 2018 until August 2020 from an array of three current- and pressure-recording inverted echo sounders showed quasi-seasonal and quasi-monthly (~28 days) variations at a depth of ~1,300 m near the Chukchi slope in the western Arctic Ocean. They revealed an increase of ~0.1°C during the winter-spring period compared with the summer-fall period. These variations were observed in the data-assimilated Hybrid Coordinate Ocean Model (HYCOM) outputs near the observation site (correlation coefficient >0.7). They confirmed that variations in near-

Part 4.

Life Sciences

4-1 Biochemistry & Molecular Biology; Chemistry, Applied; Polymer Science

A structure-based mechanism of adenosylcobinamide kinase/adenosylcobinamide phosphate guanylyltransferase (*MpaCobU*) from *Methylocapsa palsarum*

Nam, Yewon., Ahn, Yong-Yoon., Kim, Bo-Mi., Kim, Kitae., Lee, Jun Hyuck. and Do, Hackwon.

International Journal of Biological Macromolecules. 2024. 280.

doi: 10.1016/j.ijbiomac.2024.136021.

Adenosylcobinamide kinase/adenosylcobinamide phosphate guanylyltransferase (CobU) is one of the key enzymes that participate in the biosynthesis of cobalamin, specifically lining the lower ligand 5,6-dimethylbenzimidazole in the α -position of cyclic tetrapyrroline. During this process, CobU exhibits two distinct activities: kinase and nucleotidyl transferase, using two nucleoside triphosphates. A structural study of CobU from *Salmonella typhimurium* showed that guanosine triphosphate binding induces a conformational rearrangement of helix 2. This rearrangement decreases the distance between the phosphate binding loop (P-loop) and helix 2, which is important for the subsequent guanylation step of the reaction. However, these findings provide only partial insights into the mechanism of CobU at the structural level, and the precise molecular details of this mechanism have not yet been studied. As a first step towards elucidating the molecular mechanisms and sequence of events involved in the phosphorylation and guanylation steps, we report the high-resolution crystal structures of phosphorylated -*MpaCobU* (1.8 Å), the C91S mutant (1.5 Å), the guanosine diphosphate complex (1.9 Å), and the adenosylcobinamide-phosphate complex (2.6 Å) from *Methylocapsa palsarum* for the first time. High-resolution structures revealed the crucial elements governing the catalytic steps of *MpaCobU*, thereby contributing to understanding the catalytic mechanism of

CobU at the molecular level.

keywords:

Coenzyme B₁₂; Kinase; Nucleotidyl transferase; Dual enzymatic activity; *Methylocapsa palsarum*; X-ray crystallography

4-2 Microbiology

***Acidisoma cladoniae* sp. nov., an acidotolerant bacterium isolated from an Antarctic lichen**

Cho, Un., Jeon, Jehyun., Kim, Woohyun., Hong, Soon Gyu., Lee, Hyoungseok. and Lee, Yung Mi.

Antonie Van Leeuwenhoek International Journal of General and Molecular Microbiology. 2025. 118(1).

doi: 10.1007/s10482-024-02021-4.

Gram-staining-negative, aerobic, white-cream-pearly colony, coccobacilli, and non-motile bacterial strain, PAMC 29798^T was isolated from an Antarctic lichen. The strain was acidotolerant and psychrotolerant growing at pH 4.0–7.5 (optimally at pH 4.0–6.5) and 0–25 °C (optimally at 10–20 °C). The major fatty acids are Summed Feature 8, C_{18:1} 2OH, and C_{19:0} cyclo ω8c. The major respiratory quinone was Q-10. Phylogenetic and phylogenomic analyses indicated that strain PAMC 29798^T belonged to the genus *Acidisoma* and 16S rRNA gene sequences of PAMC 29798^T were closely related to *Acidisoma silvae* (97.7% sequence similarity), *Acidisoma cellulosilyticum* (96.5%), *Acidisoma tundrae* (96.5%), and *Acidisoma sibiricum* (96.3%). Genomic relatedness analyses showed that strain PAMC 29798^T was clearly distinguished from type strains of the genus *Acidisoma* based on values of average nucleotide identity (< 75%) and the digital DNA-DNA hybridization (< 19.6%). Genome analysis revealed that the genome size of PAMC 29798^T is approximately 5.0 Mb with a G+C content of 63.4%. The complete genome comprises 5 contigs containing 4636 protein-coding genes, 46 tRNA genes, and 2 rRNA operons. The genome possesses genes for light-harvesting complexes, type-II photosynthetic reaction center, and C-P lyase to solubilize organic phosphates, while genes encoding nitrogenase iron protein involved in the nitrogen fixation were not present. Based on the results of phylogenetic, genome-based relatedness, and physiological and genomic analyses, strain PAMC 29798^T is proposed to represent a novel species of the genus *Acidisoma*, with the name *Acidisoma cladoniae*. The type strain is PAMC 29798^T (=

KCTC 82159^T = JCM 35634^T).

keywords:

Acidisoma cladoniae; Lichen; Antarctica; Novel species

4-3 Marine & Freshwater Biology

Adaptive foraging strategies of Adélie penguins in the Ross Sea Region: balancing chick feeding and body condition in changing marine environments

Kim, Youmin., Kim, Jong-U., Oh, Younggeun., Park, Jinku., Lee, Kyungho., Kim, Hyun-Cheol. and Kim, Jeong-Hoon.

Marine Biology. 2025. 172(1).

doi: 10.1007/s00227-024-04575-3.

Breeding seabirds are required to balance between feeding their chicks and maintaining their body condition. Adélie penguins (*Pygoscelis adeliae*), a keystone species of the Antarctic ecosystem, have foraging behavioral flexibility that depends on the marine environment and own body condition. This study collected tracking data and weight measurements from 47 brooding penguins during two breeding seasons at Cape Hallett (72°19'S, 170°12'E), Ross Sea. In 2021, the breeding season with a high sea ice concentration, penguins had lower body weights during the early guarding period compared to the body weights of the penguins in 2022. Penguins performed three types of foraging trips - ice hole trips, ice edge trips, and pack ice trips—during the 2021 breeding season. However, in the season characterized by a low sea ice concentration (2022), most of the foraging trips were pack ice trips. Furthermore, penguins performed relatively shorter pack ice trips and had lower foraging efforts than they did in 2021. On the other hand, we found that penguins with higher initial weights lost more weight, where for every additional 1 kg of weight, individuals lost 360 g more during the tracking period. We suggest that penguins use selective foraging strategies to adapt to their situation. Additionally, they regulate their food intake for raising chicks based on their body condition. In summary, our findings suggest how Adélie penguins determine foraging strategies and allocating food according to the marine environment and their body condition.

keywords:

Pygoscelis adeliae; Foraging behavior; Parental investment; Environmental variability; Fast-ice; Ross Sea; GPS

4-4 Multidisciplinary Sciences

An Antarctic lichen isolate (*Cladonia borealis*) genome reveals potential adaptation to extreme environments

Cho, Minjoo., Lee, Seung Jae., Choi, Eunkyung., Kim, Jinmu., Choi, Soyun., Lee, Jun Hyuck. and Park, Hyun.

Scientific Reports. 2024. 14(1).

doi: 10.1038/s41598-024-51895-x.

Cladonia borealis is a lichen that inhabits Antarctica's harsh environment. We sequenced the whole genome of a *C. borealis* culture isolated from a specimen collected in Antarctica using long-read sequencing technology to identify specific genetic elements related to its potential environmental adaptation. The final genome assembly produced 48 scaffolds, the longest being 2.2 Mbp, a 1.6 Mbp N50 contig length, and a 36 Mbp total length. A total of 10,749 protein-coding genes were annotated, containing 33 biosynthetic gene clusters and 102 carbohydrate-active enzymes. A comparative genomics analysis was conducted on six *Cladonia* species, and the genome of *C. borealis* exhibited 45 expanded and 50 contracted gene families. We identified that *C. borealis* has more *Copia* transposable elements and expanded transporters (ABC transporters and magnesium transporters) compared to other *Cladonia* species. Our results suggest that these differences contribute to *C. borealis*' remarkable adaptability in the Antarctic environment. This study also provides a useful resource for the genomic analysis of lichens and genetic insights into the survival of species isolated from Antarctica.

4-5 Ecology; Evolutionary Biology

An outsider on the Antarctic Peninsula: A new record of the non-native moth *Plodia interpunctella* (Lepidoptera: Pyralidae)

Benitez, Hugo A., Salinas, Carla., Hernandez, Jordan., Mejias, Tamara Contador., Kim, Sanghee. and 8 others.

Ecology and Evolution. 2024. 14(2).

doi: 10.1002/ece3.10838.

We report the first record of the microlepidopteran *Plodia interpunctella* beyond the South Shetland Islands at the Chilean Yelcho scientific station (64°52'33.1428"S; 63°35'1.9572"W), Doumer Island, close

to the west coast of the Antarctic Peninsula. It is notable that *P. interpunctella*, a globally distributed stored product pest species, exhibits a remarkable capacity for prolonged viability within food storage facilities. The dual challenges of food transportation and storage in the context of Antarctica's challenging operational conditions may have facilitated *P. interpunctella*'s initial arrival to the Antarctic region. Non-perishable food items, such as grains, flour and rice, provide practical options for the bulk food transportation and storage required in the long-term operation of Antarctic research stations. The presence of *P. interpunctella* in Antarctica, even if restricted to synanthropic environments within buildings, is a clear threat to Antarctic biodiversity, not only through being an invasive species itself but also as a potential vector for other non-native species (bacteria, acari, between others.), which could carry diseases to the native species.

keywords:

Antarctica; Indian meal moth; non-native species; research stations; Yelcho Station

4-6 Food Science & Technology

Anti-inflammatory effects of TP1 in LPS-induced Raw264.7 macrophages

Kim, Minji., An, Jangeun., Shin, Seong-Ah., Moon, Sun Young., Kim, Moonsu., Choi, Seyeon., Kim, Huiji., Phi, Kim-Hoa., **Lee, Jun Hyuck.**, **Youn, Ui Joung.**, Park, Hyun Ho. and Lee, Chang Sup.
Applied Biological Chemistry. 2024. 67(1).
doi: 10.1186/s13765-024-00873-y.

Inflammation is an essential defense mechanism in health; however, excessive inflammation contributes to the pathophysiology of several chronic diseases. Although anti-inflammatory drugs are essential for controlling inflammation, they have several side effects. Recent findings suggest that naturally derived compounds possess physiological activities, including anti-inflammatory, antifungal, antiviral, anticancer, and immunomodulatory activities. Therefore, this study aimed to investigate the anti-inflammatory effects and molecular mechanisms of 2,5,6-trimethoxy-p-terphenyl (TP1), extracted from the Antarctic lichen *Stereocaulon alpinum*, using in vitro models. TP1 treatment decreased the production of nitric oxide (NO) and reactive oxygen species (ROS) in LPS-stimulated Raw264.7 macrophages. Additionally, TP1 treatment significantly decreased the mRNA levels of pro-inflammatory

cytokines (IL-1 β , TNF- α , IL-6) and the mRNA and protein levels of the pro-inflammatory enzymes (inducible nitric oxide synthase and cyclooxygenase-2). Moreover, TP1 suppressed lipopolysaccharide-induced phosphorylation of the NF- κ B and MAPK signaling pathways in Raw264.7 macrophages. Conclusively, these results suggest that TP1 ameliorates inflammation by suppressing the expression of pro-inflammatory cytokines, making it a potential anti-inflammatory drug for the treatment of severe inflammatory diseases.

keywords:

TP1; Anti-inflammation; NF- κ B; MAPK

4-7

Antimicrobial Peptides Targeting Oral Pathogens: Applicability as an Oral Disease Treatment and Dental Material

Im, Sehyeok., **Lee, Jun Hyuck.** and Shim, Youn-Soo.
Journal of Dental Hygiene Science. 2024. 24(4): 231-248.
doi: 10.17135/jdhs.2024.24.4.231.

Background: Antimicrobial peptides (AMPs) are small, naturally occurring molecules that are integral components of the innate immune system across many organisms. In humans, saliva is rich in various AMPs that play a pivotal role in maintaining oral health by serving as the primary line of defense in the oral cavity. These peptides are essential for protection against a broad spectrum of pathogens, including bacteria and fungi. Recently, active research has been conducted on both naturally occurring AMPs and modified or synthetic AMPs for the treatment of oral pathogens and their application in dental materials. Methods: We compiled previous studies on AMPs present in saliva and their target oral microorganisms. Additionally, we summarized research on artificially created AMPs targeting oral pathogens. Furthermore, we analyzed recent trends in applied studies, such as the development of oral rinses, toothpaste, and implant coatings using AMPs. Results: Through a literature review, we identified 19 studies on AMPs present in the oral cavity and 40 studies testing AMPs derived from other organisms or synthetically engineered against oral pathogens. Additionally, we reviewed seven studies on the development of implant coatings and oral hygiene material additives using AMPs. These findings suggest the potential for discovering or developing AMPs with activity against specific oral pathogens that can be applied to improve oral

health. Conclusion: AMPs exhibit broad antimicrobial activity against a wide range of pathogens. Their mechanisms of action primarily involve attacking and disrupting the cell membranes of target microorganisms, making them effective against various pathogens. AMPs have the potential for use as coating materials for dental implants or restorative materials that require long-term use. Further research is needed to investigate the cytotoxicity, durability, and stability of AMPs in the oral environment to support their clinical use in dentistry.

keywords:

Antimicrobial peptides; Dental implants; Oral microbiome; Oral pathogen

4-8 *Environmental Sciences; Microbiology*

Assessment of the cyst wall and surface microbiota in dormant embryos of the Antarctic calanoid copepod, *Boeckella poppei*

Arrington, Hunter B., Lee, Sung Gu., Lee, Jun Hyuck. and Covi, Joseph A.

Environmental Microbiology Reports. 2024. 16(6).

doi: 10.1111/1758-2229.70035.

Embryos of zooplankton from inland waters and estuaries can remain viable for years in an extreme state of metabolic suppression. How these embryos resist microbial attack with limited metabolic capacity for immune defence or repair is unknown. As a first step in evaluating resistance to microbial attack in dormant zooplankton, surface colonization of the Antarctic freshwater copepod, *Boeckella poppei*, was evaluated. Scanning electron micrographs demonstrate the outer two layers of a five-layered cyst wall in *B. poppei* fragment and create a complex environment for microbial colonization. By contrast, the third layer remains undamaged during years of embryo storage in native sediment. The absence of damage to the third layer indicates that it is resistant to degradation by microbial enzymes. Scanning electron microscopy and microbiome analysis using the 16S ribosomal subunit gene and internal transcribed spacer (ITS) region demonstrate the presence of a diverse microbial community on the embryo surface. Coverage of the embryos with microbial life varies from a sparse population with individual microbes to complete coverage by a thick biofilm. Extracellular polymeric substance binds debris and provides a structural element for the microbial community. Frequent observation of bacterial

fission indicates that the biofilm is viable in stored sediments.

4-9 *Environmental Sciences*

Calcium-enriched biochar shifts negative effects of fluoride on the properties of arid sandy soil

Ghiloufi, Wahida., Kim, Jinhyun. and 3 others.

Environmental Science and Pollution Research. 2024. 31(3): 4630-4639.

doi: 10.1007/s11356-023-31518-0.

This study sheds light on the influence of fluoride on the changes in the properties of alkaline sandy soils and the efficiency of calcium-enriched biochar application. The investigation involved an incubation experiment with soil contaminated with varying NaF concentrations (0, 400, 800, and 1200 mg NaF kg⁻¹ soil) and biochar (1% w/w). The data revealed that adding NaF to the soil resulted in significant increases in soil pH and decreases in total nitrogen (TN) content. Short-term fluoride pollution did not affect the microbial abundance due to certain factors such as increased soil pH and decreased microbial metabolism promoting the survival of cells under fluoride stress. However, a shift from bacterial to fungal-dominated microbial communities was observed at the highest NaF concentration. The nitrogen functional gene *amoA* was found to be highly sensitive to fluoride toxicity. The decrease in the abundance of *amoA* gene and the increase in soil pH can explain reduced nitrogen concentration. On the other hand, our findings indicated a significant decrease in enzyme activity in soil contaminated with mild to severe levels of NaF. This reduction in enzyme activity can be attributed to increased soil pH, decreased TN content, and the inhibition of microbial metabolism due to fluoride toxicity. Furthermore, the addition of calcium-rich biochar reduced fluoride solubility and adjusted pH, mitigating the negative effects of fluoride toxicity on soil properties. The use of biochar was also found to inhibit the accumulation of soil fluoride-resistant microbial genes.

keywords:

Fluoride pollution; Calcium-enriched biochar; Soil properties; Arid sandy soil

4-10 Infectious Diseases; Microbiology; Pharmacology & Pharmacy

Characterization of the extended substrate spectrum of the class A β -lactamase CESS-1 from *Stenotrophomonas* sp. and structure-based investigation into its substrate preference

Jeong, Bo-Gyeong., Kim, Myeong-Yeon., Jeong, Chang-Sook., Do, Hackwon., Hwang, Jisub., Lee, Jun Hyuck. and Cha, Sun-Shin.
International Journal of Antimicrobial Agents. 2024. 63(6).
 doi: 10.1016/j.ijantimicag.2024.107171.

Objectives: *Stenotrophomonas* spp. intrinsically resistant to many β -lactam antibiotics are found throughout the environment. CESS-1 identified in *Stenotrophomonas* sp. KCTC 12332 is an uncharacterized class A β -lactamase. The goal of this study was to reveal biochemical and structural characteristics of CESS-1.

Methods: The hydrolytic activities of CESS-1 towards penicillins (penicillin G and ampicillin), cephalosporins (cephalexin, cefaclor, and cefotaxime), and carbapenems (imipenem and meropenem) was spectrophotometrically monitored. Structural information on E166Q mutants of CESS-1 acylated by cefaclor, cephalexin, or ampicillin were determined by X-ray crystallography.

Results: CESS-1 displayed hydrolytic activities toward penicillins and cephalosporins, with negligible activity toward carbapenems. Although cefaclor, cephalexin, and ampicillin have similar structures with identical R1 side chains, the catalytic parameters of CESS-1 toward them were distinct. The k_{cat} values for cefaclor, cephalexin, and ampicillin were 1249.6 s^{-1} , 204.3 s^{-1} , and 69.8 s^{-1} , respectively, with the accompanying K_M values of $287.6 \mu\text{M}$, $236.7 \mu\text{M}$, and $28.8 \mu\text{M}$, respectively.

Conclusions: CESS-1 was able to discriminate between cefaclor and cephalexin with a single structural difference at C3 position: $-\text{Cl}$ (cefaclor) and $-\text{CH}_3$ (cephalexin). Structural comparisons among three E166Q mutants of CESS-1 acylated by cefaclor, cephalexin, or ampicillin, revealed that cooperative positional changes in the R1 side chain of substrates and their interaction with the $\beta 5$ - $\beta 6$ loop affect the distance between Asn170 and the deacylating water at the acyl-enzyme intermediate state. This is directly associated with the differential hydrolytic activities of CESS-1 toward the three structurally similar β -lactam antibiotics.

keywords:

Extended substrate spectrum class A; β -lactamase; Acyl-enzyme complexes; Crystal structure; Steady-state enzyme kinetics; *Stenotrophomonas* sp.

4-11 Multidisciplinary Sciences

Chromosome-level genome assembly and annotation of the Patagonian toothfish *Dissostichus eleginoides*

Lee, Seung Jae., Cho, Minjoo., Kim, Jinmu., Choi, Eunkyung., Choi, Soyun., Chung, Sangdeok., Lee, Jaebong., Kim, Jeong-Hoon. and Park, Hyun.
Scientific Data. 2024. 11(1).
 doi: 10.1038/s41597-024-04119-w.

The Patagonian toothfish (*Dissostichus eleginoides*) belongs to the Actinopterygii class, and the suborder Notothenioidei, which lives in cold waters in the Southern Hemisphere. We performed assembly and annotation, and we integrated the Illumina short-read sequencing for polishing, PacBio long-read sequencing for contig-level assembly, and Hi-C sequencing technology to obtain high-quality of chromosome-level genome assembly. The final assembly analysis resulted in a total of 495 scaffolds, a genome size of 844.7 Mbp and an N50 length of 36 Mbp. Among these data, we confirmed 24 scaffolds exceeded 10 Mbp and classified as chromosome-level. The completeness of BUSCO rate was over 97%. A total gene set of 32,224 was identified. Furthermore, we analyzed the presence of AFGP genes, classified into Antarctic and sub-Antarctic categories through phylogenetic analysis. This study provides a useful resource for the genomic analysis of Patagonian toothfish and genetic insights into the comparison with Antarctic fishes.

4-12 Microbiology

Comparative Genome Analysis of Polar *Mesorhizobium* sp. PAMC28654 to Gain Insight into Tolerance to Salinity and Trace Element Stress

Khanal, Anamika., Han, So-Ra., Lee, Jun Hyuck. and Oh, Tae-Jin.
Microorganisms. 2024. 12(1).
 doi: 10.3390/microorganisms12010120.

In this study, *Mesorhizobium* sp. PAMC28654 was isolated from a soil sample collected from the polar region of Uganda. Whole-genome sequencing and comparative genomics were performed to better understand the genomic features necessary for *Mesorhizobium* sp. PAMC28654 to survive and thrive in extreme conditions and stresses.

Additionally, diverse sequence analysis tools were employed for genomic investigation. The results of the analysis were then validated using wet-lab experiments. Genome analysis showed trace elements' resistant proteins (CopC, CopD, CzcD, and Acr3), exopolysaccharide (EPS)-producing proteins (ExoF and ExoQ), and nitrogen metabolic proteins (NarG, NarH, and NarI). The strain was positive for nitrate reduction. It was tolerant to 100 mM NaCl at 15 °C and 25 °C temperatures and resistant to multiple trace elements (up to 1 mM CuSO₄·5H₂O, 2 mM CoCl₂·6H₂O, 1 mM ZnSO₄·7H₂O, 0.05 mM Cd(NO₃)₂·4H₂O, and 100 mM Na₂HAsO₄·7H₂O at 15 °C and 0.25 mM CuSO₄·5H₂O, 2 mM CoCl₂·6H₂O, 0.5 mM ZnSO₄·7H₂O, 0.01 mM Cd(NO₃)₂·4H₂O, and 100 mM Na₂HAsO₄·7H₂O at 25 °C). This research contributes to our understanding of bacteria's ability to survive abiotic stresses. The isolated strain can be a potential candidate for implementation for environmental and agricultural purposes.

keywords:

cold adaptation; comparative genomics; exopolysaccharide; *Mesorhizobium* sp. PAMC28654; salinity; trace element

genome reveal four metabolite biosynthesis clusters and a variety of carbohydrate-active enzymes with potential biotechnological applications. Additionally, several interesting features related to environmental interactions were identified. Therefore, this genome data and its genomic potentials figured out in this study serve as a conner stone in further study aimed at understanding physiology of this strain which may be valuable in biotechnological purpose.

keywords:

Extremophile; Glycosidic hydrolase; Biotechnology; Gliding motility; Antibiotic resistance

4-14 Environmental Sciences; Geosciences, Multidisciplinary

Crucial Role of Bacterial Processes in the Net Community Production of the Amundsen Sea Polynya Disclosed by a Modeling Study

Kwon, Young Shin., Hahm, Doshik., Rhee, Tae Siek. and Kang, Hyoun-Woo.

Journal of Geophysical Research-Biogeosciences. 2024. 129(2).
doi: 10.1029/2023jg007718.

We investigated seasonal net community production (NCP) variations in the productive Amundsen Sea Polynya, integrating observational data and ecosystem modeling. NCP estimates (NCP_{O₂/Ar}) from in situ O₂/Ar data during the austral summer (January-March) from 2011 to 2018 were compared with those from a one-dimensional ecosystem model. Early January saw the highest NCP_{O₂/Ar} values ranging from 115 to 139 mmol O₂ m⁻² d⁻¹ among observations. Over the summer, NCP_{O₂/Ar} gradually decreased, reaching 40 mmol O₂ m⁻² d⁻¹ by late February. Late summer values, though one-third of early January, remained notably positive, indicating net autotrophy. This persisted despite sea surface temperature dropping from >−0.4°C in January to −1.33°C in late February. Refining NCP_{O₂/Ar} we modified bacterial dynamics in our ecosystem model. Significantly improved model performance resulted from two key modifications. First, we introduced bacterial uptake dependency on *Phaeocystis* primary production. Second, we heightened temperature-dependent bacterial respiration and production approximately fifteenfold. These changes revealed NCP's remarkable sensitivity to minor temperature fluctuations (<1°C). Furthermore, modified bacterial dynamics delayed the net primary production peak by 2 weeks, underlining the importance of phytoplankton-bacteria interaction in the ocean carbon cycle. Model results estimated annual NCP in

4-13 Genetics & Heredity; Marine & Freshwater Biology

Complete genome and carbohydrate-active enzymes of *Arenibacter antarcticus* KCTC 52924^T isolated from deep sea sediment of Ross Sea, Antarctica

Hwang, Kyuin., Choe, Hanna. and Kim, Kyung Mo.

Marine Genomics. 2024. 78.

doi: 10.1016/j.margen.2024.101149.

Members of the genus *Arenibacter* were widely distributed in oceanic habitats around the world and have been studied for a variety of useful properties, including antigen deactivation, pollutant degradation, and the production of antimicrobial agents. *Arenibacter antarcticus* KCTC 52924^T of our interest is an aerobic, non-motile, Gram-negative, psychrotolerant type strain isolated from the deep-sea sediment of Ross Sea, Antarctica. The extreme conditions of this habitat are believed to have diversified the substrate spectrum and range of operational conditions of the enzymes, offering both scientific interest and potential industrial benefits. Here, we obtained the complete genome sequence of this promising strain, which consists of 4,694,007 bp (G + C content of 38.8 %) with a single chromosome, 3917 protein-coding genes, 43 tRNAs, and 3 rRNA operons. The functional annotations of the

the Amundsen Sea Polynya at $4.04 \text{ mol C m}^{-2}$, aligning with summer NCP estimates ($0.2\text{--}5.9 \text{ mol C m}^{-2}$) in observational study. Our study advances NCP understanding in polar regions, emphasizing comprehensive observations, including bacterial processes, for understanding intricate biotic interactions. These findings align with past observations on bacterial metabolism and *Phaeocystis* ecological properties in the Antarctic oceans.

keywords:

net community production; bacterial metabolism; carbon cycling; Amundsen Sea Polynya; coastal Southern Ocean; ecosystem dynamics

4-15 Parasitology; Tropical Medicine

Detection of human enteric viral genes in a non-native winter crane fly, *Trichocera maculipennis* (Diptera) in the sewage treatment facilities at Antarctic stations

Lee, Sook-Young., Kim, Ji Hee., Kang, Seunghyun., Park, Kye Chung., Cho, Sung Mi., Salinas, Carla Ximena., Rebolledo, Lorena., Benitez, Hugo A., Mejias, Tamara Contador., Soutullo, Alvaro., Juri, Eduardo. and Kim, Sanghee.

Parasites & Vectors. 2024. 17(1).

doi: 10.1186/s13071-024-06555-4.

Background: The Antarctic environment is susceptible to the introduction of non-native species due to its unique ecosystem, which has evolved under geographical isolation and extreme climatic conditions over an extended period. The recent introduction of the non-native winter crane fly, *Trichocera maculipennis*, to maritime Antarctica may pose a potential threat to the Antarctic ecosystem. In this study, we evaluated the possibility of the mechanical transmission of viruses by *T. maculipennis*.

Methods: We assessed the potential for the mechanical transmission of viruses using next-generation sequencing (NGS), quantitative PCR (qPCR), and virus isolation methods from *T. maculipennis* (Tm)-related samples (Tm body-wash fluid and Tm body-ground samples) collected from habitats and sewage treatment facilities located at three research stations in Antarctica.

Results: Virome analysis detected the genomic fragments of human adenovirus (AdV) and human endogenous retrovirus (HERV) in Tm-related samples. These viruses are commonly found in human feces. In addition, plant viruses, such as pepper mild mottle virus (PMMoV) and cucumber green

mottle mosaic virus (CGMMV), both known indicators of enteric viruses, were identified in all Tm-related samples, likely originating from wastewater. However, the low quantities of AdV and HERV genomes detected in Tm-related samples through qPCR, coupled with the non-viability of AdV in virus isolation tests, indicate that *T. maculipennis* has limited potential for mechanical transmission under the conditions in the studies.

Conclusions: Our study represents the first evaluation of the potential risk of non-native species serving as vectors for viral pathogens in Antarctica. Although the viruses detected were in relatively low quantities and non-viable, this study highlights the importance of further evaluating the risks associated with non-native species, particularly as the likelihood of their introduction increases to Antarctica due to climate change and increased human activity.

keywords:

Trichocera maculipennis; Non-native winter crane fly; Antarctica; Virus; Mechanical transmission

4-16 Microbiology

Ecological Interaction between Bacteriophages and Bacteria in Sub-Arctic Kongsfjorden Bay, Svalbard, Norway

Kim, Kang Eun., Joo, Hyoung Min., Kim, Yu Jin., Kang, Donhyug., Lee, Taek-Kyun., Jung, Seung Won. and Ha, Sun-Yong.

Microorganisms. 2024. 12(2).

doi: 10.3390/microorganisms12020276.

Marine virus diversity and their relationships with their hosts in the marine environment remain unclear. This study investigated the co-occurrence of marine DNA bacteriophages (phages) and bacteria in the sub-Arctic area of Kongsfjorden Bay in Svalbard (Norway) in April and June 2018 using metagenomics tools. Of the marine viruses identified, 48–81% were bacteriophages of the families *Myoviridae*, *Siphoviridae*, and *Podoviridae*. Puniceispirillum phage HMO-2011 was dominant (7.61%) in April, and Puniceispirillum phage HMO-2011 (3.32%) and Pelagibacter phage HTVC008M (3.28%) were dominant in June. *Gammaproteobacteria* (58%), including *Eionea flava* (14.3%) and *Pseudomonas sabulinigri* (12.2%), were dominant in April, whereas *Alphaproteobacteria* (87%), including *Sulfitobacter profundus* (51.5%) and *Loktanella acticola* (32.4%), were dominant in June. The alpha diversity of the bacteriophages and bacterial communities exhibited

opposite patterns. The diversity of the bacterial community was higher in April and lower in June. Changes in water temperature and light can influence the relationship between bacteria and bacteriophages.

keywords:

metagenomics; bacteriophage; bacteria; Kongsfjorden Bay; sub-Arctic zone; ecological interaction

4-17 Environmental Sciences; Marine & Freshwater Biology

Effects of exotic *Spartina alterniflora* invasion on benthic environments in the Yellow Sea

Lee, Jongmin., Noh, Junsung., Lee, Changkeun., Lee, In Ok., Kwon, Inha., Kwon, Bong-Oh., Lee, Moo Joon., Lee, Jung-Ho., Ryu, Jongseong., **Kim, Jinhyun.** and 5 others.

Marine Pollution Bulletin. 2024. 208.

doi: 10.1016/j.marpolbul.2024.117017.

For four decades, cordgrass (*Spartina alterniflora*) has invaded salt marshes in the Yellow Sea, altering physical, biogeochemical, and biological processes. Here, we investigated the ecological effects of *S. alterniflora* invasion on benthic environments compared to native halophytes. *S. alterniflora* contributed to higher carbon accumulation rates compared with bare tidal flat in sediments (3.4 times), through greater primary production and root biomass, compared to *Suaeda japonica* (2.5 times) and *Phragmites australis* (2.4 times) over the given period. The results showed that *S. alterniflora* eradication treatments inhibited its growth but did not significantly affect the benthic communities. Compared to *P. australis* and bare tidal flats, *S. alterniflora* invasion resulted in lower greenhouse gas emission and higher contributions to macrobenthos nutrition, and increased sediment stability and carbon burial. Overall, these multiple lines of evidence provide new insights on *S. alterniflora* invasion, suggesting that the current eradication policy would be carefully reviewed.

keywords:

Blue carbon; Invasive species; Halophyte; *Spartina alterniflora*; Organic carbon; Tidal flat

4-18 Biochemistry & Molecular Biology

Elucidation of bacterial trehalose-degrading trehalase and trehalose phosphorylase: physiological significance and its potential applications

Shrestha, Prasansah., Karmacharya, Jayram., Han, So-Ra., **Lee, Jun Hyuck.** and Oh, Tae-Jin.

Glycobiology. 2023.

doi: 10.1093/glycob/cwad084.

Bacteria possess diverse metabolic and genetic processes, resulting in the inability of certain bacteria to degrade trehalose. However, some bacteria do have the capability to degrade trehalose, utilizing it as a carbon source, and for defense against environmental stress. Trehalose, a disaccharide, serves as a carbon source for many bacteria, including some that are vital for pathogens. The degradation of trehalose is carried out by enzymes like trehalase (EC 3.2.1.28) and trehalose phosphorylase (EC 2.4.1.64/2.4.1.231), which are classified under the glycoside hydrolase families GH37, GH15, and GH65. Numerous studies and reports have explored the physiological functions, recombinant expression, enzymatic characteristics, and potential applications of these enzymes. However, further research is still being conducted to understand their roles in bacteria. This review aims to provide a comprehensive summary of the current understanding of trehalose degradation pathways in various bacteria, focusing on three key areas: (i) identifying different trehalose-degrading enzymes in Gram-positive and Gram-negative bacteria, (ii) elucidating the mechanisms employed by trehalose-degrading enzymes belonging to the glycoside hydrolases GH37, GH15, and GH65, and (iii) discussing the potential applications of these enzymes in different sectors. Notably, this review emphasizes the bacterial trehalose-degrading enzymes, specifically trehalases (GH37, GH15, and GH65) and trehalose phosphorylases (GH65), in both Gram-positive and Gram-negative bacteria, an aspect that has not been highlighted before.

keywords:

CAZyme; glycoside hydrolase; trehalase; trehalose degradation pathways; trehalose phosphorylase

4-19 Multidisciplinary Sciences
Engineered ice-binding protein (FfBP) shows increased stability and resistance to thermal and chemical denaturation compared to the wildtype

Nam, Yewon., Nguyen, Dieu Linh., Hoang, Trang., Kim, Bogeun., Lee, Jun Hyuck. and Do, Hackwon.

Scientific Reports. 2024. 14(1).

doi: 10.1038/s41598-024-53864-w.

Many polar organisms produce antifreeze proteins (AFPs) and ice-binding proteins (IBPs) to protect themselves from ice formation. As IBPs protect cells and organisms, the potential of IBPs as natural or biological cryoprotective agents (CPAs) for the cryopreservation of animal cells, such as oocytes and sperm, has been explored to increase the recovery rate after freezing–thawing. However, only a few IBPs have shown success in cryopreservation, possibly because of the presence of protein denaturants, such as dimethyl sulfoxide, alcohols, or ethylene glycol, in freezing buffer conditions, rendering the IBPs inactive. Therefore, we investigated the thermal and chemical stability of FfBP isolated from Antarctic bacteria to assess its suitability as a protein-based impermeable cryoprotectant. A molecular dynamics (MD) simulation identified and generated stability-enhanced mutants (FfBP_CC1). The results indicated that FfBP_CC1 displayed enhanced resistance to denaturation at elevated temperatures and chemical concentrations, compared to wildtype FfBP, and was functional in known CPAs while retaining ice-binding properties. Given that FfBP shares an overall structure similar to DUF3494 IBPs, which are recognized as the most widespread IBP family, these findings provide important structural information on thermal and chemical stability, which could potentially be applied to other DUF3494 IBPs for future protein engineering.

keywords:

Ice-binding protein; Antifreeze protein; Cryopreservation; Chemical stability; Cold denaturation; DUF3494; Ice recrystallization inhibition; Thermal hysteresis

Do, Hackwon. and 16 others.

Nature Microbiology. 2024. 9(2).

doi: 10.1038/s41564-023-01583-9.

Probiotic supplements are suggested to promote human health by preventing pathogen colonization. However, the mechanistic bases for their efficacy in vivo are largely uncharacterized. Here using metabolomics and bacterial genetics, we show that the human oral probiotic *Streptococcus salivarius* K12 (SAL) produces salivabactin, an antibiotic that effectively inhibits pathogenic *Streptococcus pyogenes* (GAS) in vitro and in mice. However, prophylactic dosing with SAL enhanced GAS colonization in mice and ex vivo in human saliva. We showed that, on co-colonization, GAS responds to a SAL intercellular peptide signal that controls SAL salivabactin production. GAS produces a secreted protease, SpeB, that targets SAL-derived salivarinins and enhances GAS survival. Using this knowledge, we re-engineered probiotic SAL to prevent signal eavesdropping by GAS and potentiate SAL antimicrobials. This engineered probiotic demonstrated superior efficacy in preventing GAS colonization in vivo. Our findings show that knowledge of interspecies interactions can identify antibiotic- and probiotic-based strategies to combat infection.

4-21 Plant Sciences
Enhanced salt stress tolerance in plants without growth penalty through increased photosynthesis activity by plastocyanin from Antarctic moss

Bae, NoA., Shim, Su-Hyeon., Alavilli, Hemasundar., Do, Hackwon., Park, Mira., Lee, Dong Wook., Lee, Jun Hyuck., Lee, Hyoungseok. and 4 others.

Plant Journal. 2025. 121(1).

doi: 10.1111/tpj.17168.

Salinity poses a significant challenge to plant growth and crop productivity by adversely affecting crucial processes, including photosynthesis. Efforts to enhance abiotic stress tolerance in crops have been hindered by the trade-off effect, where increased stress resistance is accompanied by growth reduction. In this study, we identified and characterized a plastocyanin gene (PaPC) from the Antarctic moss *Polytrichum alpinum*, which enhanced photosynthesis and salt stress tolerance in *Arabidopsis thaliana* without compromising growth. While there were no

4-20 Microbiology
Engineered probiotic overcomes pathogen defences using signal interference and antibiotic production to treat infection in mice

differences in growth and salt tolerance between the wild type and *Arabidopsis* plastocyanin genes (*AtPC1* and *AtPC2*)-overexpressing plants, *PaPC*-overexpressing plants demonstrated superior photosynthetic efficiency, increased biomass, and enhanced salt tolerance. Similarly, *PaPC*-overexpressing rice plants exhibited improved yield potential and photosynthetic efficiency under both normal and salt stress conditions. Key amino acid residues in *PaPC* responsible for this enhanced functionality were identified, and their substitution into *AtPC2* conferred improved photosynthetic performance and stress tolerance in *Arabidopsis*, tobacco, and tomato. These findings not only highlight the potential of extremophiles as valuable genetic resources but also suggest a photosynthesis-based strategy for developing stress-resilient crops without a growth penalty.

keywords:

plastocyanin; photosynthesis; salt stress; trade-off; extremophyte; Antarctic moss

0.2–0.7°C] in soil temperature results in an increase in growing season ecosystem respiration by 30% [CI 22–38%] ($n = 136$). Our findings indicate that the stimulation of ecosystem respiration was due to increases in both plant-related and microbial respiration ($n = 9$) and continued for at least 25 years ($n = 136$). The magnitude of the warming effects on respiration was driven by variation in warming-induced changes in local soil conditions, that is, changes in total nitrogen concentration and pH and by context-dependent spatial variation in these conditions, in particular total nitrogen concentration and the carbon:nitrogen ratio. Tundra sites with stronger nitrogen limitations and sites in which warming had stimulated plant and microbial nutrient turnover seemed particularly sensitive in their respiration response to warming. The results highlight the importance of local soil conditions and warming-induced changes therein for future climatic impacts on respiration.

4-22 Multidisciplinary Sciences

Environmental drivers of increased ecosystem respiration in a warming tundra

Maes, S. L., Dietrich, J., Midolo, G., Schwieger, S., Kummu, M., Vandvik, V., Aerts, R., Althuizen, I. H. J., Biasi, C., Bjoerk, R. G., Boehner, H., Carbognani, M., Chiari, G., Christiansen, C. T., Clemmensen, K. E., Cooper, E. J., Cornelissen, J. H. C., Elberling, B., Faubert, P., Fetcher, N., Forte, T. G. W., Gaudard, J., Gavazov, K., Guan, Z., Gumundsson, J., Gya, R., Hallin, S., Hansen, B. B., Haugum, S. V., He, J. S., Hicks Pries, C., Hovenden, M. J., Jalava, M., Jonsdottir, I. S., Juhanson, J., **Jung, Ji Young.** and 40 others.

Nature. 2024. 629(8010): 105–+.

doi: 10.1038/s41586-024-07274-7.

Arctic and alpine tundra ecosystems are large reservoirs of organic carbon^{1,2}. Climate warming may stimulate ecosystem respiration and release carbon into the atmosphere^{3,4}. The magnitude and persistency of this stimulation and the environmental mechanisms that drive its variation remain uncertain^{5,6,7}. This hampers the accuracy of global land carbon-climate feedback projections^{7,8}. Here we synthesize 136 datasets from 56 open-top chamber in situ warming experiments located at 28 arctic and alpine tundra sites which have been running for less than 1 year up to 25 years. We show that a mean rise of 1.4°C [confidence interval (CI) 0.9–2.0°C] in air and 0.4°C [CI

4-23 Biochemical Research Methods; Mathematical & Computational Biology

Evidential deep learning for trustworthy prediction of enzyme commission number

Han, So-Ra., Park, Mingyu., Kosaraju, Sai., Lee, JeungMin., Lee, Hyun., **Lee, Jun Hyuck.**, Oh, Tae-Jin. and Kang, Mingon.

Briefings in Bioinformatics. 2023. 25(1).

doi: 10.1093/bib/bbad401.

The rapid growth of uncharacterized enzymes and their functional diversity urge accurate and trustworthy computational functional annotation tools. However, current state-of-the-art models lack trustworthiness on the prediction of the multilabel classification problem with thousands of classes. Here, we demonstrate that a novel evidential deep learning model (named EC PICK) makes trustworthy predictions of enzyme commission (EC) numbers with data-driven domain-relevant evidence, which results in significantly enhanced predictive power and the capability to discover potential new motif sites. EC PICK learns complex sequential patterns of amino acids and their hierarchical structures from 20 million enzyme data. EC PICK identifies significant amino acids that contribute to the prediction without multiple sequence alignment. Our intensive assessment showed not only outstanding enhancement of predictive performance on the largest databases of Uniprot, Protein Data Bank (PDB) and Kyoto Encyclopedia of Genes and Genomes (KEGG), but also a capability to discover new motif sites in microorganisms. EC PICK is a reliable EC number

prediction tool to identify protein functions of an increasing number of uncharacterized enzymes.

keywords:

enzyme commission number; evidential deep learning; biologically interpretable deep learning; ECPICK

4-24 Plant Sciences

Exploring the mechanisms underlying recovery from freeze-thaw injury in *Colobanthus quitensis*: mechanistic insights via transcriptome profiling

Min, Kyungwon., Sulaiman, Syahril., Jeong, Jihye., Lee, Hyodong., Lee, Jungeun., Lee, Jun Hyuck. and Lee, Hyoungseok.

Physiologia Plantarum. 2024. 176(6).

doi: 10.1111/ppl.14642.

Antarctic plants face significant challenges due to exposure to freeze–thaw stress throughout their life cycle. The ability to recover from freeze–thaw injuries during post-thaw recovery (PTR) periods is a crucial skill for their survival and growth. However, no research, to the best of our knowledge, has explored their recovery mechanisms at the cellular and molecular levels. To investigate the potential cellular mechanism during PTR periods, we focused on *Colobanthus quitensis*, one of solely two vascular plant species in the Antarctic Peninsula. Having determined the lethal temperature causing 50% cellular injury (LT_{50}) under freezing to be -8.0°C , we subjected plants to sub-injurious (-7.0°C) and injurious (-9.0°C) freezing treatments. We then compared recovery abilities at these stress levels using physiological indicators such as ion-leakage, PSII quantum efficiency (Fv/Fm), and antioxidant enzyme activities. Comparative analysis indicated that plants exposed to -7.0°C progressively recovered during PTR periods, showing reduced ion-leakage and increased Fv/Fm, while those stressed at -9.0°C exhibited irrecoverable damage with lower antioxidant enzymes activities. To investigate the molecular basis of recovery, we examined transcriptome changes in tissues exposed to -7.0°C during PTR periods through GO and KEGG pathway enrichment analyses. These analyses identified six potential cellular events involved in the recovery process, including ionic & pH homeostasis, cell wall remodeling, protein repair, defense against potential microbial attacks, free radical scavenging, and DNA repair. Understanding the cellular and molecular mechanisms of recovery from freeze–thaw injuries enhances our knowledge

on how Antarctic plants adapt to extreme environments, offering valuable insights into their survival strategies.

4-25 Biochemical Research Methods; Biochemistry & Molecular Biology; Biophysics; Crystallography

First crystal structure of the DUF2436 domain of virulence proteins from *Porphyromonas gingivalis*

Kim, Bogeun., Hwang, Jisub., Im, Sehyeok., Do, Hackwon., Shim, Youn-Soo. and Lee, Jun Hyuck.

Acta Crystallographica Section F-Structural Biology Communications. 2024. 80: 252-262.

doi: 10.1107/s2053230x24008185.

Porphyromonas gingivalis is a major pathogenic oral bacterium that is responsible for periodontal disease. It is linked to chronic periodontitis, gingivitis and aggressive periodontitis. *P. gingivalis* exerts its pathogenic effects through mechanisms such as immune evasion and tissue destruction, primarily by secreting various factors, including cysteine proteases such as gingipain K (Kgp), gingipain R (RgpA and RgpB) and PrtH (UniProtKB ID P46071). Virulence proteins comprise multiple domains, including the pro-peptide region, catalytic domain, K domain, R domain and DUF2436 domain. While there is a growing database of knowledge on virulence proteins and domains, there was no prior evidence or information regarding the structure and biological function of the well conserved DUF2436 domain. In this study, the DUF2436 domain of PrtH from *P. gingivalis* (PgDUF2436) was determined at 2.21 Å resolution, revealing a noncanonical β -jelly-roll sandwich topology with two antiparallel β -sheets and one short α -helix. Although the structure of PgDUF2436 was determined by the molecular-replacement method using an *AlphaFold* model structure as a template, there were significant differences in the positions of $\beta 1$ between the *AlphaFold* model and the experimentally determined PgDUF2436 structure. The *Basic Local Alignment Search Tool* sequence-similarity search program showed no sequentially similar proteins in the Protein Data Bank. However, *DaliLite* search results using structure-based alignment revealed that the PgDUF2436 structure has structural similarity Z-scores of 5.9–5.4 with the C-terminal domain of AlgF, the D4 domain of cytolysin, IgIE and the extracellular domain structure of PepT2. This study has elucidated the structure of the DUF2436 domain for the first time and a comparative analysis with similar structures has been performed.

keywords:

DUF2436 domain; oral pathogens; *Porphyromonas gingivalis*; X-ray crystallography; cysteine proteases

4-26

Functional characterization and unraveling the structural determinants of novel steroid hydroxylase CYP154C7 from *Streptomyces* sp. PAMC26508

Paudel, Prakash., Regmi, Kamal Prasad., Kim, Ki-Hwa., Lee, Jun Hyuck. and Oh, Tae-Jin.

Heliyon. 2024. 10(21): e39777-e39777.

doi: 10.1016/j.heliyon.2024.e39777.

This study characterized cytochrome P450 enzyme CYP154C7 from *Streptomyces* sp. PAMC26508, emphasizing its capability to hydroxylate steroids, especially at the 16 α -position. The enzymatic assay of CYP154C7 demonstrated effective conversion across a pH range of 7.2–7.6, with optimal activity at 30 °C in the Pdx/PdR plus NADH system. Kinetic analysis on most converted steroids (androstenedione and adrenosterone) was performed which shows a greater affinity for androstenedione (K_m , 11.06 $\pm$ 1.903 μ M; V_{max} , 0.0062 $\pm$ 0.0002 sec⁻¹) compared to adrenosterone (K_m , 34.50 $\pm$ 6.2 μ M; V_{max} , 0.0119 $\pm$ 0.0007 sec⁻¹). A whole-cell system in *Escherichia coli*, overexpressing recombinant CYP154C7, achieved substantial conversion for steroids, indicating that CYP154C7 can also be used as a potential whole-cell biocatalyst. To gain structural insights, homology models of CYP154C7 and its homologs were constructed using CYP154C5 (PDB ID: 6TO2), refined, validated, and used for docking studies. Comparative docking analysis suggests that lysine (K236) in the active site and tyrosine (Y197) in the substrate access channel of CYP154C7 are crucial for substrate selectivity and catalytic efficiency. This study suggests that CYP154C7 could be a promising candidate for developing modified steroids, providing valuable insights for protein engineering to design commercially useful CYP steroid hydroxylases with diverse substrate specificities.

keywords:

Biocatalyst; Cytochrome P450; Molecular docking; Steroid hydroxylases; *Streptomyces*

4-27 Biochemistry & Molecular Biology; Microbiology; Mycology

Fungal biodegradation of poly(butylene adipate-co-terephthalate)-polylactic acid-thermoplastic starch based commercial bio-plastic film at ambient conditions

Ko, Yongseok., Yang, Youri., Kim, Dockyu. and 3 others.

Chemosphere. 2024. 353: 141554-141554.

doi: 10.1016/j.chemosphere.2024.141554.

Microbial biodegradation of commercially available poly(butylene adipate-co-terephthalate)-polylactic acid-thermoplastic starch based bio-plastic has been pursued at high temperatures exceeding 55 °C. Herein, we first reported three newly isolated fungal strains from farmland soil samples of Republic of Korea namely, *Pyrenochaetopsis* sp. strain K2, *Staphylotrichum* sp. S2-1, and *Humicola* sp. strain S2-3 were capable of degrading a commercial bio-plastic film with degradation rates of 9.5, 8.6, and 12.2%, respectively after 3 months incubation at ambient conditions. Scanning electron microscopy (SEM) analyses showed that bio-plastic film was extensively fragmented with severe cracking on the surface structure after incubation with isolated fungal strains. X-ray diffraction (XRD) analysis also revealed that high crystallinity of the commercial bio-plastic film was significantly decreased after degradation by fungal strains. Liquid chromatography-mass spectrometry (LC–MS) analyses of the fungal culture supernatants containing the bio-plastic film showed the peaks for adipic acid, terephthalic acid (TPA), and terephthalate-butylene (TB) as major metabolites, suggesting cleavage of ester bonds and accumulation of TPA. Furthermore, a consortium of fungal strain K2 with TPA degrading bacterium *Pigmentiphaga* sp. strain P3-2 isolated from the same sampling site exhibited faster degradation rate of the bio-plastic film within 1 month of incubation with achieving complete biodegradation of accumulated TPA. We assume that the extracellular lipase activity presented in the fungal cultures could hydrolyze the ester bonds of PBAT component of bio-plastic film. Taken together, the fungal and bacterial consortium investigated herein could be beneficial for efficient biodegradation of the commercial bio-plastic film at ambient conditions.

keywords:

Biodegradation; Commercial bio-plastic film; Consortium; PBAT; *Pyrenochaetopsis* sp. strain K2

4-28 Biotechnology & Applied Microbiology; Genetics & Heredity

Gene loss in Antarctic icefish: evolutionary adaptations mimicking Fanconi Anemia?

Shin, Seung Chul., Kim, Sanghee., Kim, Han-Woo., Lee, Jun Hyuck. and Kim, Jin-Hyoung.

Bmc Genomics. 2024. 25(1).

doi: 10.1186/s12864-024-11028-0.

Background: The white-blooded Antarctic icefishes is a representative organism that survive under the stenothermal conditions of the Southern Ocean without the hemoglobin genes. To compensate for inefficient oxygen transport, distinct features such as increased heart size, greater blood volume, and reduced hematocrit density enhance the amount of dissolved oxygen and the velocity of blood flow. **Results:** Here, we investigated these unique characteristics by comparing high-quality genomic data between white-blooded and red-blooded fishes and identified the loss of *FAAP20*, which is implicated in anemia. Although the gene region containing *FAAP20* is conserved in notothenioids as shown through collinear analysis, only remnants of *FAAP20* persist in several icefish species. Additionally, we observed the loss of *SOAT1*, which plays a pivotal role in cholesterol metabolism, providing a clue for further investigations into the unique mitochondrial form of the icefish.

Conclusions: The loss of *FAAP20*, which is known to reduce erythrocyte counts under stress conditions in mice and humans, may provide a clue to understanding the genomic characteristics related to oxygen supply, such as low hematocrit, in Antarctic icefishes.

keywords:

Antarctic icefish; Gene loss; Fanconi anemia; *FAAP20*

Geothermal features in Antarctica provide favorable conditions for diverse microorganisms, yet their genomic diversity remains poorly understood. Here, we present an integrated dataset comprising PacBio HiFi and Hi-C metagenomic sequencing, along with single-cell amplified genomes (SAGs) from two high-altitude geothermal sites, Mount Melbourne and Mount Rittmann, in Antarctica. The long-read HiFi sequencing, coupled with Hi-C, enhances the understanding of microbiome diversity and functionality in this unique ecosystem by providing more complete and accurate genomic information. SAGs complement this by recovering rare microbial taxa and offering a strain-resolved perspective. This dataset aims to deepen our understanding of microbial evolution and ecology in Antarctic geothermal environments, and facilitate cross-comparison with other geothermal environments globally.

4-30

High-quality chromosome-level genome assembly of female *Artemia franciscana* reveals sex chromosome and *Hox* gene organization

Jo, Euna., Cho, Minjoo., Choi, Soyun., Lee, Seung Jae., Choi, Eunkyung., Kim, Jinmu., Kim, Jang Yeon., Kwon, Sooyeon., Lee, Jun Hyuck. and Park, Hyun.

Heliyon. 2024. 10(19): e38687-e38687.

doi: 10.1016/j.heliyon.2024.e38687.

Artemia is a crustacean genus belonging to the order Anostraca in the class Branchiopoda and lives in inland hypersaline lakes. Among the genus, *A. franciscana* is a valuable species as a fish food in the aquaculture industry or as an aquatic model organism for toxicity tests. However, genomic data for *A. franciscana* remains incomplete. In this study, high-quality genome assembly at the chromosome level of female *A. franciscana* was conducted by combining various sequencing and assembly technologies. The final *A. franciscana* assembled genome was 1.27 Gb in length, containing 21 chromosomal scaffolds (>10 Mb). The scaffold N50 was 45.3 Mb, with a complete BUSCO value of 91.0 %, thereby confirming that a high-quality genome was assembled. Gene annotation shows that the *A. franciscana* genome contained 67.26 % of repetitive sequences, and a total of 26,923 protein-coding genes were predicted. Among the 21 chromosome-scale scaffolds, chromosome 1 was identified as a sex chromosome Z. Additionally, five contigs of putative W chromosome fragments and the candidate sex-determining genes were

4-29 Multidisciplinary Sciences

Genomic profiling of Antarctic geothermal microbiomes using long-read, Hi-C, and single-cell techniques

Myeong, Nu Ri., Choe, Yong-Hoe., Shin, Seung Chul., Kim, Jinhyun., Sul, Woo Jun. and Kim, Mincheol.

Scientific Data. 2024. 11(1).

doi: 10.1038/s41597-024-03875-z.

suggested. Ten homeobox (*Hox*) genes were identified in *A. franciscana* on the chromosome 14, which were in two subclusters with a large gap. *Hox* gene organizations within 13 arthropods showed that four anostracans had conserved synteny. This study provides a new female *Artemia* genome with sex chromosome and the first complete genomic arrangement of the *Hox* cluster in Anostraca. This study will be a useful genomic and genetic reference for understanding the evolution and development of *A. franciscana*.

keywords:

Brine shrimp; Gene annotation; Hi-C scaffolding; Homeobox gene; Long-read sequencing; Sex determination; ZW chromosome

4-31 Behavioral Sciences; Zoology

Individual differences in responses to unmanned aerial vehicles among Weddell seals, *Leptonychotes weddellii*

Park, Jikang., Lee, Won Young. and Han, Chang Suk.

Animal Behaviour. 2024. 213: 173-182.

doi: 10.1016/j.anbehav.2024.05.009.

Unmanned aerial vehicles (UAVs) offer invaluable contributions to wildlife observation, reducing costs and human risk while minimizing disturbance to animals during aerial surveys. However, within a population, individual animals can exhibit different responses to UAVs. This indicates that the level of UAV disturbance might differ between individuals even when the disturbance is mild at the population level. However, few studies have investigated UAV disturbance at the individual level. In this study, we explored the variation in response to UAVs among individual Weddell seals along the Terra Nova Bay coastline in Antarctica. We also examined how internal factors such as age, group composition and whether their eyes were open, as well as external factors such as UAV flight schemes, influenced responses. Our findings showed substantial variation among individual seals in both their overall response and changes in response to descending UAVs. Notably, seals were more sensitive to UAVs with vertical flight schemes than to those with horizontal flight schemes. When seals were in groups or had their eyes closed, their vigilance responses to UAVs decreased. Therefore, our findings highlight the importance of not only considering individual factors but also avoiding vertical flight patterns during UAV-based aerial surveys of Weddell seals, thus minimising

disturbance. Additionally, we recommend developing more effective approaches for wildlife research that utilize UAVs by incorporating the consideration of individual differences in responses to UAVs.

keywords:

animal personality; individual difference; plasticity; unmanned aerial vehicle; Weddell seal

4-32 Microbiology

Interaction between phytoplankton and heterotrophic bacteria in Arctic fjords during the glacial melting season as revealed by eDNA metabarcoding

Han, Dukki., Park, Ki-Tae., Kim, Haryun., Kim, Tae-Hoon., Jeong, Man-Ki. and Nam, Seung-Il.

Fems Microbiology Ecology. 2024. 100(5).

doi: 10.1093/femsec/fiae059.

The hydrographic variability in the fjords of Svalbard significantly influences water mass properties, causing distinct patterns of microbial diversity and community composition between surface and subsurface layers. However, surveys on the phytoplankton-associated bacterial communities, pivotal to ecosystem functioning in Arctic fjords, are limited. This study investigated the interactions between phytoplankton and heterotrophic bacterial communities in Svalbard fjord waters through comprehensive eDNA metabarcoding with 16S and 18S rRNA genes. The 16S rRNA sequencing results revealed a homogenous community composition including a few dominant heterotrophic bacteria across fjord waters, whereas 18S rRNA results suggested a spatially diverse eukaryotic plankton distribution. The relative abundances of heterotrophic bacteria showed a depth-wise distribution. By contrast, the dominant phytoplankton populations exhibited variable distributions in surface waters. In the network model, the linkage of phytoplankton (Prasinophytae and Dinophyceae) to heterotrophic bacteria, particularly Actinobacteria, suggested the direct or indirect influence of bacterial contributions on the fate of phytoplankton-derived organic matter. Our prediction of the metabolic pathways for bacterial activity related to phytoplankton-derived organic matter suggested competitive advantages and symbiotic relationships between phytoplankton and heterotrophic bacteria. Our findings provide valuable insights into the response of phytoplankton-bacterial interactions to

environmental changes in Arctic fjords.

keywords:

Arctic glacial fjord; eDNA metabarcoding; heterotrophic bacteria; phycosphere; phytoplankton variability; rRNA

4-33 Environmental Sciences; Marine & Freshwater Biology

Interactions between lipid metabolism and the microbiome in aquatic organisms: A review

Yoon, Deok-Seo., Kim, Duck-Hyun., **Kim, Jin-Hyoung.**, and 5 others.

Marine Pollution Bulletin. 2024. 207.

doi: 10.1016/j.marpolbul.2024.116858.

Marine organisms' lipid metabolism contributes to marine ecosystems by producing a variety of lipid molecules. Historically, research focused on the lipid metabolism of the organisms themselves. Recent microbiome studies, however, have revealed that gut microbial communities influence the amount and type of lipids absorbed by organisms, thereby altering the organism's lipid metabolism. This has highlighted the growing importance of research on gut microbiota. This review highlights mechanisms by which gut microbiota facilitate lipid digestion and diversify the lipid pool in aquatic animals through the accelerated degradation of exogenous lipids and the transformation of lipid molecules. We also assess how environmental factors and pollutants, along with the innovative use of probiotics, interact with the gut microbiome to influence lipid metabolism within the host. We aim to elucidate the complex interactions between lipid metabolism and gut microbiota in aquatic animals by synthesizing current research and identifying knowledge gaps, providing a foundation for future explorations.

keywords:

Aquatic animal; Lipid metabolism; Fatty acid; Gut microbiota; Host-microbiome interactions

4-34 Engineering, Environmental; Environmental Sciences

Interspecific Variations in the Internal Mercury Isotope Dynamics of Antarctic Penguins: Implications for Biomonitoring

Jung, Saebom., Besnard, Lucien., Li, Mi-Ling., Reinfelder, John., Kim,

Eunhee., Kwon, Sae Yun. and **Kim, Jeong-Hoon.**

Environmental Science & Technology. 2024. 58(14): 6349-6358.

doi: 10.1021/acs.est.3c09452.

Mercury (Hg) biomonitoring requires a precise understanding of the internal processes contributing to disparities between the Hg sources in the environment and the Hg measured in the biota. In this study, we investigated the use of Hg stable isotopes to trace Hg accumulation in Adélie and emperor penguin chicks from four breeding colonies in Antarctica. Interspecific variation of $\Delta^{199}\text{Hg}$ in penguin chicks reflects the distinct foraging habitats and Hg exposures in adults. Chicks at breeding sites where adult penguins predominantly consumed mesopelagic prey showed relatively lower $\Delta^{199}\text{Hg}$ values than chicks that were primarily fed epipelagic krill. Substantial $\delta^{202}\text{Hg}$ variations in chick tissues were observed in both species (Adélie: -0.11 to 1.13‰ , emperor: -0.27 to 1.15‰), whereas only emperor penguins exhibited the lowest $\delta^{202}\text{Hg}$ in the liver and the highest in the feathers. Our results indicate that tissue-specific $\delta^{202}\text{Hg}$ variations and their positive correlations with % MeHg resulted from MeHg demethylation in the liver and kidneys of emperor penguin chicks, whereas Adélie penguin chicks showed different internal responses depending on their exposure to dietary MeHg. This study highlights the importance of considering intra- and interspecific variations in adult foraging ecology and MeHg demethylation when selecting penguin chicks for Hg biomonitoring.

keywords:

mercury stable isotope; chick carcasses; MeHg demethylation; ecotoxicology; regurgitation

4-35 Engineering, Environmental; Engineering, Chemical

Key determinants of soil labile nitrogen changes under climate change in the Arctic: A meta-analysis of the responses of soil labile nitrogen pools to experimental warming and snow addition

Kim, You Jin., Hyun, Junge., Michelsen, Anders., Kwon, Eilhann E. and **Jung, Ji Young.**

Chemical Engineering Journal. 2024. 494.

doi: 10.1016/j.cej.2024.153066.

The Arctic terrestrial ecosystems are undergoing rapid climate change, causing shifts in the dynamics of soil nitrogen (N), a pivotal but relatively underexplored

component. To understand the impacts of climate change on soil labile N pools, we performed meta- and decision-tree analyses of 391 observations from 38 peer-reviewed publications across the Arctic, focusing on experimental warming and snow addition. Soil dissolved organic nitrogen (DON), ammonium (NH_4^+), and nitrate (NO_3^-) pools under experimental warming exhibited overall standard mean differences (SMDs) ranging from -0.08 to 0.02 , with no significance ($P > 0.05$); however, specific conditions led to significant changes. The key determinants of soil labile N responses to warming were experimental duration and mean annual summer temperature for DON; annual precipitation, soil moisture, and sampling timing for NH_4^+ ; and soil layer for NO_3^- . Snow addition significantly increased all labile N pools (overall SMD = 0.23 – 0.36 ; $P < 0.05$), influenced by factors such as sampling timing and vegetation type for DON; experimental duration and soil moisture for NH_4^+ ; and soil pH for NO_3^- . By consolidating and reprocessing datasets, we not only showed the overall responses of soil labile N pools to climate manipulation experiments in Arctic tundra ecosystems but also identified key determinants for changes in soil N pools among environmental and experimental variables. Our findings demonstrate that warming and snow-cover changes significantly affect soil labile N pools, highlighting how the unique environmental characteristics of different sites influence terrestrial N cycling and underscoring the complexity of Arctic N dynamics under climate change.

keywords:

Arctic terrestrial ecosystem; Soil labile nitrogen; Experimental warming; Snow addition; Meta-analysis; Decision-tree analysis

kribbensis CHA-19, a strain that can utilize kraft lignin and its main degradation metabolite, vanillic acid, as growth substrates. Gel permeation chromatography revealed that CHA-19 decomposed polymeric lignin and degraded dehydrodivanillin (a representative lignin model compound); however, the degradative enzyme(s) and mechanism were not identified. Quantitative polymerase chain reaction with mRNAs from CHA-19 cells induced in the presence of lignin showed that the putative genes coding for two laccase-like multicopper oxidases (LMCOs) and three dye-decolorizing peroxidases (DyPs) were upregulated by 2.0- to 7.9-fold compared with glucose-induced cells, which indicates possible cooperation with multiple enzymes for lignin decomposition. Computational homology analysis of the protein sequences of LMCOs and DyPs also predicted their roles in lignin decomposition. Based on the above data, CHA-19 appears to initiate oxidative lignin decomposition using multifunctional LMCOs and DyPs, producing smaller metabolites such as vanillic acid, which is further degraded via *ortho*- and *meta*-ring cleavage pathways. This study not only helps to better understand the role of bacteria in lignin decomposition and thus in terrestrial ecosystems, but also expands the biocatalytic toolbox with new bacterial cells and their degradative enzymes for lignin valorization.

keywords:

Bacterial peroxidase; bacterial laccase; biocatalyst; biodegradation; kraft lignin; *Pseudomonas*

4-36 Biotechnology & Applied Microbiology; Microbiology

Kraft Lignin Decomposition by Forest Soil Bacterium *Pseudomonas kribbensis* CHA-19

Kim, Dockyu., Kim, Han-Woo. and Lee, Hyungseok.

Journal of Microbiology and Biotechnology. 2024. 34(9): 1867-1875.

doi: 10.4014/jmb.2406.06021.

Identification of the biochemical metabolic pathway for lignin decomposition and the responsible degradative enzymes is needed for the effective biotechnological valorization of lignin to renewable chemical products. In this study, we investigated the decomposition of kraft lignin by the soil bacterium *Pseudomonas*

4-37 Plant Sciences

Life under the snow: A year-round transcriptome analysis of Antarctic mosses in natural habitats provides insight into the molecular adaptation of plants under extreme environment

Yu, Jihyeon., Lee, Hyungseok., Cho, Sung Mi., Lee, Yelim., Kim, Dockyu., Hong, Soon Gyu., Park, Sang-Jong., Kim, Sang-Gyu., Jin, Hongshi. and Lee, Jungeun.

Plant Cell and Environment. 2024. 47(3): 976-991.

doi: 10.1111/pce.14793.

Mosses are vital components of ecosystems, exhibiting remarkable adaptability across diverse habitats from deserts to polar ice caps. *Sanionia uncinata* (Hedw.) Loeske, a dominant Antarctic moss survives extreme environmental condition through perennial lifecycles involving growth and dormancy alternation. This study explores genetic controls

and molecular mechanisms enabling *S. uncinata* to cope with seasonality of the Antarctic environment. We analysed the seasonal transcriptome dynamics of *S. uncinata* collected monthly from February 2015 to January 2016 in King George Island, Antarctica. Findings indicate that genes involved in plant growth were predominantly upregulated in Antarctic summer, while those associated with protein synthesis and cell cycle showed marked expression during the winter-to-summer transition. Genes implicated in cellular stress and abscisic acid signalling were highly expressed in winter. Further, validation included a comparison of the Antarctic field transcriptome data with controlled environment simulation of Antarctic summer and winter temperatures, which revealed consistent gene expression patterns in both datasets. This proposes a seasonal gene regulatory model of *S. uncinata* to understand moss adaptation to extreme environments. Additionally, this data set is a valuable resource for predicting genetic responses to climatic fluctuations, enhancing our knowledge of Antarctic flora's resilience to global climate change.

keywords:

Antarctica; bryophyte; dormancy; environmental adaptation; extremophyte; moss; perennial; RNA-seq; *Sanionia uncinata*; season

4-38 Biotechnology & Applied Microbiology; Immunology; Microbiology; Pharmacology & Pharmacy

Mass spectrometry-guided isolation of thiodiketopiperazines from an EtOAc-extract of *Setosphaeria rostrata* culture medium and their anti-skin aging effects on TNF- α -induced human dermal fibroblasts

Kwon, Haeun., Ann, Hee Woon., Park, Sojung., Kwon, Jaeyoung., Park, Keunwan., Ryu, Seung Mok., Guo, Yuanqiang., Kim, Jae-Jin., Yim, Joung Han., Kim, Il-Chan. and 3 others.

Journal of Antibiotics. 2024. 77(4): 257-263.

doi: 10.1038/s41429-023-00702-2.

Using mass spectrometry (MS)-guided isolation methods, a new thiodiketopiperazine derivative (1) and exserohilone (2) were isolated from an EtOAc-extract of *Setosphaeria rostrata* culture medium. The chemical structure of the new compound was elucidated by MS and NMR spectroscopy, and the absolute configurations were established by the quantum mechanical calculations of electronic circular dichroism. All isolated compounds were

examined for their effects on reactive oxygen species (ROS) production, matrix metalloproteinase 1 (MMP-1) secretion, and procollagen type I $\alpha 1$ secretion in tumor necrosis factor (TNF)- α -induced human dermal fibroblasts. Compound 1 and exserohilone (2) exhibited the inhibition of TNF- α -induced ROS generation and MMP-1 secretion. Additionally, compound 1 and exserohilone (2) increased the procollagen type I $\alpha 1$ secretion. Compound 1 docked computationally into the active site of MMP-1 (−6.0 kcal/mol).

4-39 Genetics & Heredity; Microbiology

Microbial assemblages and associated biogeochemical processes in Lake Bonney, a permanently ice-covered lake in the McMurdo Dry Valleys, Antarctica

Lee, Hanbyul., Hwang, Kyuin., Cho, Ahnna., Kim, Soyeon., Kim, Minkyung., Morgan-Kiss, Rachael., Priscu, John C., Kim, Kyung Mo. and Kim, Ok-Sun.

Environmental Microbiome. 2024. 19(1).

doi: 10.1186/s40793-024-00605-1.

Background: Lake Bonney, which is divided into a west lobe (WLB) and an east lobe (ELB), is a perennially ice-covered lake located in the McMurdo Dry Valleys of Antarctica. Despite previous reports on the microbial community dynamics of ice-covered lakes in this region, there is a paucity of information on the relationship between microbial genomic diversity and associated nutrient cycling. Here, we applied gene- and genome-centric approaches to investigate the microbial ecology and reconstruct microbial metabolic potential along the depth gradient in Lake Bonney.

Results: Lake Bonney is strongly chemically stratified with three distinct redox zones, yielding different microbial niches. Our genome enabled approach revealed that in the sunlit and relatively freshwater epilimnion, oxygenic photosynthetic production by the cyanobacterium *Pseudanabaena* and a diversity of protists and microalgae may provide new organic carbon to the environment. CO-oxidizing bacteria, such as Acidimicrobiales, Nanopelagicales, and Burkholderiaceae were also prominent in the epilimnion and their ability to oxidize carbon monoxide to carbon dioxide may serve as a supplementary energy conservation strategy. In the more saline metalimnion of ELB, an accumulation of inorganic nitrogen and phosphorus supports photosynthesis despite relatively low light levels. Conversely, in WLB the release of organic rich subglacial discharge from Taylor Glacier into

WLB would be implicated in the possible high abundance of heterotrophs supported by increased potential for glycolysis, beta-oxidation, and glycoside hydrolase and may contribute to the growth of iron reducers in the dark and extremely saline hypolimnion of WLB. The suboxic and subzero temperature zones beneath the metalimnia in both lobes supported microorganisms capable of utilizing reduced nitrogens and sulfurs as electron donors. Heterotrophs, including nitrate reducing sulfur oxidizing bacteria, such as Acidimicrobiales (MAG72) and Salinisphaeraceae (MAG109), and denitrifying bacteria, such as *Gracilimonas* (MAG7), Acidimicrobiales (MAG72) and Salinisphaeraceae (MAG109), dominated the hypolimnion of WLB, whereas the environmental harshness of the hypolimnion of ELB was supported by the relatively low in metabolic potential, as well as the abundance of halophile *Halomonas* and endospore-forming *Virgibacillus*.

Conclusions: The vertical distribution of microbially driven C, N and S cycling genes/pathways in Lake Bonney reveals the importance of geochemical gradients to microbial diversity and biogeochemical cycles with the vertical water column.

keywords:

Hypersaline; Cryosphere; Metagenomics; Biogeochemical cycles; Microbial metabolism

(MAGs) using shotgun metagenome sequencing. Taxonomic analysis identified 209 bacterial MAGs, with the predominant phyla Pseudomonadota (n = 82), Actinobacteriota (n = 38), Desulfobacterota (n = 23), along with 2 archaeal MAGs of Thermoproteota. Notably, 86% of the MAGs (n = 183) could not be classified into known species, indicating the potential presence of novel and unidentified microorganisms in the ESS. This dataset provides invaluable information on the microbial diversity and ecological functions in the rapidly changing ESS.

4-41 Environmental Sciences; Public, Environmental & Occupational Health

Molecular evidence for multiple origins and high genetic differentiation of non-native winter crane fly, *Trichocera maculipennis* (Diptera: Trichoceridae), in the maritime Antarctic

Kang, Seunghyun., Kim, Sanghee., Park, Kye Chung., Petrasianas, Andrius., Shin, Hyoung Chul., Jo, Euna., Cho, Sung Mi. and Kim, Ji Hee.

Environmental Research. 2024. 242.

doi: 10.1016/j.envres.2023.117636.

Native biodiversity and ecosystems of Antarctica safeguarded from biological invasion face recent threats from non-native species, accelerated by increasing human activities and climate changes. Over two decades ago, the winter crane fly, *Trichocera maculipennis*, was first detected on King George Island. It has now successfully colonized several research stations across King George Island. To understand the origin, genetic diversity, and population structure of this Holarctic species, we conducted mitochondrial DNA cytochrome c oxidase subunit I (COI) sequence analysis across both its native and invasive ranges. In parallel, we performed microsatellite loci analysis within the invasive ranges, utilizing 12 polymorphic microsatellite markers. Furthermore, we compared body sizes among adult males and females collected from three different locations of King George Island. Our COI sequence analysis exhibited two different lineages present on King George Island. Lineage I was linked to Arctic Svalbard and Polish cave populations and Lineage II was related to Canadian Terra Nova National Park populations, implying multiple origins. Microsatellite analysis further exhibited high levels of genetic diversity and significant levels of genetic differentiation among invasive populations. Body sizes of adult *T. maculipennis* were significantly different among invasive populations but were

4-40 Multidisciplinary Sciences

Microbial profiling of the East Siberian Sea sediments using 16S rRNA gene and metagenome sequencing

Jeon, Jehyun., Park, Yerin., Lee, Dong-Hun., Kim, Ji-Hoon., Jin, Young Keun., Hong, Jong Kuk. and Lee, Yung Mi.

Scientific Data. 2024. 11(1).

doi: 10.1038/s41597-024-04177-0.

The Arctic Ocean is experiencing significant global warming, leading to reduced sea-ice cover, submarine permafrost thawing, and increased river discharge. The East Siberian Sea (ESS) undergoes more significant terrestrial inflow from coastal erosion and river runoff than other Arctic seas. Despite extensive research on environmental changes, microbial communities and their functions in the ESS, which are closely related to environmental conditions, remain largely unexplored. Here, we investigated microbial communities in ESS surface sediments spanning latitudes from 73°N to 77°N using 16S rRNA amplicon sequencing, and reconstructed 211 metagenome-assembled genomes

not attributed to genetics. This significant genetic diversity likely facilitated the rapid colonization and establishment of *T. maculipennis* on King George Island, contributing to their successful invasion. Molecular analysis results revealed a substantial amount of genetic variation within invasive populations, which can serve as management units for invasive species control. Furthermore, the genetic markers we developed in the study will be invaluable tools for tracking impending invasion events and the travel routes of new individuals. Taken together, these findings illustrate the highly invasive and adaptable characteristics of *T. maculipennis*. Therefore, immediate action is necessary to mitigate their ongoing invasion and facilitate their eradication.

keywords:

Antarctica; Biological invasion; Winter crane fly; King George Island; Microsatellite analysis; mtDNA COI

4-42 Food Science & Technology; Nutrition & Dietetics

Muscle extracts from Antarctic fishes *Trematomus bernacchii* and *T. Newnesi* enhance myofiber regeneration and muscle function through mTOR signaling

Lee, Seongmin., Baek, Mi-Ock., Kim, Jaewon., Kim, Il-Chan., Kim, Jin-Hyoung. and Yoon, Mee-Sup.

Journal of Functional Foods. 2024. 119.

doi: 10.1016/j.jff.2024.106310.

Muscle regeneration and functional restoration are crucial for patients with sarcopenia. Antarctic fish, which are well-adapted to extreme conditions, offer potential pharmacotherapeutic insights. Our study assessed muscle extracts from *Trematomus bernacchii* (TB) and *T. newnesi* (TN) in a BaCl₂-muscle injury mouse model. TB and TN extracts notably enhanced myofiber formation during muscle regeneration, showing potent proregenerative properties. Grip strength restoration was significantly improved, accompanied by increased expression of peroxisome proliferator-activated receptor gamma coactivator 1-alpha and mitochondrial content, which are vital for post-injury recovery. The activation of the mammalian target of rapamycin and insulin-like growth factor 2 muscle enhancer activity underpinned these effects. Ultra-performance liquid chromatography-mass spectrometry and Global Natural Product Social analysis annotated taurocholic acid and its derivatives, along with denatorium, as bioactive substances

that contribute to muscle enhancement. These findings have implications for therapeutic development for muscle regeneration and functional recovery in patients with musculoskeletal injuries and sarcopenia.

keywords:

Antarctic fishes; *Trematomus*; Muscle regeneration; Mammalian target of rapamycin; Taurocholic acid; Denatorium

4-43 Biochemistry & Molecular Biology; Plant Sciences; Cell Biology; Oncology; Pharmacology & Pharmacy

New anti-adipogenic triterpenoid saponins from the aerial parts of *Glinus oppositifolius*

Phi, Kim-Hoa., Park, Min-Ha., Lee, Seulah., Koo, Man Hyung., Suh, Sung Suk. and Youn, Ui Joung.

Biomedicine & pharmacotherapy = Biomedecine & pharmacotherapie. 2024. 176: 116851-116851.

doi: 10.1016/j.biopha.2024.116851.

Glinus oppositifolius L., a member of the Molluginaceae family, has a long-standing history of utilization as both a vegetable and a medicinal agent across numerous countries. This plant possesses a diverse range of pharmacological activities and attracts scientific interest in studying its chemical profile. The present phytochemical investigation of the plant resulted in the isolation of eleven new triterpenoid saponins, accompanied by three known compounds. Their structures were elucidated by intensive spectroscopic analysis, DFT calculations, and comparison with previously reported data. The isolates were evaluated for their anti-adipogenic effect and cytotoxicity against human cancer cell lines, namely, colorectal carcinoma HCT116, hepatoblastoma cell HepG2, breast cancer cell MDA-MB-231, and human lung adenocarcinoma cell A549. Compounds 5, 7, and 13 exhibited a potent inhibitory effect against the differentiation of preadipocyte 3T3-L1. In addition, compound 13 displayed inhibitory effects against the growth of A549 cancer cells.

keywords:

Anti-adipogenic activity; Cytotoxicity; *Glinus oppositifolius*; Hopane-type saponin

4-44 Biochemistry & Molecular Biology; Chemistry, Organic

New fusidane-type nortriterpenoids from the Arctic marine-derived fungus *Simplicillium lamellicola* culture medium with their inhibitory effect on benign prostatic hyperplasia

Kwon, Haeun., Jin, Bo-Ram., Yoo, Sori., Kim, Hyo-Jung., Hwang, Bang Yeon., Guo, Yuanqiang., Yim, Joung Han., Kim, Il-Chan. and 3 others. *Bioorganic Chemistry*. 2024. 143.
doi: 10.1016/j.bioorg.2023.107070.

Three new fusidane-type nortriterpenoids, simplifusinolide A, 24-*epi* simplifusinolide A, and simplifusidic acid L (1–3), were isolated from the EtOAc extract of the Arctic marine-derived fungus *Simplicillium lamellicola* culture medium, together with fusidic acid (4) and 16-*O*-deacetylfusidic acid (5). The structures of the isolated compounds were elucidated by NMR and MS analyses. The absolute configurations of compounds 1–3 were established by the quantum mechanical calculations of electronic circular dichroism and gauge-including atomic orbital NMR chemical shifts, followed by DP4 + analysis. Benign prostatic hyperplasia (BPH) is a major urological disorder in men worldwide. The anti-BPH potentials of the isolated compounds were evaluated using BPH-1 and WPMY-1 cells. Treatment with simplifusidic acid L (3) and fusidic acid (4) significantly downregulated the mRNA levels of the androgen receptor (*AR*) and its downstream effectors, inhibiting the proliferation of BPH-1 cells. Specifically, treatment with 24-*epi* simplifusinolide A (2) significantly suppressed the cell proliferation of both BPH-1 and DHT-stimulated WPMY-1 cells by inhibiting *AR* signaling. These results suggest the potential of 24-*epi* simplifusinolide A (2), simplifusidic acid L (3) and fusidic acid (4) as alternative agents for BPH treatment by targeting *AR* signaling.

keywords:

Arctic marine-derived fungus; *Simplicillium lamellicola*; Fusidane-type nortriterpenoids; Androgen receptor; Benign prostatic hyperplasia

4-45 Ecology; Geosciences, Multidisciplinary

Novel cold-active amylase-producing bacterium from Chukchi Sea and its enzyme properties

Kim, Min Ju., Kim, Jin A., Park, Ha Ju., Yim, Joung Han., Kim, Il Chan.

and Han, Se Jong.

Polish Polar Research. 2024. 45(3): 215-230.
doi: 10.24425/ppr.2024.150879.

A cold-active amylase was purified from *Alteromonas* sp. KS7913 isolated from the Chukchi Sea in the Arctic Ocean. After purification with use of ammonium sulfate precipitation, phenyl column chromatography, and size exclusion chromatography, 200.34 U mg⁻¹ of purified amylase was obtained. The final yield was 3.4%, and the activity was 5.7-fold higher than that of the initial culture broth. KS7913 origin amylase showed a molecular weight of 70 kDa and optimal activity at 25°C, pH 7.0 in Tris-HCl buffer. The amylase was highly active, especially at 5°C, and maintained stability at basic conditions below 25°C. Copper and zinc ions inhibited enzyme activity, whereas manganese, barium, and calcium ions exhibited positive effects. This activity was maintained even in the presence of alcohol. The findings of this study supplement our understanding of cold-active amylases, and may have practical applications in low-temperature industries.

keywords:

Arctic; *Alteromonas*; cold-adapted amylase; enzyme purification

4-46 Microbiology

Novel, cold-adapted D-laminaribiose- and D-glucose-releasing GH16 endo-β-1,3-glucanase from *Hymenobacter siberiensis* PAMC 29290, a psychrotolerant bacterium from Arctic marine sediment

Kim, Do Young., Lee, Yung Mi. and 3 others. *Frontiers in Microbiology*. 2024. 15.
doi: 10.3389/fmicb.2024.1470106.

Endo-β-1,3-glucanase is a glycoside hydrolase (GH) that plays an essential role in the mineralization of β-glucan polysaccharides. In this study, the novel gene encoding an extracellular, non-modular GH16 endo-β-1,3-glucanase (GluH) from *Hymenobacter siberiensis* PAMC 29290 isolated from Arctic marine sediment was discovered through an *in silico* analysis of its whole genome sequence and subsequently overexpressed in *Escherichia coli* BL21. The 870-bp GluH gene encoded a protein featuring a single catalytic GH16 domain that shared over 61% sequence identity with uncharacterized endo-β-1,3-glucanases

from diverse *Hymenobacter* species, as recorded in the National Center for Biotechnology Information database. The purified recombinant endo- β -1,3-glucanase (rGluH: 31.0 kDa) demonstrated peak activity on laminarin at pH 5.5 and 40°C, maintaining over 40% of its maximum endo- β -1,3-glucanase activity even at 25°C. rGluH preferentially hydrolyzed D-laminarioligosaccharides and β -1,3-linked polysaccharides, but did not degrade D-laminaribiose or structurally unrelated substrates, confirming its specificity as a true endo- β -1,3-glucanase without ancillary GH activities. The biodegradability of various substrate polymers by the enzyme was evaluated in the following sequence: laminarin > barley β -glucan > carboxymethyl-curdan > curdian > pachyman. Notably, the specific activity (253.1 U mg⁻¹) and catalytic efficiency (k_{cat}/K_m : 105.72 mg⁻¹ s⁻¹ mL) of rGluH for laminarin closely matched its specific activity (250.2 U mg⁻¹) and k_{cat}/K_m value (104.88 mg⁻¹ s⁻¹ mL) toward barley β -glucan. However, the k_{cat}/K_m value (9.86 mg⁻¹ s⁻¹ mL) of rGluH for insoluble curdian was only about 9.3% of the value for laminarin, which correlates well with the observation that rGluH displayed weak binding affinity (< 40%) to the insoluble polymer. The biocatalytic hydrolysis of D-laminarioligosaccharides with a degree of polymerization between 3 and 6 and laminarin generally resulted in the formation of D-laminaribiose as the predominant product and D-glucose as the secondary product, with a ratio of approximately 4:1. These findings suggest that highly active rGluH is an acidic, cold-adapted D-laminaribiose- and D-glucose-releasing GH16 endo- β -1,3-glucanase, which can be exploited as a valuable biocatalyst for facilitating low temperature preservation of foods.

keywords:

GH16; endo- β -1,3-glucanase; cold-adapted enzyme; Arctic; marine sediment; psychrotolerant; *Hymenobacter siberiensis*

When cells are exposed to freezing temperatures, high concentrations of cryoprotective agents (CPA) prevent ice crystal formation, thus enhancing cell survival. However, high concentrations of CPAs can also cause cell toxicity. Exopolysaccharides (EPSs) from polar marine environments exhibit lower toxicity and display effects similar to traditional CPA. In this study, we sought to address these issues by i) selecting strains that produce EPS with novel cryoprotective activity, and ii) optimizing culture conditions for EPS production. Sixty-six bacteria producing mucous substances were isolated from the Ross Sea (Antarctic Ocean) using solid marine agar plates. Among them, *Pseudoalteromonas* sp. RosPo-2 was ultimately selected based on the rheological properties of the produced EPS (p-CY02). Cryoprotective activity experiments demonstrated that p-CY02 exhibited significantly cryoprotective activity at a concentration of 0.8% (w/v) on mammalian cells (HaCaT). This activity was further improved when combined with various concentrations of dimethyl sulfoxide (DMSO) compared to using DMSO alone. Moreover, the survival rate of HaCaT cells treated with 5% (v/v) DMSO and 0.8% (w/v) p-CY02 was measured at 87.9 $\pm$ 2.8% after freezing treatment. This suggests that p-CY02 may be developed as a more effective, less toxic, and novel non-permeating CPA. To enhance the production of EPS with cryoprotective activity, Response Surface Methodology (RSM) was implemented, resulting in a 1.64-fold increase in production of EPS with cryoprotective activity.

keywords:

Cryoprotective activity; exopolysaccharide; the Antarctic Sea; response surface methodology

4-47 Biotechnology & Applied Microbiology; Microbiology

Optimization of Culture Medium for the Production of an Exopolysaccharide (p-CY02) with Cryoprotective Activity by *Pseudoalteromonas* sp. RosPo-2 from the Antarctic Sea

Kang, Pilsung., Kim, Sung Jin., Park, Ha Ju., Kim, Il Chan., Han, Se Jong. and Yim, Joung Han.

Journal of Microbiology and Biotechnology. 2024. 34(5): 1135-1145.
doi: 10.4014/jmb.2402.02037.

4-48

Oral Pathogens and Their Antibiotics from Marine Organisms: A Systematic Review of New Drugs for Novel Drug Targets

Im, Sehyeok., Lee, Jun Hyuck. and Shim, Youn-Soo.
Journal of Dental Hygiene Science. 2024. 24(2): 84-96.
doi: 10.17135/jdhs.2024.24.2.84.

Background: Recent studies have elucidated the quorum-sensing mechanisms, biofilm formation, inter-pathogen interactions, and genes related to oral pathogens. This review aims to explore the recent expansion of drug targets against oral pathogens and summarize the current research on novel antibiotic substances derived from marine organisms that target oral pathogens.

Methods: A comprehensive literature review summarized the novel mechanisms pertaining to quorum-sensing signal transmission systems, biofilm formation, and metabolite exchange in oral pathogens. The amino acid sequences of the 16 proteins identified as potential drug targets were systematically classified and compared across various oral microorganisms.

Results: Through a literature review, we identified nine studies researching quorum sensing signaling inhibitors targeting oral pathogens. A comparison of the amino acid sequences of 16 potential drug targets in oral microorganisms revealed significant differences between oral pathogens and beneficial oral symbiotic microorganisms. These findings imply that it is possible to design drugs that can bind more selectively to oral pathogens.

Conclusion: By summarizing the results of recent research on the signaling mechanisms that cause pathogenicity, new drug targets against oral pathogens were proposed. Additionally, the current status of developing new antibiotics for oral pathogens using recently developed quorum sensing inhibitors and natural products derived from marine organisms was introduced. Consequently, marine natural products can be used to develop drugs targeting new proteins in oral pathogens.

keywords:

Antibiotics; Biofilms; Marine organisms; Oral pathogen; Quorum sensing

rostroconchs, which we interpret as fossilized periostracal structures. These radial threads are observed in 13 species from five valid genera, exhibiting a widespread palaeogeographical distribution encompassing Gondwana (Australia), Siberia, western Laurentia (Utah), and eastern Laurentia (Greenland), and spanning Cambrian 4–Drumian deposits. These radial threads always cover the outermost surface of shells, dividing it into regular intervals, and develop through incremental growth. They originate from the apical area of helcionelloids or the umbo of rostroconchs. Detailed examination has revealed that the radial threads initiate at the apical region, but may be absent from the protoconch (embryonic shell). The radial threads are most likely preserved by mineral encrustation on the periostracum. Similar, but not homologous, radial threads are found in other fossil and modern molluscan taxa, such as the adhesive radial lines of anomalodesmatan bivalves or the periostracal ridges of viviparid gastropods.

keywords:

Periostracum; radial thread; helcionelloids; Cambrian molluscs

4-49 Paleontology

Periostracum in Cambrian helcionelloid and rostroconch molluscs: comparison to modern taxa

Oh, Yeongju., Peel, John S., Zhen, Yong Yi., Smith, Patrick M., Lee, Mirinae. and Park, Tae-Yoon S.

Lethaia. 2024. 57(1).

doi: 10.18261/let.57.1.6.

The periostracum, a non-calcified organic layer that envelops the mineralized shell layer ('ostracum') of molluscs, acts as an initial framework for the calcified 'ostracum.' Despite its significance in biomineralization in molluscs, fossil examples of the periostracum are limited in the geological record, especially from the Palaeozoic era, due to its susceptibility to post-mortem decay. In this study, we describe radial threads found on the outer surface of Cambrian molluscs, including helcionelloids and

4-50 Environmental Sciences

Persistent organic pollutants in the Antarctic marine environment: The influence impacts of human activity, regulations, and climate change

Kim, Da-Hye., Lee, Hyemin., Kim, Kitae., Kim, Sanghee., Kim, Ji Hee., Ko, Young Wook, and 3 others.

Environmental Pollution. 2024. 363.

doi: 10.1016/j.envpol.2024.125100.

This study investigates the presence, distribution, and potential impacts of perfluoroalkyl substances (PFASs) and hexabromocyclododecanes (HBCDs) on the Antarctic marine environment. The analysis results from the King Sejong Station, the Jang Bogo Station, and Cape Evans revealed the highest concentrations of both PFASs and HBCDs at King Sejong Station, indicating the significant influence of human activity. Short-chain perfluorocarboxylic acids (PFCAs) dominated the seawater samples, with PFPeA at the highest concentration (0.076 ng/L) at King Sejong Station, whereas perfluorosulfonic acids (PFSAs) were prevalent in the sediments, with PFHxS reaching 0.985 ng/g. Total PFASs in benthos ranged from N.D. to 2.40 ng/g ww across all stations. This indicated the effects of long-range transport and glacial meltwater. α-HBCD was the most common diastereomer in

benthos samples, detected in 58.3% of samples, suggesting its selective persistency. Although risk quotient analysis revealed low immediate risks to lower-trophic organisms, potential risks remain owing to their persistence and bioaccumulation potential. Contaminant patterns changed after regulations: perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) levels decreased, unregulated PFASs increased, HBCD stereoisomer ratios shifted towards α -HBCD dominance, and overall HBCD concentrations declined. Widespread persistence of regulated substances was observed in Antarctic environments, highlighting the need for comprehensive and long-term monitoring strategies. This study provides essential baseline data on contaminant distributions across the Southern Ocean, contributing to our understanding of emerging pollutants in Antarctic regions and informing future environmental protection efforts.

keywords:

Perfluoroalkyl substances (PFASs); Hexabromocyclododecanes (HBCDs); Antarctica; Risk assessment; Long-range transport; Human activity

suggest that the dispersal range of *E. cava* could be largely expanded by the prevalent current. Inter-population genetic structure in the perspectives of isolation-by-distance (IBD) and isolation-by-environment (IBE) revealed that distance and turbidity gradient were both contributors to the gene flow of *E. cava*. However, different results appeared for a few populations, suggesting that effects of these factors could vary depending on geographic range of populations and surrounding oceanographic conditions. This study suggests that gene flow of *E. cava* could be driven by multiple seascape factors (ocean currents, coastal topography, distance and sediments) and the interplay among them at a regional scale, which is applicable to other kelp species with diverse scales.

keywords:

Ecklonia cava; Phaeophyceae; Genetic variability; Seascape genetics; Population connectivity

4-51 *Biotechnology & Applied Microbiology; Marine & Freshwater Biology*

Population genetic diversity and connectivity of the kelp species *Ecklonia cava* from the Korean coast

Choi, Dong Mun., Hong, Seokwoo., Yang, Kwon Mo., **Ko, Young Wook.** and Kim, Jeong Ha.

Journal of Applied Phycology. 2024. 36(2): 1035-1046.

doi: 10.1007/s10811-023-03096-8.

Genetic connectivity of kelp populations can provide essential information for estimating their dispersal capability and related perspectives on persistence. We examined population genetic variability to identify connectivity and potential drivers shaping population genetic clusters of *Ecklonia cava*, a foundation kelp species in the northwest Pacific region. Using microsatellite markers, we analyzed 11 local populations along the Korean coastline from Jeju Island to Ulleungdo. We found that entire study populations were segregated into two genetic groups, inner (south coast populations) and outer (Jeju Island and Ulleungdo) coastal regions, in accordance with current patterns around South Korea and geographical topography. Genetic similarity between the furthest populations (Jeju Island and Ulleungdo)

4-52 *Plant Sciences*

Potential role of ice-binding protein in mitochondria-lipid and ATP mechanisms during freezing of plant callus

Kim, Euihyun., Kwon, Gi-Sok., Choi, Sunmee., Kim, Soo-Yun., Heo, Kyeong Yeon., Kim, Young Soon., Kim, Cha Young., Kim, Soyoung., Jeong, Jae Cheol., **Hwang, Jisub., Lee, Jun Hyuck.,** Lee, Jeong Hun. and Moh, Sang Hyun.

Plant Physiology and Biochemistry. 2024. 214.

doi: 10.1016/j.plaphy.2024.108866.

Plant calli, a perpetually undifferentiated cell culture, have defects in maintaining their genetic fidelity during prolonged tissue culture. Cryopreservation using ice-binding proteins (IBP) is a potential solution. Despite a few studies on cryopreservation using IBPs in plant calli, detailed insights into the intracellular metabolism during freezing, thawing, and re-induction remain sparse. This study investigated and employed IBP from polar yeast *Leucosporidium* sp. (LeIBP) in the cryopreservation process across diverse taxa, including gymnosperms, monocots, dicots, and woody plants. Molecular-level analyses encompassing reactive oxygen species levels, mitochondrial function, and ATP and lipophilic compounds content were conducted. The results across nine plant species revealed the effects of LeIBP on callus competency post-thawing, along with enhanced survival rates, reactive oxygen species reduction, and restored metabolic activities to the level of those of fresh

calli. Moreover, species-specific survival optimization with LeIBP treatments and morphological assessments revealed intriguing extracellular matrix structural changes post-cryopreservation, suggesting a morphological strategy for maintaining the original cellular states and paracrine signaling. This study pioneered the comprehensive application of LeIBP in plant callus cryopreservation, alleviating cellular stress and enhancing competence. Therefore, our findings provide new insights into the identification of optimal LeIBP concentrations, confirmation of genetic conformity post-thawing, and the intracellular metabolic mechanisms of cryopreservation advancements in plant research, thereby addressing the challenges associated with long-term preservation and reducing labor-intensive cultivation processes. This study urges a shift towards molecular-level assessments in cryopreservation protocols for plant calli, advocating a deeper understanding of callus re-induction mechanisms and genetic fidelity post-thawing.

keywords:

Cryopreservation; Ice-binding protein; Plant callus; Mitochondrial function; Extracellular matrix

4-53 Plant Sciences

Production of the antimalarial drug precursor amorphadiene by microbial terpene synthase-like from the moss *Sanionia uncinata*

Kim, Hyeonjin., **Lee, Yelim.**, Yu, Jihyeon., Park, Jong-Yoon., **Lee, Jungeun.**, Kim, Sang-Gyu. and Hyun, Youbong.
Planta. 2024. 260(6).
doi: 10.1007/s00425-024-04558-0.

Despite increasing demand for the exploration of biological resources, the diversity of natural compounds synthesized by organisms inhabiting various climates remains largely unexplored. This study focuses on the moss *Sanionia uncinata*, known as a predominant species within the polar climates of the Antarctic Peninsula, to systematically explore its metabolic profile both in-field and in controlled environments. We here report a diverse array of moss-derived terpene volatiles, including the identification of amorphadiene, a rare sesquiterpene compound that is a precursor for antimalarial drugs. Phylogenetic reconstruction and functional validation *in planta* and *in vitro* identified a moss terpene synthase, *S. uncinata* microbial terpene synthase-like 2 (SuMTPSL2), which is associated with amorphadiene production. We demonstrate that

expressing SuMTPSL2 in various heterologous systems is sufficient to produce amorphadiene. These results highlight the metabolic diversity in Antarctica, but also provide insights into the convergent evolution leading to the synthesis of a rare plant metabolite.

keywords:

Antarctica; Amorphadiene; Microbial terpene synthase-like; Moss; Terpenes; Volatile organic compounds

4-54 Microbiology

Responses of soil micro-eukaryotic communities to decadal drainage in a Siberian wet tussock tundra

Myeong, Nu Ri., Kwon, Min Jung., Goeckede, Mathias., Tripathi, Binu M. and **Kim, Mincheol.**
Frontiers in Microbiology. 2024. 14.
doi: 10.3389/fmicb.2023.1227909.

Climate warming holds the potential to cause extensive drying of wetlands in the Arctic, but the warming-drying effects on belowground ecosystems, particularly micro-eukaryotes, remain poorly understood. We investigated the responses of soil micro-eukaryotic communities, including fungi, protists, and microbial metazoa, to decadal drainage manipulation in a Siberian wet tundra using both amplicon and shotgun metagenomic sequencing. Our results indicate that drainage treatment increased the abundance of both fungal and non-fungal micro-eukaryotic communities, with key groups such as Ascomycota (mostly order Helotiales), Nematoda, and Tardigrada being notably abundant in drained sites. Functional traits analysis showed an increase in litter saprotrophic fungi and protistan consumers, indicating their increased activities in drained sites. The effects of drainage were more pronounced in the surface soil layer than the deeper layer, as soils dry and warm from the surface. Marked compositional shifts were observed for both communities, with fungal communities being more strongly influenced by drainage-induced vegetation change than the lowered water table itself, while the vegetation effect on non-fungal micro-eukaryotes was moderate. These findings provide insights into how belowground micro-eukaryotic communities respond to the widespread drying of wetlands in the Arctic and improve our predictive understanding of future ecosystem changes.

keywords:

soil micro-eukaryotic community; drainage treatment;

permafrost thaw; climate warming; Arctic tundra

4-55 Ecology; Geosciences, Multidisciplinary

Seasonal foraging behavior of Weddell seals in relation to oceanographic environmental conditions in the Ross Sea, Antarctica

Chung, Hyunjae., Park, Jikang., Park, Mijin., Kim, Yejin., Chun, Unyoung., Yun, Sukyoung., Lee, Won Sang., Choi, Hyun A., Na, Ji Sung., Yoon, Seung-Tae. and Lee, Won Young.

Biogeosciences. 2024. 21(22): 5199-5217.

doi: 10.5194/bg-21-5199-2024.

Understanding the foraging behavior of marine animals in Antarctica is crucial for assessing their ecological significance and responses to environmental changes, such as seasonal changes in seawater or light hours. However, studying their responses to these seasonal changes remains challenging due to the difficult logistics of conducting observations, particularly during the harsh austral winter months. In this study, we investigated the influence of changes in seawater properties and light conditions on the seasonal foraging behavior of Weddell seals (*Leptonychotes weddellii*) in the Ross Sea, Antarctica. We affixed 64 Weddell seals with conductivity–temperature–depth tags for 3 consecutive years from 2021 to 2023 to record their locations and dive profiles, including depth, head acceleration, temperature, and salinity. We found that seals foraged more frequently in Modified Shelf Water and Ice Shelf Water than in Antarctic Surface Water. This preference could be connected to greater food availability. Seals also dove to greater depths and displayed increased activity in capturing prey during daylight hours. This behavior may correspond to the diel vertical migration of pelagic prey in response to varying light conditions. Consequently, marine fauna were confronted with distinct seasonal changes in the Antarctic environment and adjusted their foraging behaviors to respond to them. This highlights the importance of extrinsic factors in estimating their seasonal foraging behavior.

4-56 Microbiology; Environmental Sciences & Ecology; Public, Environmental & Occupational Health; Meteorology & Atmospheric Science

Selective transmission of airborne bacterial communities from the ocean to the atmosphere over the Northern Pacific Ocean

Jang, Jiyeon., Park, Jiyeon., Hwang, Chung Yeon., Gim, Yeontae., Park, Ki-Tae., Yoon, Young Jun., Seo, Minju. and Lee, Bang Yong.

The Science of the total environment. 2024. 957: 177462-177462.

doi: 10.1016/j.scitotenv.2024.177462.

This study simultaneously measured the taxonomic diversity of bacterial communities in both seawater and PM2.5 aerosol samples collected from the Northern Pacific Ocean during a cruise covering 7724km between 37°N 126°E and 58°N 179°E. The relative abundance of Proteobacteria, Cyanobacteria, and Firmicutes were found to be more prevalent in aerosol samples ($39 \pm 16\%$, $5.1 \pm 1.9\%$, and $3.2 \pm 1.7\%$, respectively) than in seawater samples ($26 \pm 9\%$, $3.8 \pm 1.7\%$, and $0.02 \pm 0.09\%$, respectively). The preferential aerosolization of bacterial communities such as Proteobacteria and Firmicutes was likely to be accompanied by a terrestrial origin and high hydrophobicity. Cyanobacteria could undergo increased aerosolization, possibly because of their smaller size in the significantly higher salinity open ocean (32.8 ± 0.14 PSU) compared to those in lower salinity coastal areas (31.3 ± 1.4 PSU). The results of this study indicated that bacterial properties substantially affect their transfer from the ocean to the atmosphere, possibly influencing climate change and public health.

keywords:

Aerosolization mechanisms; Atmospheric microbial ecology; Bioaerosols; Ocean-atmosphere interaction; Taxonomic diversity

4-57 Environmental Sciences; Water Resources

Soil tillage effect on the control of invasive *Spartina anglica* in a coastal wetland

Shin, Wonhyeop., Kim, Jinhyun. and 3 others.

Wetlands Ecology and Management. 2024. 32(3): 397-408.

doi: 10.1007/s11273-024-09983-2.

Spartina anglica, an invasive marsh grass, was designated as a harmful marine organism in 2016 due to

its ability to stabilize mudflats and reduce macrobenthic diversity. To control such invasive species, physical, chemical, or biological methods can be applied while chemical methods are prohibited by law due to ecological disruption. However, the preferred methods of soil tillage, cutting, and native plant restoration for managing *S. anglica* have rarely been analyzed. To compare the methods, we performed 9 treatments with four replicates, comprising control, different frequencies of clipping (once and twice) and tilling (once and twice), and different densities (50 and 100 seedling) of restoration of the native plants *Suaeda japonica* and *Phragmites australis*. To evaluate the severity of disturbance, we measured coverage, stem density, average plant height, and above-ground biomass for 2 years. We found *P. australis* and *S. japonica* did not successfully establish or survive due to niche differences and the inherent biological features of *Spartina*. However, physical removal had a stronger effect than interspecific interaction. Two cutting treatments in the early and the late growing season reduced plant height and biomass of *S. anglica* by 6 and 34%, respectively, compared with the control treatment at the rapid vegetative growth stage in the following year. We also found that two tillage treatments reduced biomass, plant cover, and stem density by 32%, 38%, and 83%, respectively, in the following year. In the study site, managing invasive species such as *S. anglica* is best achieved by physically destroying the plant using soil tillage while attempting to restore native species had marginal control effects.

keywords:

Disturbance severity; Eradication; Frequency of treatment; Invasive plant species; Mechanical control

abundance. The density of juvenile Antarctic silverfish was estimated using an acoustic backscattering theoretical model. The mean volume backscattering strength was used to investigate the vertical and horizontal distributions of juvenile Antarctic silverfish in the Antarctic Ross Sea. The survey area was located near Cape Hallett, Antarctica, where Antarctic krill (*Euphausia superba*), ice krill (*E. crystallorophias*), and Antarctic silverfish coexist. The survey was performed four times using the Korean Antarctic research ship, RV Araon (R/V, 7507 GT). Frame trawls were conducted to identify the length and weight of the target fish species in the survey area. Captured Antarctic silverfish captured measured 3–9 cm. The maximum target strength (TS) was –92.93 dB at 38 kHz, –86.63 dB at 120 kHz, and 85.89 dB at 200 kHz. The average TS was –100.00 dB at 38 kHz, –93.00 dB at 120 kHz, and –106.90 dB at 200 kHz. Most juvenile Antarctic silverfish were found at a depth of 100 m and were distributed closer to sea ice. Between nearshore and polynya waters, the fish demonstrated a proclivity for polynya waters.

keywords:

Antarctic silverfish; hydroacoustic; mean volume backscattering strength

4-59 Biochemistry & Molecular Biology; Biophysics

Structural analysis of a bacterial ankyrin-like protein secreted by *Acinetobacter baumannii*

Sung, Ji Hye., Lee, So Yeon., Lee, Chang Sup., Lee, Jun Hyuck. and Park, Hyun Ho.

Biochemical and Biophysical Research Communications. 2024. 733. doi: 10.1016/j.bbrc.2024.150573.

In bacteria, the ankyrin-like protein AnkB helps overcome stress by regulating catalase activity when expressed under stressful conditions. As the structural properties of AnkB are largely unexplored, our understanding of various AnkB-mediated functions in bacteria remains limited. In the present study, we describe the structure of AnkB from *Acinetobacter baumannii*, hereafter referred to as “AbAnkB,” which has a unique tertiary configuration compared with that of other ankyrin domain-containing proteins. Structural analysis revealed that AbAnkB has a relatively long loop between AKR3 and AKR4 and an oppositely positioned $\alpha 8$ helix. Based on amino acid conservation and protein surface analyses, we identified a hydrophobic patch that might be critical for the function of AbAnkB. To the best of our knowledge, our study is the

4-58 Fisheries; Marine & Freshwater Biology

Spatiotemporal Distribution of Antarctic Silverfish in the Ross Sea, Antarctica

Lee, Sara., Oh, Wooseok., La, Hyoung Sul., Son, Wuju., Kim, Jeong-Hoon. and Lee, Kyounghoon.

Fishes. 2024. 9(2).

doi: 10.3390/fishes9020047.

Antarctic silverfish (*Pleuragramma antarcticum*) play a crucial intermediary role in connecting top predators and krill in the food web of the Antarctic Ocean. Despite their crucial role, research on their abundance is lacking. In this study, we estimated the abundance of juvenile Antarctic silverfish as foundational data for predicting their

first to report the structure of a bacterial AnkB protein; our findings will markedly enhance our understanding of its functions in bacteria.

keywords:

Acinetobacter baumannii; AnkB; Ankyrin repeats; Crystal structure

4-60 Multidisciplinary Sciences

Structural and functional characterization of sulfurtransferase from *Fronidhabitans* sp. PAMC28461

Do, Hackwon., Nguyen, Dieu Linh., Ahn, Yong-Yoon., Nam, Yewon., Kang, Yoonji., Oh, Hoejung., Hwang, Jisub., Han, Se Jong., Kim, Kitae. and Lee, Jun Hyuck.

Plos One. 2024. 19(3).

doi: 10.1371/journal.pone.0298999.

Sulfurtransferases transfer of sulfur atoms from thiols to acceptors like cyanide. They are categorized as thiosulfate sulfurtransferases (TSTs) and 3-mercaptopyruvate sulfurtransferases (MSTs). TSTs transfer sulfur from thiosulfate to cyanide, producing thiocyanate. MSTs transfer sulfur from 3-mercaptopyruvate to cyanide, yielding pyruvate and thiocyanate. The present study aimed to isolate and characterize the sulfurtransferase *FrST* from *Fronidhabitans* sp. PAMC28461 using biochemical and structural analyses. *FrST* exists as a dimer and can be classified as a TST rather than an MST according to sequence-based clustering and enzyme activity. Furthermore, the discovery of activity over a wide temperature range and the broad substrate specificity exhibited by *FrST* suggest promising prospects for its utilization in industrial applications, such as the detoxification of cyanide.

4-61 Biochemistry & Molecular Biology; Chemistry, Applied; Polymer Science

Structural insights into the distinct substrate preferences of two bacterial epoxide hydrolases

Hwang, Jisub., Lee, Min Ju., Lee, Sung Gu., Do, Hackwon. and Lee, Jun Hyuck.

International Journal of Biological Macromolecules. 2024. 264.

doi: 10.1016/j.ijbiomac.2024.130419.

Epoxide hydrolases (EHs), which catalyze the transformation of epoxides to diols, are present in many eukaryotic and prokaryotic organisms. They have recently drawn considerable attention from organic chemists owing to their application in the semisynthesis of enantiospecific diol compounds. Here, we report the crystal structures of *BoEH* from *Bosea* sp. PAMC 26642 and *CaEH* from *Caballeronia sordidicola* PAMC 26510 at 1.95 and 2.43 Å resolution, respectively. Structural analysis showed that the overall structures of *BoEH* and *CaEH* commonly possess typical α/β hydrolase fold with the same ring-opening residues (Tyr-Tyr) and conserved catalytic triad residues (Asp-Asp-His). However, the two enzymes were found to have significantly different sequence compositions in the cap domain region, which is involved in the formation of the substrate-binding site in both enzymes. Enzyme activity assay results showed that *BoEH* had the strongest activity toward the linear aliphatic substrates, whereas *CaEH* had a higher preference for aromatic- and cycloaliphatic substrates. Computational docking simulations and tunnel identification revealed important residues with different substrate-binding preferences. Collectively, structure comparison studies, together with ligand docking simulation results, suggested that the differences in substrate-binding site residues were highly correlated with substrate specificity.

keywords:

Crystal structure; Epoxide hydrolase; Substrate specificity

4-62 Biochemistry & Molecular Biology; Biophysics

Structural insights into the role of NahX from *Pseudomonas* sp. MC1 in the naphthalene degradation pathway

Son, Jonghyeon., Park, Ae Kyung., Shin, Seung Chul., Kim, Dockyu. and Kim, Han-Woo.

Biochemical and Biophysical Research Communications. 2025. 742.

doi: 10.1016/j.bbrc.2024.151120.

Polycyclic aromatic hydrocarbons (PAHs) are among the most widespread organic pollutants known for their carcinogenic and mutagenic properties. There is a growing interest in understanding the degradation and detoxification processes of these substances using biological approaches. The bacterium *Pseudomonas* sp. MC1 contains a metabolic plasmid (81 kb) that encodes enzymes involved in the

conversion of naphthalene (the simplest and most soluble PAH) to salicylate. Therein, *nahX* is a part of the lower naphthalene degradation operon and encodes a 140-amino acid protein. However, the function of NahX remains unclear. To understand its function more clearly, we first determined the three-dimensional structure of NahX. It has a fold similar to that of HbpS, which acts as a sensory component in response to oxidative stress. Biochemical studies have also shown that NahX and HbpS exhibit heme degradation activity and bind to iron ions. Heme degradation and iron-sequestering activity protect bacteria against oxidative stress. Previous studies have shown that oxidative stress occurs during naphthalene degradation. Therefore, we postulate that NahX has a defense mechanism against the oxidative stress that may occur during naphthalene metabolism.

keywords:

NahX; Naphthalene; HbpS; Heme; Iron; *Pseudomonas* sp. MC1

4-63 WOSCategory

Structure of MltG from *Mycobacterium abscessus* reveals structural plasticity between composed domains

Lee, Gwan Hee., Kim, Subin., Kim, Do Yeon., Han, Ju Hee., Lee, So Yeon., **Lee, Jun Hyuck.**, Lee, Chang Sup. and Park, Hyun Ho.
lucrj. 2024. 11: 903-909.
doi: 10.1107/s2052252524008443.

MltG, a membrane-bound lytic transglycosylase, has roles in terminating glycan polymerization in peptidoglycan and incorporating glycan chains into the cell wall, making it significant in bacterial cell-wall biosynthesis and remodeling. This study provides the first reported MltG structure from *Mycobacterium abscessus* (maMltG), a superbug that has high antibiotic resistance. Our structural and biochemical analyses revealed that MltG has a flexible peptidoglycan-binding domain and exists as a monomer in solution. Further, the putative active site of maMltG was disclosed using structural analysis and sequence comparison. Overall, this study contributes to our understanding of the transglycosylation reaction of the MltG family, aiding the design of next-generation antibiotics targeting *M. abscessus*.

keywords:

crystal structures; lytic transglycosylase; MltG; *Mycobacterium abscessus*; protein structures; X-ray crystallography; antibiotic resistance; structural plasticity

4-64 Biodiversity Conservation; Ecology

Substrate Preferences and Interspecific Affinities of Antarctic Macroalgae: Insights from Maxwell Bay, King George Island

Ko, Young Wook., Yang, Kwon Mo. and Choi, Han-Gu.
Diversity-Basel. 2024. 16(10).
doi: 10.3390/d16100628.

This study investigates the diversity and ecological dynamics of macroalgae in Maxwell Bay, King George Island, Antarctica, focusing on species distribution, substrate composition, and interspecific interactions. Across nine survey sites, 31 macroalgal species were recorded, with 12 species identified as significant due to their considerable relative frequency, coverage, and biomass. *Palmaria decipiens* was the most dominant species in terms of frequency and coverage, while *Desmarestia anceps* had the highest biomass. The study revealed distinct substrate preferences, with *P. decipiens* favoring cobble and mud substrates, and *Himantothallus grandifolius* associating predominantly with pebble substrates. A core group of species, including *Plocamium* sp., *H. grandifolius*, *Picconiella plumosa*, *Iridaea* sp., and *Trematocarpus antarcticus*, exhibited strong ecological interactions characterized by high substrate similarity and mutual affinity. In contrast, pioneer species like *P. decipiens* and *Monostroma hariotii* showed lower affinity with other species, reflecting their early successional roles. These findings enhance our understanding of the complex interspecific relationships within Antarctic macroalgal assemblage and provide valuable baseline data for future ecological studies in the region.

keywords:

species distribution; substrate composition; interspecific interactions; macroalgal assemblage; Antarctica

4-65 Biochemistry & Molecular Biology; Chemistry, Multidisciplinary

Synthesis and Evaluation of Chloride-Substituted Ramalin Derivatives for Alzheimer's Disease Treatment

Kim, Tai Kyoung., Cho, Yongeun., **Kim, Jaewon.**, Lee, Jeongmi., **Hong, Ju-Mi.**, Cho, Heewon., Kim, Jun-Sik., Lee, Yeongyeong., **Kim, Kyung Hee.**, **Kim, Il-Chan.**, **Han, Se Jong.**, Oh, Hyuncheol., Jo, Dong-Gyu. and Yim, Joung Han.

Molecules. 2024. 29(15).

doi: 10.3390/molecules29153701.

Alzheimer's disease (AD) is a progressive neurodegenerative disorder marked by the accumulation of amyloid-beta plaques and hyperphosphorylated tau proteins, leading to cognitive decline and neuronal death. However, despite extensive research, there are still no effective treatments for this condition. In this study, a series of chloride-substituted Ramalin derivatives is synthesized to optimize their antioxidant, anti-inflammatory, and their potential to target key pathological features of Alzheimer's disease. The effect of the chloride position on these properties is investigated, specifically examining the potential of these derivatives to inhibit tau aggregation and beta-site amyloid precursor protein cleaving enzyme 1 (BACE-1) activity. Our findings demonstrate that several derivatives, particularly RA-3Cl, RA-4Cl, RA-26Cl, RA-34Cl, and RA-35Cl, significantly inhibit tau aggregation with inhibition rates of approximately 50%. For BACE-1 inhibition, Ramalin and RA-4Cl also significantly decrease BACE-1 expression in N2a cells by 40% and 38%, respectively, while RA-23Cl and RA-24Cl showed inhibition rates of 30% and 35% in SH-SY5Y cells. These results suggest that chloride-substituted Ramalin derivatives possess promising multifunctional properties for AD treatment, warranting further investigation and optimization for clinical applications.

keywords:

Alzheimer's disease; Ramalin; derivatives; antioxidant; anti-inflammatory; β -secretase; tau protein

4-66 Genetics & Heredity

The complete mitochondrial genome of *Gobionotothen gibberifrons* (Perciformes, Nototheniidae)

Kim, Jihun., Jeong, Jihye., Lee, Seungyeon., Nguyen, Phuong Thi., Han, Dong-Won., Hettiarachchi, Sachithra Amarin., Jo, Euna., Kang, Seunghyun., Kim, Il-Chan. and Kim, Jin-Hyoung.

Mitochondrial DNA Part B-Resources. 2024. 9(3): 398-402.

doi: 10.1080/23802359.2024.2333575.

The humped rockcod, *Gobionotothen gibberifrons*, is an Antarctic fish of the genus *Gobionotothen* in the family Nototheniidae and order Perciformes. To date, little biological information has been recorded about the genus *Gobionotothen*. Here, we report the first complete

mitogenome of the genus *Gobionotothen*. The mitochondrial genome of *G. gibberifrons* is 18,631 bp in length, comprising 13 protein-coding genes, 24 tRNA genes (*trnP-UGG* and *trnT-UGU* were duplicated), 2 rRNA genes, and non-coding control regions. The base composition was 53.74% for A + T and 46.26% for G + C. This new mitochondrial genome of *G. gibberifrons* provides basic information for further phylogenetic analysis, suggesting the necessity to exploit a variety of newly discovered mitogenome sequences to infer inconclusive evolutionary relationships in Antarctic fishes.

keywords:

Antarctic fish; humped rockcod; mitogenome; phylogenetic analysis

4-67 Genetics & Heredity

The complete mitochondrial genome of the ice krill *Euphausia crystallorophias* Holt & Tattersall, 1906 (Euphausiacea, Euphausiidae), from the Ross Sea, Antarctica

Kim, Sung Hoon., Kim, Taeho., Son, Wuju., Kim, Jeong-Hoon. and La, Hyoung Sul.

Mitochondrial DNA Part B-Resources. 2024. 9(4): 500-505.

doi: 10.1080/23802359.2024.2337775.

The mitogenome of *Euphausia crystallorophias* collected from the Ross Sea Region Marine Protected Area (RSR MPA) is described for the first time. The assembled mitogenome was 17,291 bp in length and consisted of two ribosomal RNAs (rRNAs), 22 transfer RNAs (tRNAs), 13 protein-coding genes (PCGs), and noncoding regions, all of which were identical to those of other euphausiid species. The most common start codon for the 13 PCGs was ATG, and the most common termination codon was TAA. The overall G + C content was 33.2% in the heavy strand. *Euphausia crystallorophias* was sister to *E. superba* in the phylogenetic analysis. The mitogenome of *E. crystallorophias* provided significant DNA molecular data for further identification and phylogenetic analysis within the euphausiids.

keywords:

Antarctic; crystal krill; euphausiid; ice krill; marine protected area (MPA); mitochondrial genome

4-68 Genetics & Heredity

The complete mitochondrial genome of *Trematomus hansonii* Boulenger, 1902 (Perciformes, Nototheniidae)

Jo, Euna., Lee, Seungyeon., Kim, Jihun., Hettiarachchi, Sachithra Amarin., Kim, Sanghee., Kim, Il-Chan., Kang, Seunghyun. and Kim, Jin-Hyoung.

Mitochondrial DNA Part B-Resources. 2024. 9(6): 701-706.

doi: 10.1080/23802359.2024.2358959.

The striped notothen *Trematomus hansonii* is an Antarctic fish species belonging to the family Nototheniidae (cod icefishes) that is distributed throughout the Southern Ocean. In this study, the complete mitochondrial genome of *T. hansonii* was sequenced using an Illumina MiSeq platform. The circular mitochondrial genome is 19,218 bp long and contains 13 protein-coding genes, 23 tRNA genes, two rRNA genes, and one control region. Notably, there are two *trnG-UCC* genes and the second gene, located between *trnE-UUC* and *trnI-GAU*, has no D-arm structure. The base composition is 56.18% of A + T and 43.82% of G + C. The phylogenetic analysis supports that *T. hansonii* is grouped into a single clade with *T. bernacchii*. This study will be a valuable resource for further research on the phylogeny and evolution of the genus *Trematomus*.

keywords:

Antarctica; Antarctic fish; mitogenome; phylogenetic analysis; striped rockcod

aspect of successful pregnancy.

Methods and results: The extracts, obtained from the muscles of these fish, significantly enhance the migration and invasion of JEG-3 cells in in vitro wound healing, Transwell, and collagen invasion assays. These effects are accompanied by an increase in matrix metalloproteinase (MMP) 9 activity, as demonstrated by zymography. Furthermore, the extracts activated Akt and protein phosphatase 1, resulting in the dephosphorylation of β -catenin at Ser33/37/Thr41, as confirmed by western blot analysis. Consequently, MMP9 is upregulated, while metalloproteinase inhibitor 1/3 is downregulated, as verified by western blot and qRT-PCR analyses. Finally, utilizing ultraperformance liquid chromatography-tandem mass spectrometry (UPLC-MS/MS) analysis, followed by matching with the Global Natural Product Social Molecular Networking library, the study annotates the compound responsible for the observed migratory activity as taurocholic acid. Importantly, the study confirms that taurocholic acid enhances cell migration in JEG-3 cells.

Conclusion: The results of this study emphasize the potential of Antarctic fish extracts in promoting extravillous trophoblast migration and invasion, which are critical for successful pregnancy.

keywords:

JEG-3 cell; matrix metalloproteinases; migration; *Trematomus bernacchii*; *Trematomus newnesi*

4-70 Biochemistry & Molecular Biology; Chemistry, Multidisciplinary

Therapeutic Potential of Ramalin Derivatives with Enhanced Stability in the Treatment of Alzheimer's Disease

Kim, Tai Kyoung., Hong, Ju-Mi., Kim, Jaewon., Kim, Kyung Hee., Han, Se Jong., Kim, Il-Chan., Oh, Hyuncheol., Jo, Dong-Gyu. and Yim, Joung Han.

Molecules. 2024. 29(22).

doi: 10.3390/molecules29225223.

Alzheimer's disease (AD) remains a significant public health challenge with limited effective treatment options. Ramalin, a compound derived from Antarctic lichens, has shown potential in the treatment of AD because of its strong antioxidant and anti-inflammatory properties. However, its instability and toxicity have hindered the development of Ramalin as a viable therapeutic agent. The primary

4-69 Food Science & Technology

The Extracts from Two Antarctic Fish Species, *Trematomus newnesi* and *Trematomus bernacchii*, Enhance JEG-3 Cell Migration and Invasion via MMP9 Activation Through Akt/Protein Phosphatase1/ β -Catenin Pathway

Khaliq, Sana Abdul., Kim, Jaewon., Kim, Il-Chan., Kim, Jin-Hyoung. and Yoon, Mee-Sup.

Molecular Nutrition & Food Research. 2024. 68(15).

doi: 10.1002/mnfr.202400028.

Scope: This study investigates the impact of extracts derived from Antarctic fish species, *Trematomus newnesi* and *Trematomus bernacchii*, on the migration of human placental trophoblast JEG-3 cells, which is a crucial

objective of this study was to synthesize and evaluate novel Ramalin derivatives with enhanced stabilities and reduced toxic profiles, with the aim of retaining or improving their therapeutic potential against AD. The antioxidant, anti-inflammatory, anti-BACE-1, and anti-tau activities of four synthesized Ramalin derivatives (i.e., RA-Hyd-Me, RA-Hyd-Me-Tol, RA-Sali, and RA-Benzo) were evaluated. These derivatives demonstrated significantly improved stabilities compared to the parent compound, with RA-Sali giving the most promising results. More specifically, RA-Sali exhibited a potent BACE-1 inhibitory activity and effectively reduced tau phosphorylation, a critical factor in AD pathology. Despite exhibiting reduced antioxidant activities compared to the parent compound, these derivatives represent a potential multi-targeted approach for AD treatment, marking a significant step forward in the development of stable and effective AD therapeutics.

keywords:

Alzheimer's disease; Ramalin; derivatives; therapeutic potential; antioxidant; tau protein; β -secretase; anti-inflammatory; Ames

4-71 Engineering, Environmental; Environmental Sciences

Toxicity and speciation of inorganic arsenics and their adverse effects on in vivo endpoints and oxidative stress in the marine medaka *Oryzias melastigma*

Byeon, Eunjin., Jeong, Haksoo., Kim, Min-Sub., Yun, Seong Chan., Lee, Jin-Sol., Lee, Min-Chul., Kim, Jin-Hyoung. and 7 others.

Journal of Hazardous Materials. 2024. 473.

doi: 10.1016/j.jhazmat.2024.134641.

Here, we investigate the effects of acute and chronic exposure to arsenate (AsV) and arsenite (AsIII) in the marine medaka *Oryzias melastigma*. *In vivo* effects, biotransformation, and oxidative stress were studied in marine medaka exposed to the two inorganic arsenics for 4 or 28 days. An investigation of embryonic development revealed no effect on in vivo parameters, but the hatching rate increased in the group exposed to AsIII. Exposure to AsIII also caused the greatest accumulation of arsenic in medaka. For acute exposure, the ratio of AsV to AsIII was higher than that of chronic exposure, indicating that bioaccumulation of inorganic arsenic can induce oxidative stress. The largest increase in oxidative stress was observed following acute exposure to AsIII, but no significant degree of oxidative stress

was induced by chronic exposure. During acute exposure to AsV, the increase in the enzymatic activity of glutathione-S-transferase (GST) was twice as high compared with exposure to AsIII, suggesting that GST plays an important role in the initial detoxification process. In addition, an RNA-seq-based ingenuity pathway analysis revealed that acute exposure to AsIII may be related to cell-cycle progression. A network analysis using differentially expressed genes also revealed a potential link between the generation of inflammatory cytokines and oxidative stress due to arsenic exposure.

Keywords:

Inorganic arsenic; Toxicity; Speciation; Oxidative stress; *Oryzias melastigma*

4-72 Environmental Sciences; Toxicology

Transcriptomic insights into the antagonistic responses of Antarctic marbled rockcod, *Notothenia rossii*, to elevated temperature and acidification

Lee, Seungyeon., Shin, Seung Chul. and Kim, Jin-Hyoung.

Ecotoxicology and Environmental Safety. 2024. 287.

doi: 10.1016/j.ecoenv.2024.117249.

The escalating impacts of climate change, particularly ocean acidification and warming, are pivotal stressors for marine ecosystems and have profound effects on biota in polar regions. This study investigated the immunological responses of the Antarctic fish *Notothenia rossii* to environmental stressors indicative of future ocean conditions under the Intergovernmental Panel on Climate Change Shared Socioeconomic Pathways 5–8.5 scenario for 2100. We exposed *N. rossii* to conditions simulating present-day conditions: control, elevated temperature, acidification, and both stressors combined over six days. Utilizing RNA-Seq for comprehensive gene expression analysis, we identified significant upregulation and downregulation of immune-related pathways, highlighting a complex interplay of genes involved in complement and coagulation cascades, the intestinal immune network for immunoglobulin A production, cytosolic DNA sensing, natural killer cell-mediated cytotoxicity, and Interleukin 17 signaling pathways. Our findings revealed a predominantly antagonistic gene expression response, suggesting an intricate balance between energy allocation for maintaining homeostasis and the capacity of the immune system to combat stressors. This reflects a potential adaptive mechanism to combined

environmental stressors, underscoring the complexity of immune responses in *N. rossii* and suggesting both potential vulnerabilities and resilience in the face of climate change. This study provides critical insights into the immunological impacts of acidification and warming on Antarctic marine species, emphasizing the need for further research to unravel the mechanisms underlying these observed changes and inform conservation strategies for polar ecosystems in a changing global climate.

keywords:

Notothenia rossii; Combined effects; Ocean acidification; Ocean warming; Antarctic fish; Transcriptome

4-73 WOSCategory

***Tricoma (Tricoma) disparseta* sp. nov. (Nematoda: Desmoscolecidae), a New Free-Living Marine Nematode from a Seamount in the Northwest Pacific Ocean, with a New Record of *T. (T.) longirostris* (Southern, 1914)**

Lee, Hyo Jin., Lee, Heegab., Kihm, Ji-Hoon. and Rho, Hyun Soo. *Diversity-Basel*. 2024. 16(10).
doi: 10.3390/d16100648.

During a survey of marine biodiversity in the deep sea off northeastern Guam, two marine desmoscolecoid nematodes belonging to the subgenus *Tricoma* were discovered. *Tricoma (Tricoma) disparseta* sp. nov. was described based on specimens collected from sponge and starfish habitats on a seamount at depths ranging from 1300 to 1500 m. *Tricoma (Tricoma) disparseta* sp. nov. is distinguished by having 59 to 62 main rings, 9 to 10 subdorsal setae, and 14 to 18 subventral setae on each side. Notable features include the differentiation in length and insertion between the subdorsal and subventral setae, as well as the amphid extending to the second or third main ring. Additionally, the spicules have a relatively small capitulum at the proximal end, while the gubernaculum is bent into a hooked shape. The specimen of *T. (T.) longirostris* observed in this study closely resembles previously reported specimens, characterized by 78 main rings, a long and narrow head shape, eight to nine subdorsal setae, 14 to 15 subventral setae, and a gubernaculum with a knobbed apophysis. Two *Tricoma* species from the Northwest Pacific Ocean are described in detail, and pictorial keys and comparative tables for species identification are provided for groups with 50 to 64 main rings.

keywords:

meiofauna; new species; morphology; taxonomy; deep sea

4-74 Engineering, Marine; Engineering, Ocean; Oceanography

Two New Species of *Desmoscolex* (Nematoda: Desmoscolecidae) from Subtidal Benthic Habitats in Korea, with a Comparative Analysis of Cephalic Setae Variability

Jung, Woojin., Kihm, Ji-Hoon. and Rho, Hyun Soo. *Journal of Marine Science and Engineering*. 2024. 12(12).
doi: 10.3390/jmse12122168.

This study describes two new species of the subgenus *Desmoscolex* (Nematoda: Desmoscolecidae) from subtidal benthic habitats in Korea, located in the Northwestern Pacific Ocean. Both species are distinguished by the absence of cephalic setae—a rare feature previously documented in only three species within this subgenus: *Desmoscolex (Desmoscolex) rostratus* Timm, 1970; *D. (D.) asetosus* Decraemer, 1975; and *D. (D.) obscurus* Bussau, 1993. The new species exhibit distinct morphological features. *Desmoscolex (D.) lanceosetatus* sp. nov. is characterized by an asymmetrical, dorsally curved head; large amphidial fovea that extend to the posterior margin of the first main ring; and lance-shaped subdorsal setae. In females, the absence of subventral setae on the 14th ring deviates from the typical arrangement of 17 main rings. *Desmoscolex (D.) rotundicephalus* sp. nov. is identified by its globular head, oval amphidial fovea, and tapering subdorsal setae with an open tip. In females, the absence of subventral setae on the 14th ring further differentiates it from closely related species. This paper provides detailed morphological descriptions supported by scanning electron microscopy (SEM) and differential interference contrast (DIC) images. Additionally, it includes a comprehensive morphological comparison with previously described species, species diagnoses, and a pictorial key for identification.

keywords:

marine; SEM and DIC imaging; northwestern Pacific Ocean; biodiversity; taxonomy

4-75 Microbiology

Unraveling nitrogen metabolism, cold and stress adaptation in polar *Bosea* sp. PAMC26642 through comparative genome analysis

Khanal, Anamika., Han, So-Ra., Lee, Jun Hyuck. and Oh, Tae-Jin.

Frontiers in Microbiology. 2025. 15.

doi: 10.3389/fmicb.2024.1505699.

Nitrogen metabolism, related genes, and other stress-resistance genes are poorly understood in *Bosea* strain. To date, most of the research work in *Bosea* strains has been focused on thiosulfate oxidation and arsenic reduction. This work aimed to better understand and identify genomic features that enable thiosulfate-oxidizing lichen-associated *Bosea* sp. PAMC26642 from the Arctic region of Svalbard, Norway, to withstand harsh environments. Comparative genomic analysis was performed using various bioinformatics tools to compare *Bosea* sp. PAMC26642 with other strains of the same genus, emphasizing nitrogen metabolism and stress adaptability. During genomic analysis of *Bosea* sp. PAMC26642, assimilatory nitrogen metabolic pathway and its associated enzymes such as nitrate reductase, NAD(P)H-nitrite reductase, ferredoxin-nitrite reductase, glutamine synthetase, glutamine synthase, and glutamate dehydrogenase were identified. In addition, carbonic anhydrase, cyanate lyase, and nitronate monooxygenase were also identified. Furthermore, the strain demonstrated nitrate reduction at two different temperatures (15°C and 25°C). Enzymes associated with various stress adaptation pathways, including oxidative stress (superoxide dismutase, catalase, and thiol peroxidase), osmotic stress (OmpR), temperature stress (Csp and Hsp), and heavy metal resistance, were also identified. The average Nucleotide Identity (ANI) value is found to be below the threshold of 94-95%, indicating this bacterium might be a potential new species. This study is very helpful in determining the diversity of thiosulfate-oxidizing nitrate-reducing bacteria, as well as their ability to adapt to extreme environments. These bacteria can be used in the future for environmental, biotechnological, and agricultural purposes, particularly in processes involving sulfur and nitrogen transformation.

keywords:

Bosea sp.; cold adaptation; comparative genomics; nitrogen metabolism; Gram-negative bacteria

4-76 Biodiversity Conservation; Entomology

When ice and sea are not barriers for flies: First report of *Trichocera maculipennis* (Diptera) in South America

Contador, Tamara., Maturana, Claudia S., Ganan, Melisa., Rendoll-Carcamo, Javier., Troncoso-Villar, Matias., Kennedy, James., Convey, Peter., Krzeminska, Ewa., Kim, Sanghee., and 4 others.

Insect Conservation and Diversity. 2024. 17(3): 551-563.

doi: 10.1111/icad.12714.

1. During the 2022/2023 austral winter, large swarms of *Trichocera* (*Saltrichocera*) *maculipennis* Meigen, 1818 (Diptera: Trichoceridae), were observed around house roofs in Puerto Williams (Navarino Island, southern Chile, 54° S). In January 2023, the presence of this species was also confirmed in Punta Arenas (53° S), with specimens collected within the Chilean Antarctic Institute warehouse facilities.

2. *Trichocera maculipennis* is native to the Holarctic region and became established on King George Island (South Shetland Islands, Maritime Antarctic) over 15 years ago. However, the species has not previously been reported from South America.

3. Taxonomic and molecular identification techniques were used to confirm the identity of the new specimens obtained from Navarino Island and Punta Arenas. Preliminary observations of the fly's habitat preferences and swarming behaviour in Puerto Williams are provided, as well as comparisons in wing morphometrics between flies from Puerto Williams and King George Island.

4. The fly's extensive distribution and high abundance in Puerto Williams are consistent with human-facilitated introduction and several years' establishment.

5. These findings emphasise the importance of implementing robust management strategies and biosecurity measures, particularly during transportation between logistical hubs in southern South America and the remote areas of the Cape Horn Biosphere Reserve and Antarctica.

keywords:

Antarctica; barcoding; Cape Horn Biosphere Reserve; exotic; geometric morphometrics; invasive; sub-Antarctic

Whole-genome sequencing of 13 Arctic plants and draft genomes of *Oxyria digyna* and *Cochlearia groenlandica*

Kim, Jun., Lim, Jiseon., Kim, Moonkyo. and Lee, Yoo Kyung.

Scientific Data. 2024. 11(1).

doi: 10.1038/s41597-024-03569-6.

To understand the genomic characteristics of Arctic plants, we generated 28–44 Gb of short-read sequencing data from 13 Arctic plants collected from the High Arctic Svalbard. We successfully estimated the genome sizes of eight species by using the *k*-mer-based method (180–894 Mb). Among these plants, the mountain sorrel (*Oxyria digyna*) and Greenland scurvy grass (*Cochlearia groenlandica*) had relatively small genome sizes and chromosome numbers. We obtained 45× and 121× high-fidelity long-read sequencing data. We assembled their reads into high-quality draft genomes (genome size: 561 and 250 Mb; contig N50 length: 36.9 and 14.8 Mb, respectively), and correspondingly annotated 43,105 and 29,675 genes using ~46 and ~85 million RNA sequencing reads. We identified 765,012 and 88,959 single-nucleotide variants, and 18,082 and 7,698 structural variants (variant size ≥ 50 bp). This study provided high-quality genome assemblies of *O. digyna* and *C. groenlandica*, which are valuable resources for the population and molecular genetic studies of these plants.

Part 5.

Policy & Technology

5-1 *Physics; Public, Environmental & Occupational Health; Environmental Sciences & Ecology; Toxicology; Biochemistry & Molecular Biology*

A novel simultaneous abatement of bromate and diphenyl phosphate using the freezing process

Ahn, Yong-Yoon. and Kim, Kitae.

Chemosphere. 2024. 367: 143629-143629.

doi: 10.1016/j.chemosphere.2024.143629.

The purification of bromate (BrO_3^-)-contaminated water has become a challenge because of its persistence and adverse effects. Furthermore, there has been concern over the release of byproducts, such as diphenyl phosphate (DHP), from flame retardants in wastewater treatment plant (WWTP). In this study, we designed the water treatment system for the oxidation of DHP accompanied by bromate (BrO_3^-) reduction via freezing the solution. A sample containing 10 μM DHP, 100 μM Br^- , and 50 μM BrO_3^- , with a pH of 3 was frozen at -20°C , approximately 25 μM BrO_3^- was reduced, and DHP was fully eliminated after a 0.5 h reaction time. Conversely, these reactions did not advance in water at 20°C . This increase in the rate of chemical reaction in ice is the consequence of the freeze concentration effect, which refers to the extraction of dissolved chemical species into the liquid-like regions of the polycrystalline ice micro-structure during the freezing of the solution. The redox reactions among DHP, Br^- , and BrO_3^- become thermodynamically favorable due to the distinctive environment in the liquid brine in ice. The efficiency of the DHP oxidation significantly increased with an increase in BrO_3^- concentration, and vice versa. The $\text{Br}^-/\text{BrO}_3^-$ -induced HOBr production is proposed as a primary oxidant for DHP degradation. The proton activity (pH) has a significant influence on the reaction efficiency. The low freezing temperature accelerated the reaction kinetics of DHP degradation and BrO_3^- reduction. The results of this study indicate the possibility of utilizing ice chemistry for the BrO_3^- reduction that concomitantly removes DHP for water

treatment. This environmentally friendly water treatment method can be considered to implement in regions with a cold climate.

keywords:

Bromate; Freezing; Hypobromous acid; Organophosphate; Water treatment

5-2

An Analysis on Measures to Strengthen Korea's Arctic Cooperation Network and Its Policy Implications

Seo, Hyun Kyo.

Korean journal of Siberian studies. 2024. 28(2): 1-34.

doi: 10.22892/ksc.2024.28.2.01.

Korea became an observer of the Arctic Council in May 2013, and in December of the same year, the government established the 'the 1st Arctic Policy Master Plan'. This Master plan included, as the detailed implementation plan, the establishment of an 'Arctic Research Consortium' that would serve as a consultative body among domestic Arctic research-related institutions, and based on this, the consortium, named KoARC (Korea Arctic Research Consortium) was officially launched in 2015. Since then, KoARC has established itself as Korea's representative Arctic industry-academia-research-government cooperation network by carrying out various projects under the support of the Korea Polar Research Institute, the secretariat. In particular, the scope of activities is expanding by increasing the number of members, including the three domestic global shipbuilding companies, and organizing various projects as well as establishing cooperation with international networks (Arctic Economic Council). This study sought to explore ways to develop Korea's Arctic cooperation network, focusing on KoARC. In the introduction, the existing literatures related to the domestic Arctic network were reviewed, and then the history of KoARC's activities was analyzed. And in the main text, domestic and overseas cases using a top-down approach to deriving development plans for KoARC were reviewed, and comparative analysis with KoARC was conducted. And then development plans based on the results of a questionnaire-survey targeting on KoARC member institutions using a bottom-up approach was derived. After deriving a development plan that pursues harmony with the results of these top-down and bottom-up approach, implications and policy recommendations were presented in the conclusion.

keywords:

Korea Arctic Research Consortium (KoARC); Arctic Research Consortium of US (ARCUS); Japan Consortium for Arctic Environmental Research (JCARE); Korean Network for the Arctic Cooperation (KoNAC); The 1st Master Plan for the Polar Activity Promotion

5-3 *Chemistry, Multidisciplinary; Crystallography; Materials Science, Multidisciplinary*

Cryoprotective Polyol-Induced Ice Microstructure Development and Enhanced Chromium(VI) Reduction in Polycrystalline Structures

Kim, Bomi. and **Kim, Kitae.**

Crystal Growth & Design. 2024. 24(21): 9030-9038.

doi: 10.1021/acs.cgd.4c01067.

Cryoprotective polyols play a crucial role in inhibiting ice crystal growth, reducing the size of bulk ice crystals in polycrystalline structures, and increasing the volume of ice grain boundaries relative to the total solution volume. This study suggests that these properties enable cryoprotective polyols to accelerate the reduction of hexavalent chromium (Cr(VI)) in ice despite the reducing agents being limited to aqueous environments. This reaction is mainly caused by the accumulation of cryoprotective polyols and Cr(VI) at the ice grain boundaries formed during freezing (i.e., the freeze concentration effect). Upon freezing a mixture of cryoprotective polyols and a 20 μM Cr(VI) solution, over 90% reduction in Cr(VI) concentration was achieved within 24 h. Higher concentrations of cryoprotective polyols in Cr(VI) enhanced the reduction kinetics of Cr(VI) over the same reaction time, implying that the cryoprotective polyols function as reducing agents under freezing conditions. Confocal Raman spectroscopy confirmed cryoprotective polyols bind to ice crystal surfaces and concentrate Cr(VI) at the ice grain boundaries. Notably, the reductive capability of cryoprotective polyols toward Cr(VI) was observed under freezing conditions, using an electroplating wastewater sample contaminated with Cr(VI) as a model system, whereas negligible reduction was observed in the aqueous phase. Enhanced Cr(VI) reduction by cryoprotective polyols in frozen solutions presents a viable approach for treating contaminated wastewater and contributes to understanding the self-purification mechanism in natural environments where these polyols are present.

5-4 *Computer Science, Information Systems; Engineering, Electrical & Electronic; Telecommunications*

Directional Wave Scattering Distribution Modes Analysis and Synthesis of Random Ocean Media Roughness for SAR Electromagnetic Interactions Using Feature Fusion in Dynamic Sea States: A Survey

Shahrezaei, Iman Heidarpour. and **Kim, Hyun-Cheol.**

IEEE Access. 2024. 12: 44351-44382.

doi: 10.1109/access.2024.3380201.

Ocean waves have long been a research topic, and numerous formulas of the ocean wave spectrum have been widely developed to provide new prospects for ocean experiments and the advancement of radar probing. Nonetheless, the wave spectra developed by researchers fall short of the standards set by remote sensing specialists, mainly due to the limitation of capturing the surface roughness influenced by both short and long waves, prompting ongoing efforts to develop a model covering a diverse scale of wavenumbers in the absence of a generally recognized reference formula. In response, a standard two-scale formulation of wave frequency spectra (WFS) was introduced, where wave height and spectral peak period are determined by sea state. The proposed composite WFS holds the potential to incorporate directional spreading, contributing to the angular distribution of ocean wave energy in the form of directional WFS, making it applicable for ocean modeling. In an effort to investigate directionality effects, an array of well-established spreading functions, including cosine-squared, half-cosine 2s, parameterized half-cosine 2s, hyperbolic secant-squared, and composite structured functions, has been developed here for numerical modeling of random ocean media (ROM) surface roughness and synthesized for their spectral scattering distribution mode, encompassing scattering pattern, scattering orientation, and fractal roughness properties. Nonetheless, the generated ROM models, each varying due to inherent limitations in directional WFS formulation and numerical approximations, demonstrate indeterminacy and unpredictability in surface features, posing challenges for accurately synthesizing ROM roughness patterns. These challenges intensify under varying sea states and different directional WFS formulas, leading to a situation where no single synthesized composite ROM model consistently outperforms the others, rendering them imprecise frameworks for analyzing roughness patterns and investigating texture electromagnetic interactions within the realm of remote sensing. As an approach, a pattern-sensitive fusion method is proposed, employing

a multi-scale transform domain (MTD) fusion scheme that leverages the learning potential of a deep super resolution network. The objective is to fuse the reconstructed ROM roughness models, generating an optimal roughness while maintaining their scattering pattern, scattering orientation, and dominant directionality, pivotal for texture consistency and, consequently, the backscattering properties from the synthetic aperture radar (SAR) viewpoint. To validate the reliability of ROM modeling and its roughness synthesis, including the texture fusion and raw data generation, a comprehensive objective quality assessment technique is utilized. These assessments demonstrate the complete consistency of the simulation results with the underlying spectral theory, highlighting their potential contribution to projects related to ocean radar probing and remote sensing.

keywords:

Read only memory; Scattering; Sea surface; Surface roughness; Rough surfaces; Surface waves; Sea state; Directional wave frequency spectrum; fractal fusion; random ocean media; sea state; synthetic aperture radar

5-5 Environmental Sciences; Geography, Physical; Geosciences, Multidisciplinary

Education and outreach activities by the Antarctic Treaty Parties: topics and target audiences

Xavier, Jose C., Mateev, Dragomir, Wilmotte, Annick., Pena-Aguirre, Andrea., Jupe, Julie., Ramos-Garcia, Sonia., Abreu, Jose., Alfonso, Juan A., Badhe, Renuka., Beck, Inga., Bialik, Robert J., Carvalho, Andreia., Cotta, Mihaela., Choquet, Anne., Dotta, Silvia., Fioretti, Anna M., Fikizolo, Lisolomzi., Grabow, Johanna., Griffin, Eoghan., Guimaro, Hugo R., Fialho, Patricia., Fragao, Joana., Huffman, Louise T., Jung, Chaerin., Nath, Chandrika., Ozsoy, Burcu., de Pomereu, Jean., Queiros, Jose P., Seco, Jose., Shin, Hyoungh Chul. and 7 others.

Antarctic Science. 2024. 36(6): 514-523.

doi: 10.1017/s0954102024000257.

The relevance of education and outreach (E&O) activities about the Antarctic Treaty has been recognized at the Antarctic Treaty Consultative Meetings (ATCM) and at the Committee for Environmental Protection (CEP). This study examines the key topics and the target audiences detailed in papers submitted to the ATCM on E&O. Since the Antarctic Treaty entered into force in 1961, a total of 216 ATCM papers on E&O have been produced. The number of papers has increased substantially since the mid-1990s.

'Science' (76.9%) and 'Wildlife/Biodiversity/Environment' (75.5%) were the most addressed topics in these papers, while the 'Public' (81.0%) and those attending 'Schools' (69.0%) are the main target audiences. 'Science' in ATCM papers increased ~120-fold from 1961–1997 to 2015–2023, while ATCM papers discussing engagement with the 'Public' increased ~40-fold during the same period. 'Climate change' was first mentioned in 2006, and the number of papers per year increased fourfold by 2015–2023. This study shows the increasing interest in E&O through time, addressing key topics to relevant audiences related to the Antarctic region. From an educational perspective, attention should be paid to emerging topics (e.g. equity, diversity and inclusion), and the engagement of early-career professionals and educators should be made a priority.

keywords:

Antarctic educational cooperation; Antarctic Treaty; diversity and inclusion; equity; Intersessional Contact Group on Education and Outreach; science communication

5-6 Environmental Sciences; Marine & Freshwater Biology

Exploring micropollutants in polar environments based on non-target analysis using LC-HRMS

Kang, Daeho., Ahn, Yong-Yoon., Moon, Hyo-Bang., Kim, Kitae. and Jeon, Junho.

Marine Pollution Bulletin. 2024. 209.

doi: 10.1016/j.marpolbul.2024.117083.

The routine use of chemicals in polar regions contributes to unexpected occurrence of micropollutants, with sewage discharge as a prominent pollution source. The aim of this study was to identify and quantify micropollutants in polar environments near potential point sources using non-target analysis (NTA) with liquid chromatography high-resolution mass spectrometry. Seawater samples were collected from Ny-Ålesund, Svalbard and Marian Cove, King George Island, in 2023. We tentatively identified 32 compounds with NTA, along with 105 homologous series substances. Of these, 18 substances were confirmed, and 13 were quantified using the internal standard method. Most quantified substances in the Ny-Ålesund, including caffeine, naproxen, and polyethylene glycols (PEGs), exhibited concentrations ranged from 0.9 to 770,000 ng/L. In Marian Cove, the analysis predominantly detected acetaminophen, with concentrations ranging from 13 to 35 ng/L. The findings

underscore the presence and spatial distribution of emerging micropollutants resulting from wastewater discharge in polar regions.

keywords:

Polar environment; Micropollutants; High-resolution mass spectrometry; Non-target analysis; Ny-Ålesund; Marian Cove

5-7 Chemistry, Multidisciplinary; Materials Science, Multidisciplinary

Facile Approach for Designing Icephobic Coatings Using Polymers/Silica Nanoparticle Composites via Self-Formation of Superhydrophobic Surfaces

Patil, Aravind H., Trinh, Ngoc Le., Do, Hackwon., Gaiji, Houda., Kang, Youngho., Lee, Joohan., Chung, Changhyun. and Lee, Han-Bo-Ram. *Advanced Materials Interfaces*. 2024. 11(11).
doi: 10.1002/admi.202300919.

Ice accumulation and proliferation adversely affect the activities of various residential, commercial, and polar research stations. Although significant efforts are devoted to preventing ice adhesion to various surfaces by developing various anti-icing coatings, it is still necessary to enhance overall performance and durability. Herein, a facile approach is proposed for fabricating an icephobic coating on an aluminum 6061 (Al) substrate, by coating a poly(dimethylsiloxane) (PDMS)/ poly(tetrafluoroethylene) (PTFE) composite through a spin-coating method, followed by sprinkling of SiO₂ nanoparticles (NPs). Crosslinker/ binder-free adhesion between PDMS and PTFE is achieved by utilizing secondary-induced electrostatic dipole-dipole interactions, these interactions are supported by density functional theory (DFT) calculations as well as structural studies. Moreover, the controlled addition of PTFE powder to PDMS improves the water-repellency, mechanical strength, and surface roughness of the coating. The self-formation of the superhydrophobic state of the PDMS/PTFE composite is achieved by sprinkling SiO₂ NPs. The sprinkled SiO₂ NPs are protected by the PDMS/PTFE composite, which serves as a stress concentrator to achieve low ice adhesion. Furthermore, freezing at low temperatures can be delayed by controlling the heat flow rate, interfacial contact area, and surface texture. This indicates the feasibility of the proposed method for various promising anti-icing applications.

keywords:

freezing delay time; icephobicity; PDMS/PTFE; SiO₂ NPs; superhydrophobicity

5-8

Four Decades of Polar Research in Remote Sensing: A Comprehensive Review

Kim, Hyun-Cheol.

Korean Journal of Remote Sensing. 2024. 40(5): 867-879.
doi: 10.7780/kjrs.2024.40.5.2.12.

This review analyzes the progress of polar science, emphasizing the scientific and technological achievements reflected in research papers published in the Korean Journal of Remote Sensing over the last 40 years. Polar research, particularly in the context of climate change, is a relatively young but rapidly expanding field. This review includes approximately 40 studies highlighting the application of advanced remote sensing technologies such as Synthetic Aperture Radar, multispectral, and hyperspectral imaging, LiDAR, alongside machine learning and deep learning techniques. These technologies have played a critical role in observing and analyzing the changes in sea ice and glaciers in the Arctic and Antarctic and in studying the evolving polar environment. The review covers a broad spectrum of polar research topics, including sea ice detection and classification, glacier movement tracking, atmospheric temperature estimation, and monitoring changes in ocean color and chlorophyll concentrations. Additionally, it emphasizes recent advancements in artificial intelligence methods, which have enhanced the ability to predict complex environmental changes in polar regions with greater accuracy. This review highlights the importance and potential of remote sensing technologies in driving future advancements in the field by presenting the most recent research findings related to climate change, a central issue in polar science. The 40th anniversary of the Korean Society of Remote Sensing marks a significant milestone in the history of remote sensing in Korea and the development of polar science. Over the past four decades, the society has served as a key national platform for promoting polar research through remote sensing technologies and has introduced numerous pioneering studies. In this context, this review reflects on past achievements and explores future challenges in polar science. It also provides insights into the emerging challenges the field will likely encounter. It discusses how remote sensing technologies can contribute to developing strategies to address ongoing and future changes in polar

environments.

keywords:

Arctic; Antarctic; Sea ice; Glacier; Polar remote sensing;
Climate

5-9 *Toxicology; Public, Environmental & Occupational Health; Environmental Sciences & Ecology; Physics; Biochemistry & Molecular Biology*

Freezing-enhanced degradation of azo dyes in the chloride-peroxymonosulfate system

Ahn, Yong-Yoon., Kim, Jungwon., Jeon, Junho. and Kim, Kitae.

Chemosphere. 2024. 359: 142261-142261.

doi: 10.1016/j.chemosphere.2024.142261.

In this study, we investigated the freezing-induced acceleration of dye bleaching by chloride-activated peroxymonosulfate (PMS). It has been observed that the oxidation of chloride by PMS generates a free chlorine species, such as hypochlorous acid (HOCl), under mild acidic and circumneutral pH condition. This process is the major reason for the enhanced oxidation capacity for electron-rich organic compounds (e.g., phenol) in the chloride-PMS system. However, we demonstrated that the chloride-PMS system clearly reduced the total organic carbon concentration (TOC), whereas the HOCl system did not lead to decrease in TOC. Overall, the chemical reaction is negligible in an aqueous condition if the concentrations of reagents are low, and freezing the solution accelerates the degradation of dye pollutants remarkably. Most notably, the pseudo-first order kinetic rate constant for acid orange 7 (AO7) degradation is approximately 0.252 h^{-1} with 0.5 mM PMS, 1 mM NaCl, initial pH 3, and a freezing temperature of -20°C . AO7 degradation is not observed when the solution is not frozen. According to a confocal Raman-microscope analysis and an experiment that used an extremely high dose of reactants, the freeze concentration effect is the main reason for the acceleration phenomenon. Because the freezing phenomenon is spontaneous at high latitudes and at mid-latitudes in winter, and the chloride is ubiquitous elsewhere, the frozen chloride-PMS system has potential as a method for energy-free and eco-friendly technology for the degradation of organic pollutants in cold environments.

keywords:

Acid orange 7; Chloride; Freezing; Hypochlorous acid;
Oxidation; Peroxymonosulfate

5-10 *Green & Sustainable Science & Technology; Environmental Sciences; Environmental Studies*

Mapping Renewable Energy among Antarctic Research Stations

de Witt, Magnus., Chung, Changhyun. and Lee, Joohan.

Sustainability. 2024. 16(1).

doi: 10.3390/su16010426.

This paper presents an overview of current electricity generation and consumption patterns in the Antarctic. Based on both previously published and newly collected data, the paper describes the current status of renewable-energy use at research stations in the Antarctic. A more detailed view of electricity systems is also presented, demonstrating how different types of resources may be used and combined. The paper will serve as a guide to various renewable-energy generation technologies, highlighting well-established praxis, lessons learned, and potential ideas for improvement. Several renewable electricity generation technologies that have proven effective for use in the Antarctic environment are described, as well as those that are currently in use. Finally, the paper summarizes the major lessons learned to support future projects and close the knowledge gap. The use of renewable-energy sources has the potential to reduce research stations' greenhouse gas emissions, making research in Antarctica more sustainable. The availability of high-quality energy is crucial for survival and to allow scientists to conduct meaningful research at research stations under harsh Antarctic conditions.

keywords:

Antarctica; renewable energy; remote energy; energy resources

5-11 Mathematics, Interdisciplinary Applications

The Impact of Sentinel-1-Corrected Fractal Roughness on Soil Moisture Retrievals

Lee, Ju Hyoung. and Kim, Hyun-Cheol.

Fractal and Fractional. 2024. 8(3).

doi: 10.3390/fractalfract8030137.

Fractals are widely recognized as one of the best geometric models to depict soil roughness on various scales from tillage to micro-topography smaller than radar wavelength. However, most fractal approaches require an additional geometric description of experimental sites to be analysed by existing radiative transfer models. For example, fractal dimension or spectral parameter is often related to root-mean-square (RMS) height to be characterized as the microwave surface. However, field measurements hardly represent multi-scale roughness. In this study, we rescaled Power Spectral Density with Synthetic Aperture Radar (SAR)-inverted rms height, and estimated non-stationary fractal roughness to accommodate multi-scale roughness into a radiative transfer model structure. As a result, soil moisture was retrieved over the Yanco site in Australia. Local validation shows that the Integral Equation Model (IEM) poorly simulated backscatters using inverted roughness as compared to fractal roughness even in anisotropic conditions. This is considered due to a violation of time-invariance assumption used for inversion. Spatial analysis also shows that multi-scale fractal roughness better illustrated the hydrologically reasonable backscattering partitioning, as compared to inverted roughness. Fractal roughness showed a greater contribution of roughness to backscattering in dry conditions. Differences between IEM backscattering and measurement were lower, even when the isotropic assumption of the fractal model was violated. In wet conditions, the contribution of soil moisture to backscattering was shown more clearly by fractal roughness. These results suggest that the multi-scale fractal roughness can be better adapted to the IEM even in anisotropic conditions than the inversion to assume time-invariance of roughness.

keywords:

soil roughness; soil moisture; fractal method; power-law spectrum; synthetic aperture radar (SAR)

5-12 Toxicology; Environmental Sciences & Ecology; Public, Environmental & Occupational Health; Biochemistry & Molecular Biology

Visible light-induced photocatalytic degradation of tetrabromobisphenol A on platinumized tungsten oxide

Tarif, Ahmed., Tran, Khen Duy., Ahn, Yong-Yoon., Kim, Kitae., Kim, Jungwon. and Park, Hyunwoong.

Chemosphere. 2024. 363: 142785-142785.

doi: 10.1016/j.chemosphere.2024.142785.

In this study, we investigated the degradation of the flame retardant tetrabromobisphenol A (TBBPA) using platinumized tungsten oxide (Pt/WO₃), synthesized via a simple photodeposition method, under visible light. The results of degradation experiments show a significant enhancement in TBBPA degradation upon surface platinumization of WO₃, with the degradation rate increasing by 13.4 times compared to bare WO₃. The presence of Pt on the WO₃ surface stores conduction band electrons, which facilitates the two-electron reduction of oxygen and enhances the production of valence band holes (h_{VB}⁺) and hydroxyl radicals (•OH). Both h_{VB}⁺ and •OH are significantly involved in the degradation of TBBPA in the visible light-irradiated Pt/WO₃ system. This was verified through fluorescence spectroscopy employing coumarin as a chemical probe and oxidizing species-quenching experiments. The analysis of degradation products and their toxicity assessment demonstrate that the toxicity of TBBPA-contaminated water is significantly reduced after Pt/WO₃ photocatalysis. The degradation rate of TBBPA increased with increasing Pt/WO₃ dosage, reached an optimum at a Pt content of 0.5 wt%, but decreased with increasing TBBPA concentration. The decrease in degradation efficiency of Pt/WO₃ was minor, both in the presence of various anions and after repeated use. This study proposes that Pt/WO₃ is a viable photocatalyst for the degradation of TBBPA in water under visible light.

keywords:

Flame retardant; Platinumized tungsten oxide; Tetrabromobisphenol A; Toxicity assessment; Visible light

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